ESSAYS ON FINANCIAL ECONOMETRICS

by

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A Dissertation submitted to the

Graduate School–New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Economics

written under the direction of

Norman Rasmus Swanson

and approved by

New Brunswick, New Jersey

January, 2010

ABSTRACT OF THE DISSERTATION

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This dissertation comprises of three essays in financial econometrics. The first essay discusses the efficacy of alternative simulation models of the short term interest rate. This is done by constructing consistent specification tests that allow us to carry out a "horse-race" comparing various one, two, and three factor models (possiblely with jumps), across multiple historical sample periods. We find that the choice of model for simulating the future distribution of short rates is highly sample dependent, and structural breaks appear to be an important component to be considered.

The second essay presents a model that focuses on exploring the profitability of portfolio-based trading strategies that variously combine downside risk, momentum, and mean reversion by carrying out a series of pseudo real-time trading experiments using different combination trading strategies. We find, contrary to the existing literature, that momentum effects are sensitive to value and size factors. In particular, downside risk plays an important role when portfolios are sorted based on size and value.

The third essay re-examines the empirical linkage between macroeconomic variables and financial markets. Our evaluation focuses on the use of a large variety of state-of-the-art ex-ante predictive accuracy tests as well as more standard in-sample regression diagnostics. We observe substantive shifts in the dynamics of macroeconomic factor models, which have noteworthy effects on the predictive content of the factors when used to predict returns.

Acknowledgements

Many thanks are own to my dissertation advisor, Norman Swanson, for the numerous comments and suggestions that he made during the writing of this thesis. Norm taught me what a researcher need to know about research.

I am extremely grateful to my committee members, Roger Klein, John Landon Lane, and Elena Goldman, for helpful comments. Many thanks to seminar participants at Rutgers University, and to Bruce Mizrach, Hiroki Tsurumi, Ronald J. Balvers, Yangru Wu, and Martin K. Perry for their help and comments during the process.

In addition, I appreciate support from economics department. Special thanks to Dorothy Rinaldi for her effort in creating a supportive environment for learning. I must also thank Norm and John for providing financial support during the fifth year of graduate school.

I would also like to thank my friends Shiliang, Liuling, Ying, Guo, zhihua, Kaveh, Li, Noha, Soumyanetra, Ilker and Demet for all the days we spent together.

Finally I would like to thank my parents, my sisters and Guofeng for their unlimited love and support for every choice I have ever made.

Dedication

To my parents and Guofeng

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Chapter 1

introduction

This dissertation considers the forecasting performance and specification analysis of both continuous and discrete time series models. The purpose of the second paper is to add to the empirical evidence on the efficacy of alternative simulation models of the short term interest rate. This is done by constructing consistent specification tests that allow us to carry out a "horse-race" comparing various one, two, and three factor models (possibly with jumps), across multiple historical sample periods. We begin by outlining a three factor version of the simulation based specification test of Bhardwaj, Corradi and Swanson (BCS: 2008), which is based on a comparison of simulated and true conditional distributions and confidence intervals. Simulated distributions/intervals are constructed using estimated parameters and historical distributions/intervals are calculated using empirical conditional distributions based on observed data. For multi-factor models involving latent variables, the latent factors are integrated out of the final test statistics. Our evaluation involves comparing six affine models of the short rate during four historical periods, referred to as: "Post Bretton-Woods"; "Pre-1990s"; "The Stable 1990s"; and "Post 1990s". Based on the examination of Eurodollar rate data, we find that the CIR model, which is often rejected in the literature, performs best among the candidate models in "The Stable 1990s", while there is little to choose between one and two factor models when considering the "Post 1990s" period. Examination of "Pre 1990s" data, on the other hand, suggests there is little to choose between 2 and 3 factor models, and the one factor CIR model performs relatively poorly. Interestingly, when our entire "Post Bretton-Woods" sample of weekly data from 1971 to 2008 is used to estimate the competing models, the "best" model is the three factor CHEN (1996) model examined by Andersen, Benzoni and Lund (2004). We conclude that the choice of model for simulating the future distribution of short rates is highly sample dependent; and when long samples of data are used which likely span different economic regimes, more complicated models are likely to be selected as “best” than is actually warranted, if the current regime is expected to continue throughout the length of the simulation period of interest. We provide evidence that structural breaks appear to be an important component of many diffusion models of the short rate.

The third chapter examines trading strategies based on momentum effects in the U.S. stock market. We offer new empirical evidence on the relevance of momentum and mean revision effects in stock trading. We also modify oft analyzed trading strategies using these two effects to include downside risk effects. Our analysis is carried out in a series of real-time trading experiments, and by applying state of the art out-of-sample (non)linear Granger causality tests. Contrary to findings in the extant literature, we provide evidence that momentum effects are sensitive to value and size factors. In particular, downside risk plays an important role when portfolios are sorted based on size and value. Finally, we carry out a series of time series based ex-ante prediction experiments where we assess whether there is anything to choose between various different models that we consider in our trading strategy experiments. Interestingly, our findings point to little statistical difference, in a mean square forecast error sense, between the different models, suggesting that one may need to carry out direct ex-ante profitability analysis in order to reconcile our predictive time series results with our cross sectional trading strategy and excess return analysis.

The forth chapter re-examines the empirical linkage between various macroeconomic variables and financial markets. In particular, we examine the predictive content of a consumption leverage variable discussed in Bansal, Dittmar and Lundblad (2005) and the so-called “cay" variable discused in Lettau and Ludvigson (2001a,b), using the 25 size and book-to-market sorted Fama- French portfolios. Our evaluation focuses on the use of a large variety of state-of-the-art ex-ante predictive accuracy tests as well as more standard in-sample regression diagnostics. We observe substantive shifts in the dynamics of our “macroeconomic factor models", which have noteworthy effects on the predictive content of the factors when used to predict both real returns and excess returns.

Chapter 2

An Empirical Analysis of Diffusion Model Stability Across Different Historical Episodes

2.1 Introduction

Diffusion processes are used in virtually all aspects of continuous time finance from yield curve to exchange rate modeling, for the purpose of prediction, simulation and pricing. This has led to many papers recently being published in the field, numerous of which are a part of the ongoing "quest" to specify diffusions that adequately capture the dynamics in financial variables; and hence the quest for reliable models that are analytical tractable and directly applicable for financial quantitative modeling. In this paper we join the quest by undertaking a specification search of alternative short rate models. Our search centers upon the evaluation, via state of the art consistent specification tests, of simulated ex ante distributions constructed using a variety of multi factor models both with and without jumps.

One characteristic of continuous time models that is crucial to the application of such models is that only a few of those currently in use by practitioners have closed form solutions (see e.g. Cox, Ingersoll, and Ross (CIR: 1985), Black and Scholes (1973), and Hull and White (1990)). Many do not have closed form solutions, particularly those involving one or multiple latent variables (see e.g. the stochastic mean model of Balduzzi et al. (1998), the stochastic volatility model of Heston (1993), the three-factor model of Chen (1996), and the three-factor model with jumps discussed in the noteworthy paper by Andersen, Benzoni and Lund (ABL: 2004)). This issue has implications not only for pricing formulae derived from the models, but also for estimation. In recent years, many methods have been developed for the estimation of continuous time models and the (often unknown in closed form) conditional densities associated with them. For example, Ait-Sahalia (1999, 2002, 2008) provides closed form approximations of the unknown conditional densities using Hermite polynomials, for one-factor, stochastic volatility, and multi-factor models, respectively. These methods that are due to Ait-Sahalia have led to the development of numerous consistent specification tests for evaluating individual models. Another approach to the estimation problem is to use estimators of distribution functions based on historical data as well as based on simulated data, such as that discussed in Bhardwaj, Corradi and Swanson (2008) (see also Duffie and Singleton (1993)). Such estimators lead to tests characterized by parametric rates of convergence. Our approach in this paper is to implement and provide modifications of tests of the variety introduced by Bhardwaj, Corradi and Swanson (BCS: 2008) in order to carry out a "horse-race" where we "select" the best model, from amongst a relatively large class of alternatives. This approach is closest to the discrete time, point mean square forecast error, model selection approach of White (2000) which is widely used in empirical finance (see e.g. Sullivan, Timmerman and White (1999, 2001)).

As alluded to above, the question of whether particular parametric representations of diffusion processes have acceptable explanatory power relative to the "true" underlying dynamics has led to the development of many specification tests. Such specification tests for continuous-models can be divided into multiple categories. One category focuses on nonparametric tests (see e.g. Ait-Sahalia(1996, 2002), Ait-Sahalia, Fan and Peng (2006), and Hong and Li (2005)), where tests are characterized by the nonparametric estimation (e.g. using kernels) of transition densities; and model implied transition densities are often compared with their nonparametric counterparts. Another category involves the examination of generalized cross spectra (see e.g. Hong and Li (2005)). A third category that includes papers by Andersen, Benzoni and Lund (ABL: 2004), Thompson (2004), BCS (2008), Chen and Hong (2005), and Corradi and Swanson (2008), to name but a few, uses parametric methods to examine the fit of model. The testing approach used in this paper falls within this category, and is based upon the examination of models via comparison of distributional analogs of mean square forecast errors that measure the difference between simulated conditional confidence intervals (or distributions) generated using fitted parametric models and empirical conditional confidence intervals (or distributions) estimated using historical data. In addition to directly implementing the BCS (2008) test to achieve this end, we also provide a straightforward extension of the BCS (2008) test that allows for the comparison of three factor models (as opposed to evaluating only one and two factor models as in BCS (2008)). Of final note is that in these tests, a crucial element is the feature that the effect of latent variables is integrated out, thus allowing us to retain the parametric nature of the tests.

One feature of the current literature is that the application of different specification tests and different data sets has led to a variety of different conclusions. For example, Ait-Sahalia (1996) test fails to reject the Chan, Karolyi, Longstaff and Sanders (CKLS:1992) model and nonlinear drift model (Ait-Sahalia, 1996). On the other hand, Hong and Li (2005) strongly reject all univariate affine models of the Euro dollar rate, and suggest that even very sophisticated models (including GARCH, regime switching, and jumps) do not adequately capture interest rate dynamics. BCS (2008) also reject the CIR (1985) model, and conclude that stochastic volatility models are superior to the CIR model. To some extent, one might argue that the mixed evidence in the extant literature can be attributed to the fact that many analyses have been carried out using (relatively) small numbers of models and varying data samples, many of which can be tied to particular historical "episodes". In light of this, we examine multiple time periods and a relatively rich set of models in this paper. More specifically, we first discuss an easy to apply testing approach useful for model selection; and we extend the approach to include the comparison of three factor models. We then compare the simulation performance 6 alternative models including one, two, and three factor models with and without jumps. This aspect of our paper is closest to ABL (2004). Finally, and perhaps most importantly, we evaluate the competing models during different historical sample periods. This is an important element of our analysis not only because of the reasons discussed above, but also because structural breaks in the true underlying dynamics might be prevalent of sample periods are not carefully defined, and such breaks might be expected to have important effects on tests used to assess alternative term structure models.

Our empirical evaluation involves comparing six affine models of the short rate during four historical periods, referred to as: "Post Bretton-Woods", "Pre-1990s", "The Stable

1990s", and "Post 1990s" Our findings are based on an evaluation of the one month Eurodollar deposit rate collected at a weekly frequency, and can be summarized as follows. The CIR model, which is often rejected in the literature, performs best among the candidate models in "The Stable 1990s", while there is little to choose between one and two factor models when considering the "Post 1990s" period. Examination of "Pre 1990s" data, on the other hand, suggests there is little to choose between 2 and 3 factor models, although the one factor CIR model performs relatively poorly. Interestingly, when our entire sample of weekly data from 1970 to 2008 is used to evaluate the competing models, the "best" performer is the three factor CHEN (1996) model examined by ABL (2004). We conclude that the choice of model for simulating the future distribution of short rates is highly sample dependent; and when long samples of data are used which likely span different economic regimes, more complicated models are likely to be selected as "best" than is actually warranted, particularly if the current regime is expected to continue throughout the length of the simulation period of interest. Put differently, structural breaks appear to be an important component of simple diffusion models of the short rate.

The rest of this paper is organized as follows. In Section 2, we review the specification test. Section 3 presents the short term interest rate models considered in this paper. Section 4 provides the data. Empirical results are given in section 5. Section 6 summarizes the results and concludes.

2.2 Consistent Specification Tests

The specification test we adapt is the BSC (2008) test, which is a Kolmogorov type test utilizing a simple simulation based approach to construct conditional distributions when the functional form of the conditional density is unknown. The distributions are in turn used to form predictive confidence intervals for time period $t+\tau$, given information up to period t. Thereafter, for a given diffusion model the unknown conditional distribution is replaced by the simulated counter part. The specification test measures the difference between simulated conditional confidence distributions generated using fitted parametric models and empirical conditional distributions implied by historical data. The approach of

BCS builds upon pioneering specification testing work discussed in Corradi and Swanson (2005), Ait-Sahalia (1996, 2006) and Hong and Li (2005, 2007).

2.2.1 The BCS (2008) test

The BCS test is based on the comparison of the empirical cumulative distribution function (CDF) and the cumulative distribution function implied by the specification of the drift and the variance under a given null model. To illustrate the idea, consider a parametric diffusion process:

$$dX_t = b(X_t, \theta^\dagger)dt + \sigma(X_t, \theta^\dagger)dW_t, \tag{2.1}$$

where W_t is a Brownian motion, and the true parameter vector is $\theta_0 = (b_0', \sigma_0')' \in \Theta$, Θ is a compact subset of $\Re^K$. Under correct specification of the diffusion process, we have that $b(\cdot,\cdot) = b_0(\cdot,\cdot)$ and $\sigma(\cdot,\cdot) = \sigma_0(\cdot,\cdot)$, that is $\theta^\dagger = \theta_0$. Note that the stationary density, $f(x, \theta^\dagger)$, and its associated invariant probability measure are uniquely determined by $b(\cdot)$ and $\sigma^2(\cdot)$ (the drift and variance terms in the model) (BCS(2008)). The alternative hypothesis is that the parameters in the above diffusion process do not coincide with the true parameters. Instead of comparing parameters directly (see Ait-Sahalia et al. (2006)), we compare the cumulative distribution function. The null and alternative hypotheses are:

$H_0 : F_\tau(u|X_t, \theta^\dagger) = F_{0,\tau}(u|X_t, \theta_0)$, for all u, a.s.

H_A : $\Pr\left(F_\tau(u|X_t, \theta^\dagger) - F_{0,\tau}(u|X_t, \theta_0) \neq 0\right) > 0$, for some $u \in U$, with non-zero Lebesgue measure.

To construct a specification test, we follow BCS (2008) by defining the $\tau - step$ ahead conditional distribution of $X_{t+\tau}^{\theta^\dagger}$, given $X_t^{\theta^\dagger} = X_t$, as:

$$F_\tau(u|X_t, \theta^\dagger) = \Pr\left(X_{t+\tau}^{\theta^\dagger} \leq u | X_t^{\theta^\dagger} = X_t\right), \tag{2.2}$$

where $t = 1, 2, 3, ..., T - \tau$. Instead of comparing $F_\tau(u|X_t, \theta^\dagger)$ and $F_{0,\tau}(u|X_t, \theta_0)$, we need to replace $F_\tau(u|X_t, \theta^\dagger)$ with its simulated counterpart. Namely:

$$\widehat{F}_\tau(u|X_t,\widehat{\theta}_{T,N,h}) = \frac{1}{S}\sum_{s=1}^{S} 1\left\{X_{s,t+\tau}^{\widehat{\theta}_{T,N,h}} \leq u\right\} \tag{2.3}$$

where $\widehat{\theta}_{T,N,h}$ is estimated by using the whole sample of T observations. Here, $\widehat{\theta}_{T,N,h}$ converges to $\theta^\dagger$, and S is the number of simulation paths. BCS (2008) show that $\frac{1}{S}\sum_{s=1}^{S} 1\left\{X_{s,t+\tau}^{\widehat{\theta}_{T,N,h}} \leq u\right\}$ is a consistent estimate of $F_\tau(u|X_t,\theta^\dagger)$.

In order to test the above hypotheses, we measure the departure from the null hypothesis by defining the test statistic $Z_T = \sup_{u\times v\in U\times V}|Z_T(u,v)|$,where

$$Z_T(u,v) = \frac{1}{\sqrt{T-\tau}}\sum_{t=1}^{T-\tau}\left(\frac{1}{S}\sum_{s=1}^{S} 1\left\{X_{s,t+\tau}^{\widehat{\theta}_{T,N,h}} \leq u\right\} - 1\{X_{t+\tau}\leq u\}\right) 1\left\{X_t \leq v\right\}, \tag{2.4}$$

and U and V are compact sets on the real line. BCS outline block-bootstrap methods (see details in CS (2005, 2007, 2008)) for constructing critical values for this test. Specially, the bootstrap statistic is $Z_T^* = \sup_{u\times v\in U\times V}|Z_T^*(u,v)|$, where

$$\begin{aligned} Z_T^*(u,v) &= \frac{1}{\sqrt{T-\tau}}\sum_{t=1}^{T-\tau}\left(\frac{1}{S}\sum_{s=1}^{S} 1\left\{X_{s,t+\tau}^{\widehat{\theta}^*_{T,N,h}} \leq u\right\} - 1\{X_{t+\tau}^*\leq u\}\right) 1\left\{X_t^* \leq v\right\} \\ &\quad -\frac{1}{\sqrt{T-\tau}}\sum_{t=1}^{T-\tau}\left(\frac{1}{S}\sum_{s=1}^{S} 1\left\{X_{s,t+\tau}^{\widehat{\theta}_{T,N,h}} \leq u\right\} - 1\{X_{t+\tau}\leq u\}\right) 1\left\{X_t \leq v\right\} \end{aligned} \tag{2.5}$$

and where X_t^* is a resampled series constructed using standard block-bootstrap methods, $\widehat{\theta}^*_{T,N,h}$ is estimated parameter using the resampled data, X_t^*, and is in turn used to construct simulated paths, $X_{s,t+\tau}^{\widehat{\theta}^*_{T,N,h}}$, $s = 1, ..., S$ and $t = 1, ..., T-\tau$. In order to generate the empirical distribution of Z_T^*, one performs B bootstrap replications (B large). Then, one compares Z_T with the percentiles of the empirical distribution of Z_T^*, and rejects H_0 if Z_T is greater than the $(1-\alpha)th$-percentile. Otherwise, one fails to reject. BCS (2008) has proved that the test carried out in this manner is correctly asymptotically sized, and has unit asymptotic power.

2.2.2 Multi factor versions of the BCS test

For two-factor model (e.g. stochastic mean and stochastic volatility models, where $X_t = (X_t^1, X_t^2)'$), the difficulty lies in dealing with the initial value for the simulation process, given that the latent variable in X_t is unobservable. BCS (2008) integrate out this effect by first simulating a long path of length N observations for latent variable X_t^2. Second, they take the simulated values in the first step as starting values for the latent variable and simulate $S \times N$ paths in order to form, $\widehat{F}_\tau(u|X_t, \widehat{\theta}_{T,N,h})$. The associated test statistic in Eq(2.4) is:

$$Z_T(u,v) = \frac{1}{\sqrt{T-\tau}} \sum_{t=1}^{T-\tau} \left(\frac{1}{NS} \sum_{j=1}^{N} \sum_{s=1}^{S} 1\left\{ X_{j,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}} \leq u \right\} - 1\{X_{t+\tau}^1 \leq u\} \right) 1\left\{ X_t^1 \leq v \right\}. \tag{2.6}$$

Similarly, the bootstrap statistic analogous to that given in Eq(2.5) is $Z_T^* = \sup_{u \times v \in U \times V} |V_T^*(u,v)|$, where

$$\begin{aligned} Z_T^*(u,v) &= \frac{1}{\sqrt{T-\tau}} \sum_{t=1}^{T-\tau} \left(\frac{1}{NS} \sum_{j=1}^{N} \sum_{s=1}^{S} 1\left\{ X_{j,s,t+\tau}^{1,\widehat{\theta}^*_{T,N,h}} \leq u \right\} - 1\{X_{t+\tau}^{1*} \leq u\} \right) 1\left\{ X_{t+\tau}^{1*} \leq v \right\} \\ &\quad - \frac{1}{\sqrt{T-\tau}} \sum_{t=1}^{T-\tau} \left(\frac{1}{NS} \sum_{j=1}^{N} \sum_{s=1}^{S} 1\left\{ X_{j,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}} \leq u \right\} - 1\{X_{t+\tau}^1 \leq u\} \right) 1\left\{ X_{t+\tau}^1 \leq v \right\} \end{aligned} \tag{2.7}$$

Of note that we use $X_{t+\tau}^1$ and $X_{j,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}}$ to construct the conditional interval because only X_t^1 is observable in X_t.

Now, consider a three-factor model (see e.g. the “CHEN” and “CHENJ” models discussed below), where $X_t = \left(X_t^1, X_t^2, X_t^3\right)'$, and $W_t = \left(W_t^1, W_t^2, W_t^3\right)$ are mutually independent standard Brownian motions in Eq(2.1). The key issue concerns how to construct the conditional distribution $F_\tau(u|X_t, \theta^\dagger) = \Pr\left(X_{t+\tau}^{\theta^\dagger} \leq u | X_t^{\theta^\dagger} = X_t\right)$ without knowing the starting value of X_t^2 and X_t^3. To deal with this issue, we propose a simple simulation based method that is an immediate consequence of the approach discussed in BCS for one and two factor models:

Step 1: Given the estimated parameter $\widehat{\theta}_{T,N,h}$, generate a path of length N (a large number) for $X_t^{1,\widehat{\theta}_{T,N,h}}$.The trick is to use the mean of stochastic volatility and the mean of stochastic mean in $\widehat{\theta}$ as the initial start values for these two latent variables. Retrieve $X_t^{2,\widehat{\theta}_{T,N,h}}$ and $X_t^{3,\widehat{\theta}_{T,N,h}}$, $t = 1, 2, ..., N$ from the path.

Step 2: Given the observable X_t^1 and the $N \times N$ simulated latent paths ($X_j^{2,\widehat{\theta}_{T,N,h}} \times X_m^{3,\widehat{\theta}_{T,N,h}}$ $j, m = 1, ..., N$) as the start values , we simulate τ-step ahead $X_{t+\tau}^{1,\widehat{\theta}_{T,N,h}}$. Since *the start values for the two latent variables are* $N \times N$ *length, so for each* X_t^1 *we have* N^2 *path, that is* $F_{\tau,i}(u|X_t,\widehat{\theta}) = \frac{1}{N^2}\sum_{m=1}^{N}\sum_{j=1}^{N} 1\left\{X_{j,m,t+\tau}^{1,\widehat{\theta}_{T,N,h}} \leq u\right\}$, *where* i *denotes the ith simulation.*

Step 3: Simulate $X_{t+\tau}^{1,\widehat{\theta}_{T,N,h}}$ *S times, that is to repeat step 2 S times.* $\frac{1}{S}\sum_{i=1}^{S} F_{\tau,i}(u|X_t,\widehat{\theta}_{T,N,h})$ *is the estimator of* $F_\tau(u|X_t,\theta^\dagger)$.

Step 4: Construct the statistic for the null of correct specification of the conditional distribution:

$$Z_T = \sup_{u\times v\in U\times V} |Z_T(u,v)|,$$

where

$$Z_T(u,v) = \frac{1}{\sqrt{T-\tau}}\sum_{t=1}^{T-\tau}\left(\frac{1}{N^2 S}\sum_{m=1}^{N}\sum_{j=1}^{N}\sum_{s=1}^{S} 1\left\{X_{j,m,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}} \leq u\right\} - 1\{X_{t+\tau}^1 \leq u\}\right) 1\left\{X_t^1 \leq v\right\} \tag{2.8}$$

All of the results outlined in BCS (2008) generalize immediately to the current setting. In particular, the following results hold.

Proposition 1 (follows immediately from Proposition 2 in BCS (2008): Assume that $T, N, S \to \infty$. Then, if $h \to 0$, $T/N \to 0$, $T/S \to 0$, $h^2 T \to 0$,and the model is correctly specified, the following result holds for any X_t^1, $t \geq 1$:

$$\frac{1}{N^2 S}\sum_{m=1}^{N}\sum_{j=1}^{N}\sum_{s=1}^{S} 1\left\{X_{j,m,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}} \leq u\right\} - F_0(u|X_t,\theta_0) \xrightarrow{pr} 0, \text{uniformly in } u$$

Similarly, we can implement the same bootstrap method as that outlined in BCS (2008) in order to form the resampled series, X_t^{1*} and construct bootstrap statistics. Namely:

Step 1: Resample X_t^1. *In particular, we draw b blocks (with replacement) of length l, where* $bl = T$. *Thus, each block is equal to* $X_{i+1}^1, ..., X_{i+l}^1$, *for some* $i = 0, ..., T-l+1$, *with probability* $1/(T-l+1)$. *More formally, let* I_k, $k = 1, ..., b$ *be iid discrete uniform random variables on* $[0, 1, ..., T-l+1]$. *Then, the resampled series,* X_t^{1*} *is such that* $\{X_1^{1*}, X_2^{1*}, ..., X_l^{1*}, X_{l+1}^{1*}, ..., X_T^{1*}\} = \{X_{I_1+1}^1, X_{I_1+2}^1, ..., X_{I_1+l}^1, X_{I_2}^1, ..., X_{I_b+l}^1\}$, *and so a resampled series consists of b blocks that are discrete iid uniform random variables, conditional on the sample. Use these data to construct* $\widehat{\theta}_{T,N,h}^*$.

Step 2: Repeat Steps 1-3 in constructing $Z_T(u,v)$, but we use X_t^{1*} and $\widehat{\theta}_{T,N,h}^*$ to replace X_t^1 and $\widehat{\theta}_{T,N,h}$ respectively, to construct the conditional distribution for $X_{t+\tau}^{1*}$. *Particularly,*

$X_{j,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}^{*}}$ *is the simulated value at simulation s, constructed using* $\widehat{\theta}_{T,N,h}^{*}$, *and* $X_{t}^{1,\widehat{\theta}_{T,N,h}^{*}}$, $X_{j,h}^{2,\widehat{\theta}_{T,N,h}^{*}}$, $X_{m,h}^{3,,\widehat{\theta}_{T,N,h}^{*}}$ *as initial value.* Of note that we use the same set of random errors used in $X_{j,m,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}}$to construct $X_{j,m,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}^{*}}$.

Step 3: Construct the bootstrap statistic, which is the bootstrap counterpart of Z_T*:*

$$Z_T^* = \sup_{u\times v\in U\times V} \left| Z_T^*(u,v) \right|, \tag{2.9}$$

where

$$\begin{aligned} Z_T^*(u,v) \quad = \quad & \frac{1}{\sqrt{T-\tau}} \sum_{t=1}^{T-\tau} \left(\frac{1}{N^2 S} \sum_{m=1}^{N} \sum_{j=1}^{N} \sum_{s=1}^{S} 1\left\{ X_{j,m,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}^{*}} \leq u \right\} - 1\{X_{t+\tau}^{1,*} \leq u\} \right) 1\left\{ X_t^{1,*} \leq v \right\} \\ & - \frac{1}{\sqrt{T-\tau}} \sum_{t=1}^{T-\tau} \left(\frac{1}{N^2 S} \sum_{m=1}^{N} \sum_{j=1}^{N} \sum_{s=1}^{S} 1\left\{ X_{j,m,s,t+\tau}^{1,\widehat{\theta}_{T,N,h}} \leq u \right\} - 1\{X_{t+\tau}^{1} \leq u\} \right) 1\left\{ X_t^{1} \leq v \right\}, \end{aligned}$$

Step 4: Repeat step 1-3 B times to generate the empirical distribution of the B bootstrap statistics.

The first order asymptotic validity of inference carried out using bootstrap statistics formed as outlined above follows immediately from BCS (2008).

2.3 The Models

We take the ever useful CIR model as our univariate candidate model, although much of the focus of this paper is on multifactor models with one or two latent variables. Our multifactor models include a stochastic mean model, stochastic volatility model, and three-factor model. Although modelling financial variables using continuous time diffusion processes simplifies the analytical work, empirical observation suggests that there are often violent movements in underlying measures of these variables, and hence models with jumps have become important. For example, such models often better explain excess kurtosis and skewness. Thus, we also consider models with jumps, as suggested in the key “continuous-time model horse-race" paper by ABL (2004). However, our models differ somewhat from ABL (2004). For example, we consider the jump processes that are driven by two separate Poisson draws (jump up and jump down) with different intensities, and different jump magnitudes, as documented in Chacko and Das (2002). In total, we consider six short rate affine models, all of which are outlined briefly below.

The Cox-Ingersoll-Ross (CIR) Model: We follow CIR (1985) and posit that:

$$dr(t) = \kappa_r (\theta - r(t))\, dt + \sigma_r \sqrt{r(t)} dW_r(t), \tag{2.10}$$

where we assume that $W_r(t)$ is Brownian motion, θ is the long-run mean of interest rate, κ_r is the mean-reversion speed, and σ_r is the standard deviation of the interest rate, which we assume it is a constant. Different from Vasicek model (1977), the process $r(t)$ is a square-root diffusion process and it can not take negative values ($2\kappa_r\theta > \sigma_r^2$).

Stochastic Mean Model (SM): We generalize the above model by allowing for a time varying mean, $\theta(t)$, where $\theta(t)$ is itself is a mean reverting process that converges to its unconditional mean:

$$\begin{aligned} dr(t) &= \kappa_r (\theta(t) - r(t))\, dt + \sigma_r dW_r(t), \\ d\theta(t) &= \kappa_\theta \left(\overline{\theta} - \theta(t)\right) dt + \sigma_\theta \sqrt{\theta(t)} dW_\theta(t), \end{aligned} \tag{2.11}$$

where we assume that $W_r(t)$ and $W_\theta(t)$ are independent Brownian motions. $\overline{\theta}$ and σ_θ are the mean and standard deviation of the stochastic mean process $\theta(t)$, respectively. Of note is that the mean process $\theta(t)$ can not take negative values provided that $2\kappa_\theta\overline{\theta} > \sigma_\theta^2$. Stationarity requires that κ_r and κ_θ (which controls mean reversion speed) are greater than zero.

Stochastic Volatility Model (SV): We consider the prototypical stochastic volatility (SV) model proposed by Heston (1993) that has been extensively examined in the literature (see e.g. Chen (1996), Andersen, and Lund (1997), ABL (2004), and Ait-Sahalia and Kimmel (2007)). Namely:

$$\begin{aligned} dr(t) &= \kappa_r (\overline{r} - r(t))\, dt + \sqrt{V(t)} dW_r(t), \\ dV(t) &= \kappa_v (\overline{v} - V(t))\, dt + \sigma_v \sqrt{V(t)} dW_v(t), \end{aligned} \tag{2.12}$$

where κ_r and κ_v are the mean-reversion speeds of the interest rate and the variance thereof, respectively; which are required to be greater than zero to avoid nonstationarity. Additionally, $\overline{v}$ is the mean of the variance, and σ_v is the volatility of variance. $W_r(t)$ and $W_v(t)$

are scalar Brownian motions in some probability measure. We assume that $W_r(t)$ and $W_v(t)$ are not independent, but correlated. In particular, $dW_r(t)\, dW_v(t) = \rho dt$, where the correlation ρ is some constant in [-1,1]. Finally, Volatility is a square-root diffusion process, which implies that $2\kappa_v \overline{v} > \sigma_v^2$.

Stochastic Volatility Model with Jumps (SVJ): We relax the SV by allowing for discontinuous dynamics. In particular, we add Poisson-exponential jumps to the model, as follows:

$$\begin{aligned} dr(t) &= \kappa_r(\overline{r} - r(t))\,dt + \sqrt{V(t)}dW_r(t) + J_u dq_u - J_d dq_d, \\ dV(t) &= \kappa_v(\overline{v} - V(t))\,dt + \sigma_v\sqrt{V(t)}dW_v(t), \end{aligned} \tag{2.13}$$

where q_u and q_d are Poisson processes with jump intensity λ_u and λ_d respectively, and are independent of the Brownian motions $W_r(t)$ and $W_v(t)$. In particular, λ_u is the probability of a jump up, $\Pr(dq_u(t) = 1) = \lambda_u$ and λ_d is the probability of a jump down, $\Pr(dq_d(t) = 1) = \lambda_d$. J_u and J_d are jump up and jump down sizes and have exponential distributions: $f(J_u) = \frac{1}{\zeta_u}\exp\left(-\frac{J_u}{\zeta_u}\right)$ and $f(J_d) = \frac{1}{\zeta_d}\exp\left(-\frac{J_d}{\zeta_d}\right)$, where ζ_u, $\zeta_d > 0$ are the jump magnitudes, which are the means of the jumps, J_u and J_d.

Three Factor Model (CHEN): We combine various features of the above models, by considering a version of the oft examined 3-factor model due to Chan, Karolyi, Longstaff and Sanders (1992), which is discussed in detail in Dai and Singleton (2000). In particular, we consider the Chen (1996) 3-factor model:

$$\begin{aligned} dr(t) &= \kappa_r(\theta(t) - r(t))\,dt + \sqrt{V(t)}dW_r(t), \\ dV(t) &= \kappa_v(\overline{v} - V(t))\,dt + \sigma_v\sqrt{V(t)}dW_v(t), \\ d\theta(t) &= \kappa_\theta\left(\overline{\theta} - \theta(t)\right)dt + \sigma_\theta\sqrt{\theta(t)}dW_\theta(t), \end{aligned} \tag{2.14}$$

where $W_r(t)$, $W_v(t)$ and $W_\theta(t)$ are independent Brownian motions, and V and θ are the stochastic volatility and stochastic mean of short rate r, respectively. As discussed above, non-negativity for $V(t)$ and $\theta(t)$ requires that $2\kappa_v\overline{v} > \sigma_v^2$ and $2\kappa_\theta\overline{\theta} > \sigma_\theta^2$.

Three Factor Jump Diffusion Model (CHENJ): ABL (2004) extend the three factor Chen (1996) model by incorporating jumps in the short rate process, hence improving the ability of the model to capture the effect of outliers, and to address the finding by Piazzesi

(2004, 2005) that violent discontinuous movements in underlying measures may arise from monetary policy regime changes. The model is defined as follows:

$$\begin{aligned} dr(t) &= \kappa_r(\theta(t) - r(t))\,dt + \sqrt{V(t)}dW_r(t) + J_u dq_u - J_d dq_d, \\ dV(t) &= \kappa_v(\overline{v} - V(t))\,dt + \sigma_v\sqrt{V(t)}dW_v(t), \\ d\theta(t) &= \kappa_\theta\left(\overline{\theta} - \theta(t)\right)dt + \sigma_\theta\sqrt{\theta(t)}dW_\theta(t), \end{aligned} \tag{2.15}$$

where q_u and q_d are Poisson processes with jump intensities λ_u and λ_d, respectively; and are independent of the Brownian motions $W_r(t)$, $W_v(t)$ and $W_\theta(t)$. In particular, λ_u is the probability of a jump up, $\Pr(dq_u(t) = 1) = \lambda_u$ and λ_d is the probability of a jump down, $\Pr(dq_d(t) = 1) = \lambda_d$. J_u and J_d are jump up and jump down sizes and have exponential distributions $f(J_u) = \frac{1}{\zeta_u}\exp\left(-\frac{J_u}{\zeta_u}\right)$ and $f(J_d) = \frac{1}{\zeta_d}\exp\left(-\frac{J_d}{\zeta_d}\right)$, where ζ_u, $\zeta_d > 0$ are the jump magnitudes, which are the means of the jumps J_u and J_d.

2.4 Data

In order to facilitate the comparison of our empirical findings with those of BCS (2008), we use the same data set as they do. Namely, we use data collected on the one-month Eurodollar deposit rate as our proxy of the short rate. Our data ranges from January 1971 to April 2008 (1,996 weekly observations). Other yields that are often considered in the literature include the monthly federal funds rate (Ait-Sahalia (1999)), monthly yields on zero-coupon bonds with different maturities (see Duffee (2002) and Diebold and Li (2006, 2008)), the weekly 3-month T-bill rate (see Anderson, Benzoni and Lund (2004) and Durham (2001)), and even yields with longer maturities like the 6-month LIBOR (see Piazzesi (2001)).

To perform our empirical analysis, we divide the sample into 3 sub-samples corresponding roughly to three historical episodes (see Figure 2.1). One is the "Pre 1990s" period, from January 1971 to February 1991. A second period is the "Stable 1990s" period, from March 1991 to January 2001. A final period is the "Post 1990s" from February 2001 to April 2008. Of note is that the "Stable 1990s" is the longest economic expansion that the United States has ever experienced. In early 1990s, the Federal Reserve returned to targeting the federal fund rate. The Federal Reserve fixed the federal funds rate at 3% from late 1992 until February 1994, and increased the rate to 6% by early 1995. Only in January 2001, did the Federal Reserve begin to cut rates again. Interest rate during this expansion period were quite stable. During our "Pre 1990s" sample period, the Federal Reserve targeted, at various times, monetary aggregates and interest rates, which resulted to some extent in elevated interest rate volatility relative to that experienced during the 1990s. Moreover, high inflation and recessions in 1980s also increased volatility over this period. The "Post 1990s" period has also been more volatile, as federally manipulated interest rates were first lowered in order to stimulate the economy after the high-tech bubble crash, were later increased to accommodate increasing inflation and concerns about the booming housing market, and have recently again been lowered due to global financial concerns surrounding the recent crash of the U.S. housing market and related problems associated with related derivative mortgage products.

2.5 Empirical Results

We construct specification tests for four periods: January 1971- April 2008 ("Post Bretton-Woods"), January 1971- February 1991 ("Pre-1990s"), March 1991- January 2001 ("The Stable 1990s"), and February 2001- April 2008 ("Post-1990s"). Prior to reporting these results, however, we discuss broad characteristics of our data via examination of various summary statistics; and we also discuss our parameter estimation results.

2.5.1 Summary statistics

Table 2.1 reports various summary statistics for the data, including the mean, median, variance, skewness, kurtosis and Jarque-Bera test statistics. The "Post Bretton-Woods" data has a mean of 0.0687 (i.e. 6.87%), standard deviation of 0.0365 (3.65%), has positive skewness of 1.1939, and has a distribution that is peaked (leptokurtic) relative to a normal distribution, with a kurtosis value of 5.1710. The Jarque-Bera test indicates that the sample does not follow a normal distribution. The three sub-samples are also not normally distributed; and they have quite different distributional properties. The "Pre-1990s" period is quite volatile, and has the highest mean (9.08%), and the highest standard deviation (3.43%). This is due to the high inflation/interest rate regime in 1980s (the maximum interest rate during the period was 24%). In contrast, the "Stable 1990s" period is much more stable, with mean of 5.08%, standard deviation of 1.09%, and smaller skewness and kurtosis. Of note is that the Federal Reserve Bank fixed the federal funds rate at 3% from late 1992 until 02/1994, and then increased the rate to 6% by early 1995, keeping it at this level until January 2001. This may explain why the "Stable 1990s" period is negatively skewed (-0.699), although all other samples have significant positive skewness. As opposed to the other two sub-samples, the "Post-1990s" period demonstrates a bimodal distribution (see the discussion of in Section 4 for details). Of note is that in 2004 the Eurodollar rate reached a low of 1.04%. Moreover, it is not surprising that the Eurodollar rate data that we examine shares the same patterns of increase and decrease as the federal funds rate, which explains the sharp decreases and increases in the Eurodollar rate in the "Post-1990s" period. Compared with other samples, the "Post-1990s" period has the lowest mean (3.17%), but has a relatively high standard deviation (1.68%). These results suggest that interest rate models that are "regime-dependent" may provide a better fit to data generated during a particular regime. Of course, a difficulty with modelling individual regimes will be ascertaining whether the period to be simulated can be expected to remain within the regime.

2.5.2 Estimation results

One of the many available estimation method for models of the variety considered here is efficient method of moments (EMM) proposed by Gallant, and Tauchen (1996, 1997), which calculates moment functions by simulating the expected value of the score implied by an auxiliary model. Parameters are then computed by minimizing a chi-square criterion function. An alternative estimation procedure based on method of moments is generalized method of moments (GMM), as documented in Jiang and Knight (2002) (see also Chacko and Viceira (2003)), which can be used to easily estimate relatively complicated processes including all of the models considered in this paper, but which requires the existence of a closed form expression for the empirical conditional characteristic function.Since the conditional characteristic functions and associated moments are of the underlying continuous time process, and are not discrete approximation, so that estimation is free from discretization error associated with simulation based estimators. In our empirical analysis, we have found that these GMM estimates appear to be stable and robust.

Estimation results for the different sample periods are summarized in Tables 2.2-2.5, where parameter estimates are annualized (this is done for weekly data by setting $\tau = \frac{1}{52}$), to accord with the extant literature. Table 2.2 reports the estimation results for the whole sample. The CIR model has an estimate of $\overline{r} = 6.57\%$, which is very close to the observed sample mean of 6.87%. Of note is that the CIR model has a very high standard deviation of 11.8%, which is much higher than the observed sample standard deviation of 3.65%. This discrepancy is likely driven by the model itself, which assumes that volatility is constant, and is one reason why the CIR model is often rejected in literature.[1]

The SM model extends the CIR model by allowing for a time varying drift. The long term mean, $\overline{\theta}$, is estimated to be 5.58%. Further, our estimates of the speed of mean reversion (i.e. κ_r and κ_θ) are 0.2169 and 0.2926, respectively. Compared with the estimation results reported by ABL (2004), the short rate $r(t)$ reverts slowly to its time-varying mean $\theta(t)$, and $\theta(t)$ reverts a little bit faster to its long-run mean, $\overline{\theta}$. Of note is that some of the SM parameters are not highly significant (e.g. the mean reversion parameter), perhaps accounting to some extent of the SM model's inability to fully capture the fat tailed behavior of our data.

The SV model extends the CIR by allowing for time varying volatility. As shown in Table 2.2, the unconditional mean is $\overline{r} = 5.55\%$, and the mean reversion speed is 0.210. The half life of shocks in this model is three and a half years (i.e. the first order autoregressive coefficient is $e^{-\frac{\kappa_r}{52}} = 0.996$, at the weekly level), which corresponds to the strong serial dependence observed in the data. Furthermore, the first order autoregressive coefficient for the volatility process in the SV model is $e^{-\frac{\kappa_v}{52}} = 0.951$, which is again indicative of strong serial dependence. In this model, the estimate of ρ is -0.192, suggesting small negative conditional correlation between the short rate and its stochastic volatility.

Our SVJ model estimation results are as expected. In this model, the estimates of μ

[1] see e.g. Ait-Sahalia (1996), Tauchen (1997), Bandi (2002), BCS (2008) etc..

and κ_r are very close to the corresponding values in the SV model. Examination of the jump coefficients suggests that there is a clear asymmetry in the magnitude and intensity of up and down jumps. Our estimates indicate that the average size of an up-jump is small, at only 7 basis points; but with a high intensity of 5.49. As parameters are annualized, this means that there are roughly 5.5 up-jumps of average size 7 basis points, in a year. On the contrary, we estimate roughly 3.2 down-jumps per year, but with a much larger average size of 11.4 basis points.[2] Thus, the total number of jumps (up and down) to the interest rate process is estimated to be roughly 8-9. This result is in line with the observation of Piazzesi (2005) that jumps in the short rate are linked closely to the Federal Open Market Committee (FOMC) meetings; and the FOMC usually meets 8 times per year.[3]

Turning now to our three factor models, the findings in Table 2.2 indicate that the estimated value of κ_θ increases significantly, relative to the value obtained under the SM model. In other words, $\theta(t)$ reverts to its long-run mean, $\overline{\theta}$, at a much faster rate than the SM model. The other estimated parameters in the CHEN and CHENJ models are as expected. The most notable caveat is for CHENJ, where the jump up and jump down sizes both decrease when compared with the estimates from the SVJ model, which suggests that the SVJ model accommodates time-varying mean variation in the jump specification. This in turn suggests that model misspecification imparted by not including enough time varying components in short rate models may lead to substantially biased estimates of the remaining parameters in the model. It appears that increasing model complexity substantively changes other parameter estimates.

Table 2.3 summarizes estimation results for the "Pre-1990s" sample period. Of note is that all models that we discussed above do capture the relatively higher interest rate mean and volatility in the "Pre-1990s", as expected. The CIR model has $\overline{r} = 9.24\%$, and a much higher mean reversion speed κ_r. Similarly, the long term mean, $\overline{\theta}$, is estimated to be 8.32% in the SM model. Furthermore, our estimates of the speed of mean reversion (i.e. κ_r κ_θ and κ_v) are higher in Table 2.3. Interestingly, the estimates in Table 2.3 are

[2] As starting values in our optimization, we use a jump intensity of 3 up and 3 down jumps per year (*i.e.* $\lambda_u, \lambda_d = 3$). Further, the jump sizes are initially set to 25 basis points, following Piazzesi (2005).

[3] There are some emergency meetings beyond the 8-meeting agenda if needed.

not particularly supportive of our stochastic volatility and three-factor models, in the sense that the parameters are poorly identified with standard errors that increase relatively to Table 2.2. However, we shall see that these models do fare well against the competitors when comparing simulated distributions using our BCS type tests. Of final note is that we have more jumps up and jumps down in this period, and jump sizes are higher than those reported in Table 2.2. These results are sensible, and reflect the high volatility of interest rate during the "Pre-1990s" period.

Table 2.4 summarizes estimation results for the "Stable 1990s" period. The stable interest rates during this period ensure that the long run mean estimators (i.e. $\overline{r}$ and $\overline{\theta}$), the volatility estimators (i.e. σ_r, σ_θ and σ_v), and the speed of mean reversion estimators (i.e. κ_r, κ_θ and κ_v) are amongst the lowest across all sample periods. In early 1990s, the Federal Reserve Bank began to target interest rates quite vigorously and met 8 times per year, since 1994. Not surprisingly, the market short rate tended to fluctuate in a narrow band around the interest rate target until the next target was announced. Thus, rates between successive FOMC meetings were quite stable. One possibility here is that the change in targets might be captured by up and down jumps, particularly given that our SVJ CHENJ models estimate the total jumps during this period to be around 7. This is consistent with the fact that the Fed changed interest rate targets infrequently during this period.[4] Moreover, jump down sizes are much bigger than the jump up sizes during this period, in line with the empirical evidence.

Finally, "Post-1990s" estimation results are provided in Table 2.5. In this period, the Federal Reserve Bank decreased interest rates from 6% in 2001 to 1% in 2003; and then increased rates to 5.25% by 2007, and decreased them to 2% by April 2008. The sharp up and down swings in the target rate induce an apparent bimodality in the distribution of the Eurodollar rate. The estimates for this period are in some sense "between" those reported for the "Pre-1990s" and "Stable 1990s" periods. The most interesting finding in this period is that both the jump up size and jump down size are bigger than any other period, and

[4] The Fed changed interest rate target 10 times in 1991, 3 times in 1992, 6 times in 1994, 3 times in 1995, once in 1997, 3 times in 1998, 1999, and 2000, and twice before March 2001. The Fed didn't change interest rate in 1993 and 1996. (From the Federal Reserve Board)

the total jump intensity is around 11 times per year.

2.5.3 Specification test results

Tables 2.6-2.9 report our specification results for the 4 sample periods. Tests are carried out using $\tau-$step ahead confidence intervals. We set $\tau = \{1, 2, 4, 12\}$, corresponding to one week, two weeks, one month, and one quarter ahead conditional distribution evaluation periods. The confidence intervals that we use in test statistic construction are chosen based on the properties of our historical data. In particular, we set $\underline{u}$ and $\overline{u}$ equal to $\overline{X} \pm \sigma_X$ and $\overline{X} \pm 0.5\sigma_X$, respectively. Additionally, we set our simulation sample length as $S = 10T$,where T is the historical sample length. The simulation sample length for latent variables is set at $N = 10T$. In our implementation of the bootstrap, we set block length to be 20, and carry out 100 bootstrap replications. In the tables, test statistics (denoted by V_T) and 5%, 10%, 15% and 20% bootstrap critical values are given. Single starred entries denote rejection at the 10% level.

"Post Bretton-Woods"

Results are presented in Table 2.6. Not surprisingly, the CIR model is rejected for all τ, with any confidence interval. Moreover, the SV model performs the best amongst the CIR, SV and SVJ models. These results are in line with those reported in BCS (2008). Interestingly, though, we find that the three-factor model (CHEN) not considered in BCS (2008) performs at least as well as the SV model. moreover, the failure to reject the CHEN model at the 20% level indicates that the CHEN model is in some crude sense "better" than the SV model. Increased model complexity may help capture the spot rate dynamics when long samples of data across many historical regimes are used to calibrate models. Of further note is that the CHENJ model performs better than the SVJ model.

To further illustrate the findings of Table 2.6, we plot kernel densities of our simulated data and actual data in Figure 2.2, for selected models. Specifically, we choose points that represent the left tail, middle points and right tail of our historical data as evaluation points, and construct kernel density estimates. Figure 2.2a contains plots of the simulated density at $x = 0.03$. Compared with the CIR, the SV and CHEN models are more concentrated around the actual data point. Moreover, the 3-factor CHEN model has higher kurtosis than the SV model. These findings are in line with the specification test result suggesting that CHEN is superior to the other candidate models. Similar results are reported in Figures 2.2b-d for other evaluation points.

"Pre 1990s"

Table 2.7 presents specification results for the "Pre-1990s" period. Although some models perform relatively better than others, the extremely high rejection frequency indicates that none of the six models adequately capture interest rate dynamics for this period. This finding is consistent with Hong and Li (2005), where their univariate model is rejected without exception, multifactor models provide only a little improvement, and even their most sophisticated model does not capture the dynamics of short rates. Figure 2.3 contains plots of simulated densities for the CIR, SV and CHEN models. Figures 2.3a-d exhibits that none of the models yield simulated densities that are centered around the actual data points. The CIR model yields the worst results, amongst the three models. Note also that as the evaluation point is increased from $x = 0.08$, to $x = 0.20$, the simulated densities for the three models move further away from the actual points, suggesting, as expected, the difficulties in mimicking tail behavior.

"The Stable 1990s"

The most interesting result we find in Table 2.8 is that the univariable CIR model beats all multifactor models in the "Stable 1990s" period. The CIR model fails to be rejected for all values of τ, and for all confidence intervals, at any confidence level. This result is in stark contrast to our findings for the whole sample and the "Pre-1990s" periods. As discussed in Section 2.5.1, this is perhaps not surprising given the stable monetary regime of the 1990s; and reminds us that our different models perform very differently depending upon the particular regime from whence the data we fit are taken. Figures 2.4a-d display plots of the simulated densities for the CIR, SM and CHENJ models. We choose the SM model instead of the SV model in Figure 2.4 because the SM model is the "second best" from amongst the six candidate models. The CHENJ model is depicted in order to illustrate how the jump process distorts the simulated densities in this stable period. As evidenced upon inspection of Figure 2.4a, the CIR model is superior to the SM model in that CIR-simulated data is more concentrated around the actual evaluation point. As expected, the simulated density for the CHENJ model is far from the evaluation point. Similar conclusions emerge upon examination of Figures 2.4c-d.

"Post-1990s"

The bimodality associated with the "Post-1990s" period makes our specification test results quite different from those reported for our other sample periods. The SM model "outperforms" other models. The rejection frequency for the CIR model is low as well. Surprisingly, we fail to reject the null of correct specification for the complex three-factor with jumps CHENJ model. These results are sensible given the underlying characteristics in this period. The SM model captures the changing mean in this period. However, since the Federal Reserve Bank changed the target rate with higher frequency and larger magnitudes during this period, the CHENJ model which combines stochastic mean and jump components also performs well.[5] Moreover, the CHENJ model appears to be able to capture possible outliers in this period via its inclusion of two latent variables. Figures 2.5a-b contain plots of empirical densities for the SM, CIR and SV models at the two modal points ($x = 0.02$ and $x = 0.05$). The densities associated with the SM model have higher peak and narrower tails than those for the CIR model, at both evaluation points. As expected, the SV model has densities with very fat tails; but these are centered far from the evaluation point. Of final note is that there are evaluation points for which other models do beat the SM model, but the SM performs best in overall. This is a feature which should be expected, and underscores the importance of using not only the portmanteau type specification tests but also individual densities for evaluating alternative models.

[5] The Fed changed interest rate target 11 times in 2001, once in 2002 and 2003, 5 times in 2004, 8 times in 2005, 4 times in 2006 and 2008, 3 times in 2007. (From the Federal Reserve Board). See also the estimate discussion in section 6.2.

2.6 Conclusion

This paper implements simulation based specification tests in order to study the performance of different affine multifactor diffusion processes across various historical sample periods. We begin with outlining the simulation testing framework used to carry out our specification analysis. thereafter, we examine Eurodollar interest rate data using (i) a basic statistical analysis; (ii) specification tests; and (iii) simulation based kernel density estimates of distributions around particular evaluation points on the support of our historical dataset. we find that the CIR model, which is often rejected in the literature, performs best among the candidate models in “The Stable 1990s”, while there is little to choose between one and two factor models when considering the “Post 1990s” period. Examination of “Pre 1990s” data, on the other hand, suggests there is little to choose between 2 and 3 factor models, although the one factor CIR model performs relatively poorly. Interestingly, when our entire sample of weekly data from 1970 to 2008 is used to estimate the competing models, the “best” performer is the three factor CHEN (1996) model examined by Andersen, Benzoni and Lund (2004). We conclude that the choice of model for simulating the future distribution of short rates is highly sample dependent; and when long samples of data are used which likely span different economic regimes, more complicated models are likely to be selected as “best” than is actually warranted, particularly if the current regime is expected to continue throughout the length of the simulation period of interest. Put differently, structural breaks appear to be an important component of simple diffusion models of the short rate.

Many topics for further research remain. For example, from a theoretical perspective, it remains to construct specification tests that do not integrate out the effects of latent factors. It also remains to construct truly “ex ante” model selection type predictive accuracy tests using the techniques discussed in this paper as a starting point. From an empirical perspective, it remains to determine whether it is in some sense “optimal” to fit models to shorter data samples when simulating future scenarios, and if so, exactly how “short” should samples be?

Table 2.1: Summery statistics for different subsamples

Sample period	Date	Mean	Median	Std. Dev.	Skewness	Kurtosis	JB
Post Bretton-Woods	01/1971-04/2008	0.0687	0.0594	0.0365	1.1939	5.1710	844.9710
Pre 1990s	01/1971-02/1991	0.0908	0.0831	0.0343	1.3553	4.9309	483.6905
The Stable 1990s	03/1991-01/2001	0.0508	0.0541	0.0109	-0.6995	2.4096	49.8637
Post 1990s	02/2001-04/2008	0.0317	0.0286	0.0168	0.1909	1.4539	39.5192

Notes: This table reports the summary statistics for our historical data. The“Post Bretton Wood” stands for period from January 1971 to April 2008. The “Stable 1990” period starts from March 1991 to January 2001. The “Pre 1990s” period covers January 1971 to Febrary 1991. The “Post 1990s" period is Febrary 2001 to April 2008. See section 4 for details.

Table 2.2: Parameter estimates for various spot interest rate models- “Post Bretton Woods” (01/1971-04/2008)

Parameter	Models					
	CIR	SM	SV	SVJ	CHEN	CHENJ
κ_r	0.3068	0.2169	0.2104	0.2415	0.1261	0.4037
	(0.1872)	(0.2892)	(0.0196)	(0.0084)	(0.5749)	(0.0414)
$\bar{r}$	0.0657		0.0555	0.0739		
	(0.0383)		(0.0293)	(0.0930)		
σ_r	0.1180	0.0168				
	(0.0281)	(0.0181)				
κ_θ		0.2926			0.3373	0.2763
		(1.8639)			(0.5592)	(2.05324)
$\bar{\theta}$		0.0558			0.0504	0.0659
		(0.0163)			(0.0174)	(0.15981)
σ_θ		0.0217			0.0021	0.1907
		(0.6261)			(0.5669)	(9.26265)
κ_v			2.8066	2.2931	2.8979	2.1159
			(0.2488)	(0.0036)	(0.1150)	(1.90270)
$\bar{v}$			0.0003	0.0005	0.0002	0.0006
			(0.8117)	(0.0003)	(0.0003)	(0.00127)
σ_v			0.0191	0.0149	0.0054	0.0034
			(0.0319)	(0.0045)	(0.0006)	(0.02581)
ρ			-0.1921	-0.1050		
			(0.00966)	(0.0471)		
λ_u				5.4919		8.1042
				(10.3636)		(2.22153)
ζ_u				0.0007		0.0005
				(0.0035)		(0.00455)
λ_d				3.1210		2.8334
				(5.2057)		(1.20637)
ζ_d				0.0011		0.0007
				(0.0114)		(0.0100)

Notes: Results are based on exactly identified GMM estimation, using conditional moments. Numerical values in parentheses are standard errors. Parameter estimates are constructed using weekly interest rate data expressed in decimal form on a yearly basis. The dataset includes 1996 weekly observations on the Eurodollar deposit Rate for the period 01/1971 to 04/2008.

Table 2.3: Parameter estimates for various spot interest rate models- "Pre 1990s" (01/1971-02/1991)

Parameter	Models					
	CIR	SM	SV	SVJ	CHEN	CHENJ
κ_r	0.6707	0.2680	0.2633	0.3012	0.2410	0.4311
	(0.2815)	(1.3272)	(0.0217)	(0.0104)	(0.5612)	(0.0541)
$\overline{r}$	0.0924		0.0831	0.0719		
	(0.0583)		(0.0332)	(0.0876)		
σ_r	0.1304	0.0139				
	(0.0618)	(0.0241)				
κ_θ		0.4996			0.3012	0.2248
		(1.3286)			(0.6714)	(3.0004)
$\overline{\theta}$		0.0832			0.0844	0.0939
		(0.2507)			(0.1402)	(0.1785)
σ_θ		0.0015			0.0001	0.1845
		(1.2231)			(0.6112)	(6.4524)
κ_v			3.5006	2.5922	3.004	2.1204
			(1.0124)	(1.0132)	(0.9802)	(1.8557)
$\overline{v}$			0.0002	0.0007	0.0002	0.0006
			(0.9278)	(0.0004)	(0.0012)	(0.0009)
σ_v			0.0124	0.0102	0.0094	0.0059
			(0.0571)	(0.0158)	(0.0007)	(0.0412)
ρ			-0.3379	-0.1105		
			(0.0012)	(0.0612)		
λ_u				7.8910		9.1260
				(9.2389)		(4.1125)
ζ_u				0.0028		0.0001
				(0.0052)		(0.0047)
λ_d				3.5981		3.8258
				(6.0245)		(1.3107)
ζ_d				0.0027		0.0000
				(0.0187)		(0.0100)

Notes: Results are based on exactly identified GMM estimation, using conditional moments. Numerical values in parentheses are standard errors. Parameter estimates are constructed using weekly interest rate data expressed in decimal form on a yearly basis. The dataset includes 1040 weekly observations on the Eurodollar deposit Rate for the period 01/1971 to 02/1991.

Table 2.4: Parameter estimates for various spot interest rate models- "The Stable 1990s" (03/1991-01/2001)

Parameter	Models					
	CIR	SM	SV	SVJ	CHEN	CHENJ
κ_r	0.2590	0.0256	0.0380	0.3018	0.0611	0.2707
	(0.1872)	(0.2892)	(0.0196)	(0.0084)	(0.5749)	(0.0414)
$\overline{r}$	0.0493		0.0306	0.0538		
	(0.0383)		(0.0293)	(0.0930)		
σ_r	0.0325	0.0011				
	(0.0281)	(0.0181)				
κ_θ		0.3700			0.2792	0.3072
		(0.8639)			(0.5592)	(2.0534)
$\overline{\theta}$		0.0262			0.0464	0.0635
		(0.0163)			(0.0174)	(0.1591)
σ_θ		0.1393			0.0000	0.1175
		(0.6261)			(0.5669)	(9.2625)
κ_v			3.4392	2.5901	3.1010	2.1182
			(0.2488)	(0.0036)	(0.1150)	(1.9027)
$\overline{v}$			0.0000	0.0000	0.0000	0.0000
			(0.8117)	(0.0003)	(0.0003)	(0.0012)
σ_v			0.0014	0.0098	0.0056	0.0001
			(0.0319)	(0.0045)	(0.0006)	(0.0258)
ρ			-0.4783	-0.1027		
			(0.00966)	(0.0471)		
λ_u				5.8901		5.1601
				(10.3636)		(2.2215)
ζ_u				0.0006		0.0006
				(0.0035)		(0.00455)
λ_d				1.6102		2.8361
				(5.2057)		(1.2063)
ζ_d				0.0030		0.0016
				(0.0114)		(0.0100)

Notes: Results are based on exactly identified GMM estimation, using conditional moments. Numerical values in parentheses are standard errors. Parameter estimates are constructed using weekly interest rate data expressed in decimal form on a yearly basis. The dataset includes 516 weekly observations on the Eurodollar deposit Rate for the period 03/1991 to 01/2001.

Table 2.5: Parameter estimates for various spot interest rate models- "Post-1990s" (02/2001-04/2008)

Parameter	Models					
	CIR	SM	SV	SVJ	CHEN	CHENJ
κ_r	0.0661	1.5631	0.0501	0.2959	0.0494	0.3638
	(0.1872)	(0.2892)	(0.0196)	(0.0084)	(0.5749)	(0.0414)
$\overline{r}$	0.0066		0.0297	0.0341		
	(0.0383)		(0.0293)	(0.0930)		
σ_r	0.0270	0.0072				
	(0.0281)	(0.0181)				
κ_θ		0.0948			0.3175	0.2870
		(0.8639)			(0.5592)	(2.0534)
$\overline{\theta}$		0.0369			0.0395	0.0501
		(0.0163)			(0.0174)	(0.1591)
σ_θ		0.0559			0.0032	0.1844
		(0.6261)			(0.5669)	(9.2625)
κ_v			2.8131	2.4921	2.1006	2.1192
			(0.2488)	(0.0036)	(0.1150)	(1.9027)
$\overline{v}$			0.0000	0.0001	0.0001	0.0005
			(0.8117)	(0.0003)	(0.0003)	(0.0012)
σ_v			0.0001	0.0053	0.0011	0.0056
			(0.0319)	(0.0045)	(0.0006)	(0.0258)
ρ			-0.0080	-0.1039		
			(0.00966)	(0.0471)		
λ_u				9.8901		8.1663
				(10.3636)		(2.2215)
ζ_u				0.0008		0.0007
				(0.0035)		(0.00455)
λ_d				2.5109		2.8284
				(5.2057)		(1.2063)
ζ_d				0.0014		0.0022
				(0.0114)		(0.0100)

Notes: Results are based on exactly identified GMM estimation, using conditional moments (see Section 5.1 for complete details). Numerical values in parentheses are standard errors. Parameter estimates are constructed using weekly interest rate data expressed in decimal form on a yearly basis. The dataset includes 361 weekly observations on the Eurodollar deposit Rate for the period 03/1991 to 04/2008.

Table 2.6: BCS Specification Test Results - "Post Bretton Woods" (01/1971-04/2008)

τ	$(\underline{u},\overline{u})$	Z_T	5% CV	10% CV	15% CV	20% CV
		Panel A: CIR model				
1	$\overline{X} \pm 0.5\sigma_X$	7.6849*	3.1545	2.547	2.4623	2.3259
	$\overline{X} \pm \sigma_X$	3.2358*	2.5774	2.1852	1.8792	1.7112
2	$\overline{X} \pm 0.5\sigma_X$	7.8948*	3.4789	2.8263	2.6949	2.5459
	$\overline{X} \pm \sigma_X$	3.5375*	3.4202	2.7714	2.2988	2.1371
4	$\overline{X} \pm 0.5\sigma_X$	8.1198*	4.0356	3.6690	3.2178	3.0321
	$\overline{X} \pm \sigma_X$	4.6621*	4.1774	3.4463	2.7442	2.5116
12	$\overline{X} \pm 0.5\sigma_X$	8.2578*	4.9334	4.6311	4.1175	3.8153
	$\overline{X} \pm \sigma_X$	4.3236*	4.3271	4.0430	3.2378	2.9430
		Panel B: SM model				
1	$\overline{X} \pm 0.5\sigma_X$	2.5413*	2.3687	2.0954	1.9418	1.7709
	$\overline{X} \pm \sigma_X$	1.3541	1.9753	1.5800	1.5287	1.3832
2	$\overline{X} \pm 0.5\sigma_X$	4.9409*	2.865	2.5337	2.3589	2.1716
	$\overline{X} \pm \sigma_X$	1.9275	2.7766	2.1624	2.0454	1.8669
4	$\overline{X} \pm 0.5\sigma_X$	4.458*	3.6752	3.0572	2.8474	2.6978
	$\overline{X} \pm \sigma_X$	2.6682	3.6691	2.8754	2.5688	2.4361
12	$\overline{X} \pm 0.5\sigma_X$	4.6565*	4.9105	4.5935	4.1004	3.7776
	$\overline{X} \pm \sigma_X$	3.6026	4.2818	3.9715	3.1955	2.896
		Panel C: SV model				
1	$\overline{X} \pm 0.5\sigma_X$	2.7497*	2.1241	1.8347	1.6676	1.5071
	$\overline{X} \pm \sigma_X$	1.588	2.0788	1.6446	1.5606	1.3061
2	$\overline{X} \pm 0.5\sigma_X$	4.5939*	3.0177	2.4339	2.3535	2.1769
	$\overline{X} \pm \sigma_X$	2.1179	2.8281	2.2565	1.9379	1.8781
4	$\overline{X} \pm 0.5\sigma_X$	4.7983*	3.7316	3.0996	2.9495	2.7172
	$\overline{X} \pm \sigma_X$	2.7067	3.6797	2.986	2.5461	2.4111
12	$\overline{X} \pm 0.5\sigma_X$	4.5106	4.9098	4.6402	4.1072	3.7795
	$\overline{X} \pm \sigma_X$	3.3907	4.309	3.9615	3.2079	2.9145
		Panel D: SVJ model				
1	$\overline{X} \pm 0.5\sigma_X$	7.6238*	3.3036	2.7993	2.6599	2.4747
	$\overline{X} \pm \sigma_X$	3.6849*	3.1811	2.4833	2.3179	2.0802
2	$\overline{X} \pm 0.5\sigma_X$	9.3633*	3.5341	3.0816	2.8441	2.7297
	$\overline{X} \pm \sigma_X$	6.8586*	3.8487	3.09	2.7141	2.5736
4	$\overline{X} \pm 0.5\sigma_X$	9.4501*	3.9981	3.5636	3.1653	2.9555
	$\overline{X} \pm \sigma_X$	8.6409*	4.0904	3.3501	2.882	2.6444
12	$\overline{X} \pm 0.5\sigma_X$	9.5099*	4.9325	4.6329	4.1214	3.8286
	$\overline{X} \pm \sigma_X$	7.5193*	4.3004	4.0379	3.2431	2.9499
		Panel E: CHEN model				
1	$\overline{X} \pm 0.5\sigma_X$	2.3669*	2.0425	1.9033	1.7238	1.5467
	$\overline{X} \pm \sigma_X$	0.9058	1.6132	1.3218	1.1854	1.1292
2	$\overline{X} \pm 0.5\sigma_X$	2.2719	2.5855	2.3067	2.1109	1.9748
	$\overline{X} \pm \sigma_X$	1.2835	2.0783	1.8050	1.6640	1.5379
4	$\overline{X} \pm 0.5\sigma_X$	4.6785*	3.3399	2.8554	2.5715	2.4243
	$\overline{X} \pm \sigma_X$	1.9738	3.2468	2.4091	2.3106	2.0996
12	$\overline{X} \pm 0.5\sigma_X$	5.1255*	4.8303	4.5125	4.0266	3.7428
	$\overline{X} \pm \sigma_X$	2.7088	4.2981	3.7180	3.1320	2.8495
		Panel F: CHENJ model				
1	$\overline{X} \pm 0.5\sigma_X$	2.0889	3.1863	2.6303	2.4718	2.3248
	$\overline{X} \pm \sigma_X$	2.2357	2.8803	2.3542	1.9214	1.8177
2	$\overline{X} \pm 0.5\sigma_X$	2.3842	3.582	3.0588	2.8634	2.6814
	$\overline{X} \pm \sigma_X$	3.4545*	3.7212	2.9444	2.5755	2.3482
4	$\overline{X} \pm 0.5\sigma_X$	4.4168*	4.0294	3.6211	3.1599	2.9629
	$\overline{X} \pm \sigma_X$	7.5231*	4.2088	3.4633	2.9612	2.5637
12	$\overline{X} \pm 0.5\sigma_X$	4.5989	4.9292	4.6377	4.1277	3.8382
	$\overline{X} \pm \sigma_X$	10.2708*	4.291	4.0231	3.2393	2.9466

Notes: Numerical entries in the table are specification test statistics (Z_T) and 5% &, 10%, 15% & 20% nominal level critical values, for tests constructed using intervals given in the first column of the table, and for $\tau = 1, 2, 4, 12$ (see discussion in Section 5.3 for complete details). Single starred entries denote rejection at the 10% level. The simulation periods considered is $10T$, and T denotes the number of observations in the sample. The block length is set equal to 20 observations, and empirical bootstrap distributions are constructed using 100 bootstrap replications. See Section 2 for further details.

Table 2.7: BCS Specification Test Results - "Pre 1990s" (01/1971-02/1991)

τ	$(\underline{u},\overline{u})$	Z_T	5% CV	10% CV	15% CV	20% CV
		Panel A: CIR model				
1	$\overline{X} \pm 0.5\sigma_X$	3.0621*	3.1776	2.7526	2.5984	2.3811
	$\overline{X} \pm \sigma_X$	4.3167*	2.3715	2.2112	1.9665	1.8351
2	$\overline{X} \pm 0.5\sigma_X$	3.2222*	3.2599	3.0063	2.6997	2.4409
	$\overline{X} \pm \sigma_X$	3.7536*	2.5201	2.3269	2.0755	2.0159
4	$\overline{X} \pm 0.5\sigma_X$	3.2372*	3.2051	3.0603	2.8355	2.5866
	$\overline{X} \pm \sigma_X$	3.9062*	2.6936	2.4758	2.2142	2.0143
12	$\overline{X} \pm 0.5\sigma_X$	3.5181*	3.4822	3.207	2.9923	2.829
	$\overline{X} \pm \sigma_X$	4.8191*	3.3907	2.934	2.5063	2.2456
		Panel B: SM model				
1	$\overline{X} \pm 0.5\sigma_X$	2.1246*	1.894	1.7853	1.5781	1.4595
	$\overline{X} \pm \sigma_X$	1.4402*	1.5117	1.291	1.1216	1.0835
2	$\overline{X} \pm 0.5\sigma_X$	2.9384*	2.3969	2.208	2.0303	1.9181
	$\overline{X} \pm \sigma_X$	2.7169*	1.9704	1.8251	1.6266	1.4405
4	$\overline{X} \pm 0.5\sigma_X$	4.4785*	2.868	2.6531	2.4043	2.3229
	$\overline{X} \pm \sigma_X$	4.1935*	2.4847	2.2121	2.0652	1.7826
12	$\overline{X} \pm 0.5\sigma_X$	5.108*	3.4445	3.2023	2.9759	2.8799
	$\overline{X} \pm \sigma_X$	4.9432*	3.3752	2.9254	2.5031	2.242
		Panel C: SV model				
1	$\overline{X} \pm 0.5\sigma_X$	2.2098*	1.8653	1.711	1.5733	1.4188
	$\overline{X} \pm \sigma_X$	1.2619	1.4679	1.3092	1.1554	1.1051
2	$\overline{X} \pm 0.5\sigma_X$	3.0606*	2.4498	2.2609	2.0829	1.9631
	$\overline{X} \pm \sigma_X$	2.4584*	1.9421	1.7792	1.5924	1.4197
4	$\overline{X} \pm 0.5\sigma_X$	4.1544*	2.946	2.6783	2.4498	2.3623
	$\overline{X} \pm \sigma_X$	3.7409*	2.4776	2.2168	2.0691	1.8145
12	$\overline{X} \pm 0.5\sigma_X$	4.5846*	3.4287	3.1896	2.9691	2.8689
	$\overline{X} \pm \sigma_X$	4.9187*	3.3818	2.9549	2.5059	2.2432
		Panel D: SVJ model				
1	$\overline{X} \pm 0.5\sigma_X$	3.4909*	2.7795	2.6401	2.3864	2.2027
	$\overline{X} \pm \sigma_X$	4.3968*	2.07	1.7367	1.5673	1.3806
2	$\overline{X} \pm 0.5\sigma_X$	4.2639*	3.1524	2.759	2.5538	2.3089
	$\overline{X} \pm \sigma_X$	5.9699*	2.6649	2.1528	1.9113	1.7427
4	$\overline{X} \pm 0.5\sigma_X$	4.9671*	3.1785	3.0284	2.723	2.4721
	$\overline{X} \pm \sigma_X$	7.4484*	2.6825	2.3997	2.1844	1.9203
12	$\overline{X} \pm 0.5\sigma_X$	6.1157*	3.474	3.2245	2.9963	2.8029
	$\overline{X} \pm \sigma_X$	8.2848*	3.3933	2.9431	2.5166	2.2336
		Panel E: CHEN model				
1	$\overline{X} \pm 0.5\sigma_X$	2.0832*	1.8622	1.736	1.562	1.4393
	$\overline{X} \pm \sigma_X$	1.2411	1.3957	1.2458	1.0909	1.0293
2	$\overline{X} \pm 0.5\sigma_X$	2.8921*	2.3902	2.2048	2.0296	1.9082
	$\overline{X} \pm \sigma_X$	2.1367*	1.8986	1.6724	1.5164	1.4043
4	$\overline{X} \pm 0.5\sigma_X$	3.9971*	2.9022	2.6382	2.4548	2.2916
	$\overline{X} \pm \sigma_X$	3.4145*	2.4277	2.1706	2.0134	1.7298
12	$\overline{X} \pm 0.5\sigma_X$	4.4202*	3.4439	3.1872	2.9723	2.8697
	$\overline{X} \pm \sigma_X$	4.4658*	3.3772	2.9859	2.5033	2.2207
		Panel F: CHENJ model				
1	$\overline{X} \pm 0.5\sigma_X$	3.7299*	2.9199	2.6056	2.3829	2.1805
	$\overline{X} \pm \sigma_X$	1.7909	1.9087	1.7949	1.5684	1.447
2	$\overline{X} \pm 0.5\sigma_X$	2.9169	3.1639	2.9512	2.5912	2.4237
	$\overline{X} \pm \sigma_X$	4.2558*	2.393	2.1676	1.9767	1.8339
4	$\overline{X} \pm 0.5\sigma_X$	5.3726*	3.1566	3.0369	2.776	2.5466
	$\overline{X} \pm \sigma_X$	8.8116*	2.6327	2.4196	2.2155	2.0058
12	$\overline{X} \pm 0.5\sigma_X$	7.3999*	3.4854	3.2477	3.0059	2.8021
	$\overline{X} \pm \sigma_X$	11.0151*	3.4029	2.9527	2.5128	2.2434

Notes: See notes to Table 2.6.

Table 2.8: BCS Specification Test Results - "The Stable 1990s" (03/1991-01/2001)

τ	$(\underline{u},\overline{u})$	Z_T	5% CV	10% CV	15% CV	20% CV
		Panel A: CIR model				
1	$\overline{X} \pm 0.5\sigma_X$	1.743	2.6772	2.519	2.3908	2.2301
	$\overline{X} \pm \sigma_X$	1.4215	1.7076	1.5674	1.4895	1.3517
2	$\overline{X} \pm 0.5\sigma_X$	1.9155	2.9635	2.6364	2.4659	2.3378
	$\overline{X} \pm \sigma_X$	1.4151	2.3901	2.1124	1.9591	1.7915
4	$\overline{X} \pm 0.5\sigma_X$	1.7242	3.2826	2.9931	2.7374	2.501
	$\overline{X} \pm \sigma_X$	2.3068	3.2457	3.0113	2.4816	2.3736
12	$\overline{X} \pm 0.5\sigma_X$	1.7088	3.47	2.9462	2.7378	2.3888
	$\overline{X} \pm \sigma_X$	2.6992	3.557	3.1466	2.9817	2.8276
		Panel B: SM model				
1	$\overline{X} \pm 0.5\sigma_X$	2.2283*	1.8019	1.5585	1.4458	1.3906
	$\overline{X} \pm \sigma_X$	0.2205	0.4275	0.3689	0.3253	0.2926
2	$\overline{X} \pm 0.5\sigma_X$	3.3549*	2.4955	2.2605	1.8627	1.7101
	$\overline{X} \pm \sigma_X$	0.3074	0.6781	0.5977	0.5494	0.493
4	$\overline{X} \pm 0.5\sigma_X$	4.3109*	3.1	2.5784	2.347	2.0711
	$\overline{X} \pm \sigma_X$	0.4181	1.1967	1.0937	0.9361	0.86
12	$\overline{X} \pm 0.5\sigma_X$	3.1586	3.8378	3.2441	3.0625	2.7503
	$\overline{X} \pm \sigma_X$	0.8719	2.6774	2.4825	2.4048	2.3169
		Panel C: SV model				
1	$\overline{X} \pm 0.5\sigma_X$	2.1092	2.4951	2.1144	1.9801	1.8458
	$\overline{X} \pm \sigma_X$	0.2203	0.4064	0.3616	0.3616	0.3169
2	$\overline{X} \pm 0.5\sigma_X$	4.3226*	3.6056	2.8024	2.6646	2.5099
	$\overline{X} \pm \sigma_X$	0.2205	0.6309	0.5861	0.5412	0.4964
4	$\overline{X} \pm 0.5\sigma_X$	5.6127*	3.7268	3.2304	2.6068	2.3773
	$\overline{X} \pm \sigma_X$	0.221	1.171	1.1218	1.0363	1.032
12	$\overline{X} \pm 0.5\sigma_X$	7.2161*	4.8256	4.3276	4.0473	3.6399
	$\overline{X} \pm \sigma_X$	1.1136	3.0511	2.9087	2.8182	2.5466
		Panel D: SVJ model				
1	$\overline{X} \pm 0.5\sigma_X$	3.9202*	2.3198	1.972	1.8152	1.7045
	$\overline{X} \pm \sigma_X$	1.2275*	1.0654	0.9135	0.8631	0.7727
2	$\overline{X} \pm 0.5\sigma_X$	5.6993*	2.91	2.5822	2.2936	2.1378
	$\overline{X} \pm \sigma_X$	3.4687*	2.2945	1.9649	1.9119	1.6689
4	$\overline{X} \pm 0.5\sigma_X$	8.0184*	3.1449	2.8082	2.6843	2.3019
	$\overline{X} \pm \sigma_X$	4.6234*	3.1318	2.9289	2.3785	2.2673
12	$\overline{X} \pm 0.5\sigma_X$	7.1228*	3.5211	2.9906	2.5983	2.4542
	$\overline{X} \pm \sigma_X$	3.2521	3.6154	3.2698	3.0074	2.8243
		Panel E: CHEN model				
1	$\overline{X} \pm 0.5\sigma_X$	1.1898*	1.2982	1.1381	1.0555	0.9659
	$\overline{X} \pm \sigma_X$	0.0441	0.3134	0.2686	0.2686	0.2686
2	$\overline{X} \pm 0.5\sigma_X$	3.7492*	3.4063	2.779	2.5541	2.3748
	$\overline{X} \pm \sigma_X$	0.1764	0.6259	0.5363	0.4915	0.4915
4	$\overline{X} \pm 0.5\sigma_X$	5.3033*	3.7219	3.1929	2.5194	2.3847
	$\overline{X} \pm \sigma_X$	0.8397	1.3842	1.2046	1.1148	0.9984
12	$\overline{X} \pm 0.5\sigma_X$	9.3987*	3.8648	3.4118	3.197	2.9153
	$\overline{X} \pm \sigma_X$	3.3408*	3.1894	2.9631	2.7976	2.6462
		Panel F: CHENJ model				
1	$\overline{X} \pm 0.5\sigma_X$	1.2177	2.661	2.2292	1.9944	1.788
	$\overline{X} \pm \sigma_X$	2.024*	2.249	1.9447	1.8089	1.5967
2	$\overline{X} \pm 0.5\sigma_X$	1.9958	3.5217	3.0749	2.8393	2.6268
	$\overline{X} \pm \sigma_X$	3.5283*	3.2828	2.8685	2.608	2.3076
4	$\overline{X} \pm 0.5\sigma_X$	3.6745*	3.462	3.0426	2.8255	2.5908
	$\overline{X} \pm \sigma_X$	7.8632*	3.403	3.0572	2.7751	2.5688
12	$\overline{X} \pm 0.5\sigma_X$	4.0284*	3.5635	3.0355	2.7559	2.3334
	$\overline{X} \pm \sigma_X$	9.4419*	3.4723	3.0325	2.9193	2.7301

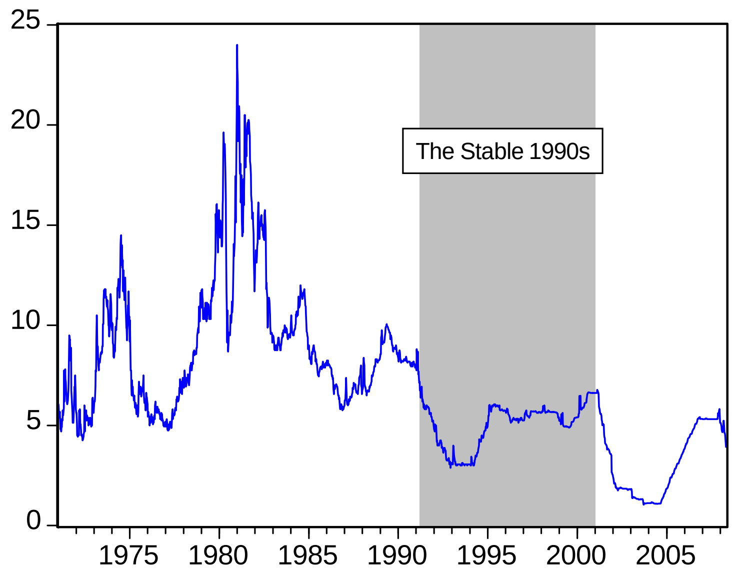
Notes: See notes to Table 2.6.

Table 2.9: BCS Specification Test Results - "Post 1990s" (02/2001-04/2008)

τ	$(\underline{u},\overline{u})$	Z_T	5% CV	10% CV	15% CV	20% CV
		Panel A: CIR model				
1	$\overline{X} \pm 0.5\sigma_X$	0.4175	1.1416	0.969	0.896	0.8026
	$\overline{X} \pm \sigma_X$	1.4744*	1.6624	1.3556	1.2694	1.1859
2	$\overline{X} \pm 0.5\sigma_X$	0.9852	1.9374	1.6573	1.5173	1.2902
	$\overline{X} \pm \sigma_X$	1.7948	2.5406	2.272	1.907	1.8487
4	$\overline{X} \pm 0.5\sigma_X$	1.5983	3.0862	2.5308	2.2108	1.8881
	$\overline{X} \pm \sigma_X$	1.904	3.4499	3.166	2.6652	2.4737
12	$\overline{X} \pm 0.5\sigma_X$	1.3776	3.6922	3.0861	2.7607	2.6046
	$\overline{X} \pm \sigma_X$	4.8384*	4.9892	4.3831	4.113	3.8376
		Panel B: SM model				
1	$\overline{X} \pm 0.5\sigma_X$	1.6069	3.5855	3.3937	3.1795	2.8959
	$\overline{X} \pm \sigma_X$	3.0268	4.1986	3.9257	3.4385	3.3061
2	$\overline{X} \pm 0.5\sigma_X$	1.5331	3.6565	3.3421	3.2023	2.8789
	$\overline{X} \pm \sigma_X$	2.0864	4.2483	3.7961	3.3232	3.2102
4	$\overline{X} \pm 0.5\sigma_X$	1.4989	3.4702	3.1957	3.0996	2.8728
	$\overline{X} \pm \sigma_X$	1.786	4.2643	3.764	3.3165	3.1994
12	$\overline{X} \pm 0.5\sigma_X$	1.0684	3.3503	2.9153	2.6545	2.473
	$\overline{X} \pm \sigma_X$	2.7817	4.4871	3.9436	3.752	3.4919
		Panel C: SV model				
1	$\overline{X} \pm 0.5\sigma_X$	0.3163	0.6696	0.5703	0.4852	0.461
	$\overline{X} \pm \sigma_X$	1.0861*	1.252	1.0647	0.9806	0.8843
2	$\overline{X} \pm 0.5\sigma_X$	0.5631	1.1241	0.9481	0.8816	0.8139
	$\overline{X} \pm \sigma_X$	1.8053*	1.7908	1.6109	1.4518	1.3552
4	$\overline{X} \pm 0.5\sigma_X$	1.3555	1.9716	1.6916	1.3984	1.3023
	$\overline{X} \pm \sigma_X$	2.9899*	2.8014	2.6081	2.2876	2.1157
12	$\overline{X} \pm 0.5\sigma_X$	3.7886*	3.6672	3.2848	2.7219	2.2963
	$\overline{X} \pm \sigma_X$	4.2665*	4.7145	4.0067	3.769	3.5775
		Panel D: SVJ model				
1	$\overline{X} \pm 0.5\sigma_X$	2.4083*	1.8806	1.8207	1.6944	1.6047
	$\overline{X} \pm \sigma_X$	6.1295*	3.5185	3.3276	3.1516	2.7994
2	$\overline{X} \pm 0.5\sigma_X$	5.8102*	3.5004	2.9123	2.7156	2.5503
	$\overline{X} \pm \sigma_X$	9.4311*	4.5093	3.8751	3.5117	3.2937
4	$\overline{X} \pm 0.5\sigma_X$	13.7926*	3.7881	3.4008	3.1998	3.0058
	$\overline{X} \pm \sigma_X$	9.4604*	4.416	3.8425	3.6305	3.3264
12	$\overline{X} \pm 0.5\sigma_X$	15.1804*	3.7861	3.5181	3.2501	3.1429
	$\overline{X} \pm \sigma_X$	9.568*	5.2128	4.1002	3.9262	3.7118
		Panel E: CHEN model				
1	$\overline{X} \pm 0.5\sigma_X$	0.6316	1.1613	1.0557	0.9502	0.8974
	$\overline{X} \pm \sigma_X$	4.4211*	3.8638	3.2832	2.9446	2.7554
2	$\overline{X} \pm 0.5\sigma_X$	3.4429	3.9571	3.4538	3.1609	3.0027
	$\overline{X} \pm \sigma_X$	4.4799*	4.1628	3.4456	3.2871	2.8943
4	$\overline{X} \pm 0.5\sigma_X$	8.6148*	6.2591	5.8883	4.8281	4.7224
	$\overline{X} \pm \sigma_X$	4.4924*	4.4947	3.9868	3.4023	3.2448
12	$\overline{X} \pm 0.5\sigma_X$	3.4744*	3.2064	2.9047	2.5646	2.4222
	$\overline{X} \pm \sigma_X$	4.3134*	6.8154	6.5045	6.0347	5.5766
		Panel F: CHENJ model				
1	$\overline{X} \pm 0.5\sigma_X$	1.8064	3.6712	3.4365	3.0852	2.82
	$\overline{X} \pm \sigma_X$	1.9258	4.1339	3.5039	3.3921	3.1739
2	$\overline{X} \pm 0.5\sigma_X$	1.1563	3.5044	3.363	3.105	2.9053
	$\overline{X} \pm \sigma_X$	3.4039	4.2549	3.6242	3.3535	3.2984
4	$\overline{X} \pm 0.5\sigma_X$	1.6572	3.4857	3.1576	3.0951	2.8673
	$\overline{X} \pm \sigma_X$	4.7218*	4.356	3.5848	3.3104	3.1274
12	$\overline{X} \pm 0.5\sigma_X$	1.6528	3.2081	2.9162	2.6076	2.4327
	$\overline{X} \pm \sigma_X$	5.6215	4.5307	4.0599	3.7381	3.4972

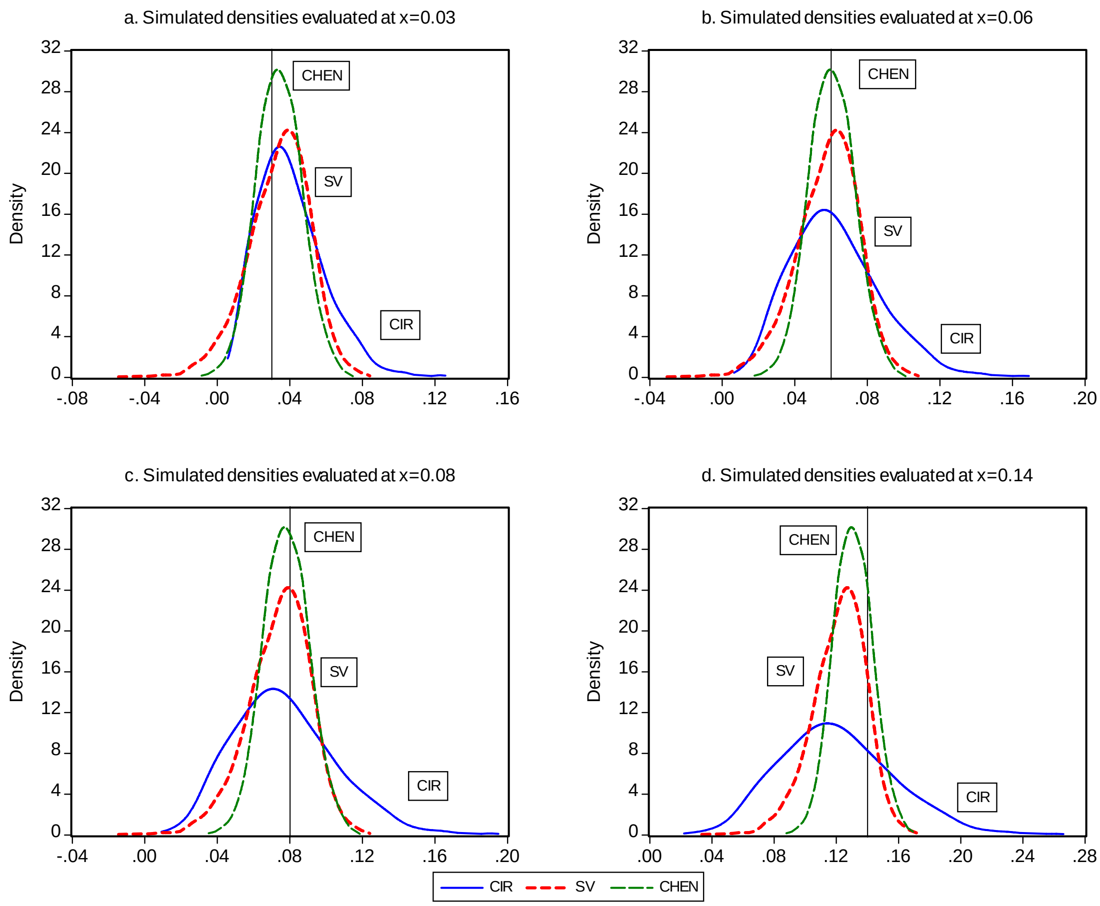
Notes: See notes to Table 2.6.

Figure 2.1: Eurodollar rate 01/08/1971-04/24/2008



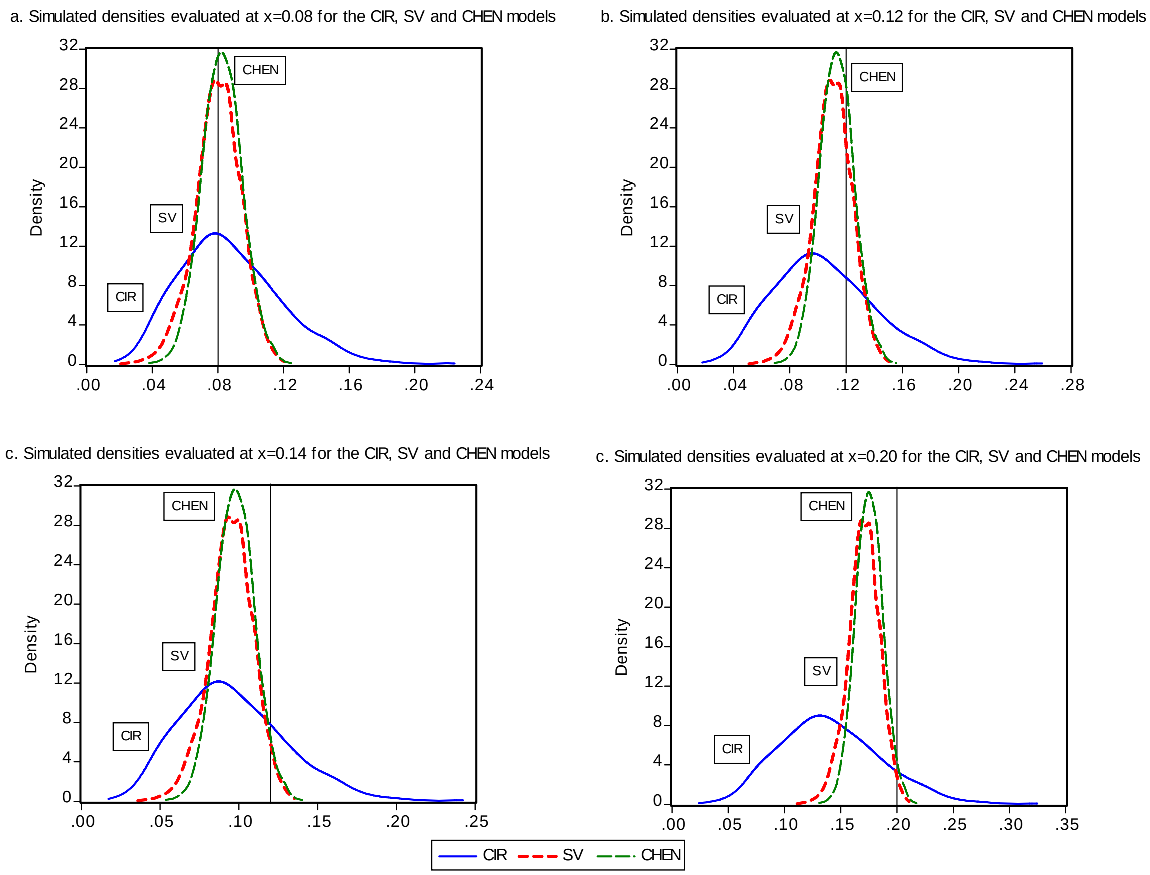
Notes: This figure plots empirical weekly data on the Eurodollar rate for the period 01/08/1971 to 04/24/2008. The shadowed is the "Stable 1990s" period, which covers period 03/1991- 01/2001.

Figure 2.2: Simulated densities for the CIR, SV and CHEN models-"Post Bretton-Woods" (01/1971-04/2008)



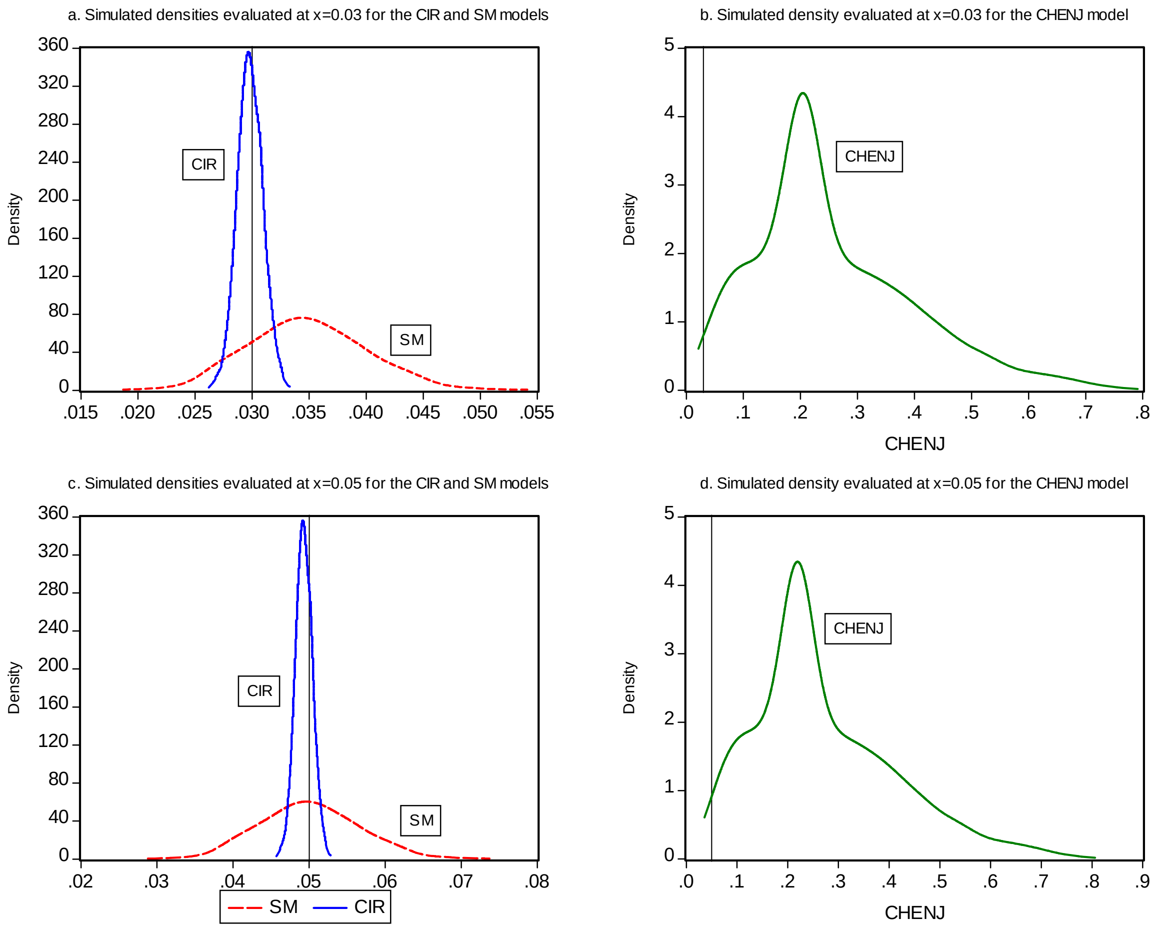
Note: This figure contained kernel density estimates for selected models and selected evaluation points, where evaluation points are taken from the support of the historical data, and correspond roughly to regions of the support sociated with mean or model behavior, as well as tail behavior.

Figure 2.3: Simulated densities for the CIR, SV and CHEN models-“Pre 1990s" (01/1971-02/1991)



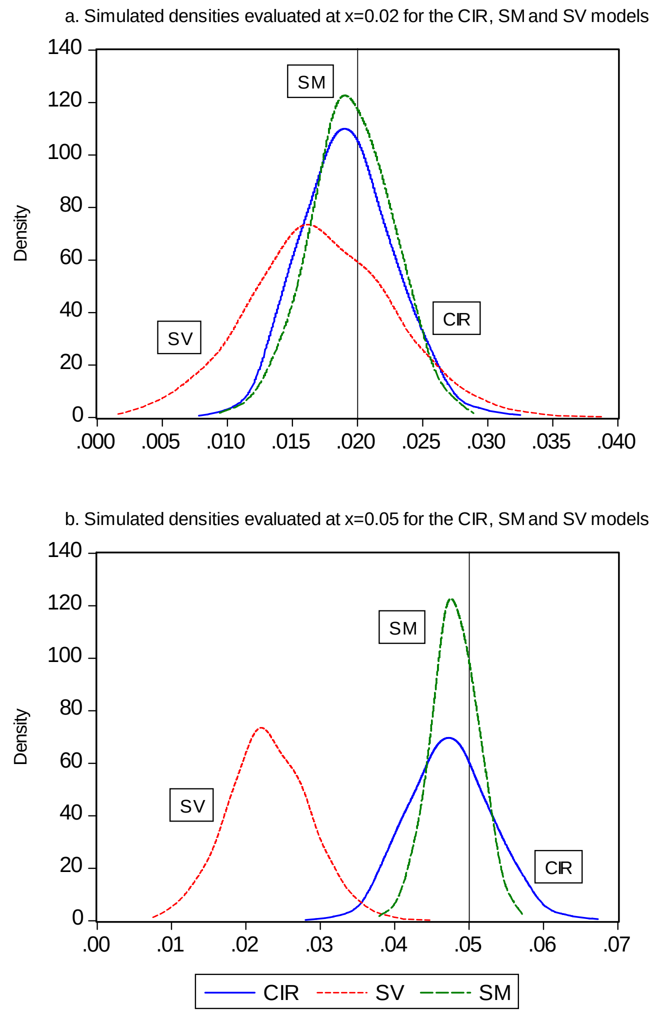
Notes: See Figure 2.

Figure 2.4: Simulated densities for the CIR, SM and CHENJ models-“The Stable 1990s" (03/1991-01/2001)



Notes: See Figure 2.

Figure 2.5: Simulated densities for the CIR, SM and SV models-"Post 1990s" (02/2001-04/2008)



Notes: See Figure 2.

Chapter 3

Further Empirical Evidence on Momentum, Mean Reversion, Downside Risk, and Excess Returns

3.1 Introduction

Numerous studies have found that average stock return movements are related to past movements. For example, the tendency of rising asset prices to rise further has been widely noted in the empirical finance literature. This effect is often referred to as the momentum effect, and was first shown to be prevalent by Jegadeesh and Titman (1993), where it was noted that excess returns of approximately 1% were associated with stocks that exhibited strong past performance. This finding was further confirmed by Chan, Jegadeesh, and Lakonishok (1996), and Rouwenhorst (1998); and is a major puzzle in finance, given the fact that efficient market theory admits such behavior only in certain special circumstances such as when there are demand and supply changes or when new information becomes available. One explanation of the momentum effect is that investors are irrational, as they fail to incorporate new information into their transaction prices (see e.g. Daniel, Hirschleifer, and Subrahmanyam (1998) and Barberis, Shleifer, and Vishny (1998)). Other proponents of the behavioral explanation for momentum effects include DeBondt and Thaler (1985,1987), DeLong et al. (1990), and Hong and Stein (1999). One alternative explanation does not rely on irrationality to explain momentum excess returns, but instead focuses on price bubbles as the cause for observed momentum returns (see e.g. Crombez (2001)). A related strand of the literature (see e.g. DeBondt and Thaler (1985, 1987), Chopra, Lakonishok, and Ritter (1992), and Richards (1997)) find that average stock returns follow a mean reversion process, which means that a contrarian strategy of sorting portfolios by previous returns, holding those with the worst prior performance, and shorting those with the best prior performance generates positive excess returns. While mean reversion and momentum arguments appear contradictory, many of the above authors have argued, for example, that behavioral theories to explain the observed pattern of momentum at short horizons and mean reversion at long horizons. In this paper we offer new empirical evidence on the relevance of momentum and mean revision effects in stock trading. We also modify oft analyzed trading strategies using these two effects to include downside risk effects. Our analysis is carried out in a series of real-time trading experiments, and by applying state of the art out-of-sample (non)linear Granger causality tests.

Momentum trading strategies, which involve trading based on past returns, and in particular holding assets that generate higher past returns and shorting those that generate lower past returns, has continued to be profitable in recent years, as documented by Chan, Hameed and Tong (2000), Grundy and Martin (2001), Jegadeesh and Titman (2001), Lewellen (2002), and others. Moreover, according to Balvers and Wu (2006) that there is no direct contradiction in the profitability of contrarian and momentum trading strategies since contrarian strategies work for a sorting (holding) period ranging from 3 to 5 years, while momentum strategies typically work for a sorting (holding) period ranging from 3 month to 12 months. Balvers and Wu (2006) show this by combining mean reversion effects and momentum effects in a single indicator, interpreted as an expected return, and by using their indicator to trade in 18 developed equity markets. They find that their combination of momentum-contrarian strategies outperform both pure momentum and pure contrarian strategies with significant excess annual returns. Our work builds on their work by additionally considering so-called downside risk. The impetus for our construction and consideration of this risk measure stems from the work of Cooper (2004), who argues that momentum returns are related to market state, and in particular that momentum returns will be higher in bull markets, and lower in bear markets. Our new risk factor thus relates expected returns with current market state, and can be used to explain observed downside return skewness.[1]

Our empirical analysis is implemented by considering an investment strategy that exploits premia in the cross section by jointly considering downside risk, momentum and mean

[1] The extant literature does not support the existence of momentum effects at short time horizons, such as one-month. For the case when the holding period is 1 month, excess returns have been found to be substantially lower and sometimes negative (see e.g. Lean (2004)), consistent with arguments given by Jegadeesh (1990) and Lehmann (1990). Harvey and Siddique (2000) explain the failure of momentum trading strategies for short holding periods using the fact that momentum strategies are negatively skewed, and refer to this as "skewness risk". They argue that one-month excess returns are related to the downside risk. Furthermore, Ang and Chen (2006) show that there are systematic variations in the cross-section of stock returns that are linked to the downside risk. They show that stocks with higher downside risk have higher expected returns which can not be explained by the market beta, the size effect and the book-to-market effect.

reversion. Our approach nests pure momentum and pure mean reversion effects as special cases and is estimated using data for the 25 Fama-French size and book-to-market portfolios. In particular, we compare pure momentum, pure contrarian, and other combination strategies in both the long run (sorting/holding periods of 3 to 18 month) and the short run (sorting/holding period of 1 to 6 months). Interestingly, combined mean reversion and momentum strategies do not generate excess returns of the magnitude noted by Balvers and Wu (2006) for the international equity market, when U.S. data are used in our experiments. Moreover, our trading strategies that use all three measures outperform simpler two measure strategies in the case of high book-to-market portfolios in the short run, and high size portfolios in the long run. In summary, we add to the important findings of Balvers and Wu (2006) by noting the importance of downside risk, and by noting that our more complicated trading strategy uncovers theretofore unknown book-to-market and size portfolio effects.

It is worth noting that our size and book-to-market portfolios exhibit momentum as strong as that found for the individual stocks and industries examined by Lewellen (2002). Contrary to our findings, Jegadeesh and Titman (1993), and Fama and French (1996) show that the momentum returns between different size portfolios are very close, so it is not profitable to trade among size portfolios. They note that momentum profits are not attributable to size, or book-to-market effects. Lewellen (2002) studies momentum in stock returns by focusing on the role of industry, size, and book-to-market (B/M) factors. He notes that size and B/M portfolios are well diversified, so momentum can't be attributed to firm- or industry-specific returns. He argues that excess covariance, not underreaction, explains momentum in the portfolios, which supports the use of our downside risk factor. While our findings differ from these, in that we find evidence of book-to-market and size effects, it should be stressed that all of the above research focuses on pure momentum strategies, hence accounting to some extent for the differences in our findings. In particular, and as noted above, we find that our comprehensive trading strategy is highly successful for high book-to-market portfolios in the short run, and for high size portfolios in the long run. Furthermore, our momentum and downside risk combination strategy beats the pure downside risk strategy proposed by Ang and Chen (2006), who find that the short run (one month) downside risk premium is approximately 6% per annum.

As a final somewhat more technical experiment, we examine the marginal predictive ability of momentum factor and downside risk factor for excess returns. This is done by constructing out-of-sample (non)linear Granger causality tests of the variety developed in Corradi and Swanson (2002,2005) . In particular, we asses the additional "explanatory power" associated with using our combination strategies instead of our various pure trading strategies. In contrast to our other findings in this paper, we find that there is little to choose between the different trading strategies, when comparing ex-ante predictive ability via implmentation of the out-of-sample causality tests.

This paper is meant to add to the extant literature on the subject of the usefulness of momentum and related trading strategies. Many issues remain unanswered and are left for future research. For example, from an empirical perspective, it remains to construct ex-ante predictive accuracy (causality) tests where the objective function used to estimate models and to evaluate out-of-sample predictions is based on a measure of trading profits rather than mean square error loss. It also remains to examine the performance of the three pronged trading strategy assessed in this paper when using international equity data, as in Balvers and Wu (2006). From a theoretical perspective, it remains to develop behavioral and related theories that incorporate our new findings that there are book to market and size effects..

The rest of the paper is organized as follows. Section 2 outlines the momentum, mean reversion, and downside risk model that we are going to examine. Data and estimation is discussed in Section 3, and our empirical findings are presented in Section 4. Finally, concluding remarks are given in Section 5. Technical details of the causality test used in the paper are given in the appendix.

3.2 An integrated mean reversion-momentum-skewness (downside risk) model

In this section, we show how mean reversion, momentum, and downside risk may be priced in a cross-sectional equilibrium setting. Specifically, we start with the model originating from Fama and French (1988) and Summers (1986), and developed in Balvers and Wu (2006). We then augment the model in order to allow for mean reversion, momentum, and skewness in equity prices. Balvers and Wu (2006) define p_t^i as the natural log of the equity price index of stock i with dividends, so that the continuously compounded return r_t^i is given as:

$$r_t^i = p_t^i - p_{t-1}^i, \tag{3.1}$$

where superscripts denote individual stock indices. Now, recall that equity prices can be separated into permanent and temporary components, where permanent component comes from systematic risk, and temporary components derive from unsystematic risk. The price of stock i is thus given by:

$$p_t^i = y_t + x_t^i, \tag{3.2}$$

where y_t is the market price component, which may have both permanent and transitory components, and where x_t^i is the stock-specific component , which is transitory. Combining equations (1) and (2) we get:

$$r_t^i = y_t - y_{t-1} + x_t^i - x_{t-1}^i.$$

In our empirically implementation, we consider portfolios (Fama-French portfolios) for a homogeneous group of stocks, enabling us to address and examine model structure. In particular, we assume that stock-specific shocks are transitory (i.e. stationary). The theoretical motivation for this important assumption is based on the idea of "convergence". Namely, we assume that the non-market components in equity prices in the stocks we examine are stationary. Given enough stocks, i, and assuming that the market and stock-specific components are uncorrelated, we can set the average change in the stock-specific component equal to zero. Thus:

$$r_t^w = y_t - y_{t-1}, \tag{3.3}$$

where r_t^w represents the average return in the U.S. stock market, say, so that we can use value weighted CRSP stock returns as a market return proxy.

To illustrate the effects of mean-reversion, momentum, and downside risk at the same time, we formulate the temporary component x_t^i as :

$$x_t^i = (1 - \delta^i)\mu^i + \delta^i x_{t-1}^i + \sum_{j=1}^{J} \rho_j^i (x_{t-j}^i - x_{t-j-1}^i) + \beta_{t-1}^i (r_{t-1}^i - r_{t-1}^w) + \eta_t^i \tag{3.4}$$

Equation (3.4) generalizes the model used in Balvers and Wu (2006), Cooper (2004), and Ang and Chen(2006), as it allows for all three effects. In this model, we have a constant, μ^i, an autoregressive coefficient, δ^i, momentum coefficients, ρ_j^i, a downside-risk coefficient, β_t^i , and the mean-zero normal random variable, η_t^i (which is serially and cross-sectionally uncorrelated). Equations (3.1) through (3.4) describe an integrated mean reversion-momentum-skewness model. The excess return of stock i can be derived from these four equations as:

$$r_t^i - r_t^w = -(1-\delta^i)(x_{t-1}^i - \mu^i) + \sum_{j=1}^{J} \rho_j^i (x_{t-j}^i - x_{t-j-1}^i) + \beta_{t-1}^i (r_{t-1}^i - r_{t-1}^w) + \eta_t^i. \quad (3.5)$$

Following by Balvers and Wu (2006), we use the following notation in order to simplify our subsequent discussion:

$$\begin{aligned} R_t^i &= r_t^i - r_t^w \quad (3.6) \\ MRV_t^i &= -(1-\delta^i)(x_{t-1}^i - \mu^i) \\ MOM_t^i &= \sum_{j=1}^{J} \rho_j^i (x_{t-j}^i - x_{t-1}^i) \\ CMC_t^i &= \beta_{t-1}^i (r_{t-1}^i - r_{t-1}^w) \end{aligned}$$

Thus,

$$R_t^i = MRV_t^i + MOM_t^i + CMC_t^i + \eta_t^i, \quad (3.7)$$

where R_t^i at the left-hand side of equation (3.7) is the excess return for portfolio i; MRV_t^i and MOM_t^i represent the mean reversion component of return and the momentum component of returns, respectively. The final term, CMC_t^i, represents the downside-risk component of returns, and was not examined by Balvers and Wu. Note also that the unconditional expectation of the mean reversion term, $E(MRV)$, is equal to zero, since $E(x_t^i) = \mu^i$ (see equation (3.4)). Similarly, it can be shown that the unconditional expectation of the momentum, $E(MOM)$, and downside-risk, $E(CMC)$, components are zero. Hence, the average excess returns, R_t^i, are zero, which allows us to decompose the realized portfolio return r_t^i into the global return r_t^w, a mean-reversion component, a momentum component, a down-side risk return component, and a shock component.

Our focus on investment strategies designed to exploit mean reversion, momentum and downside risk is similar to the approach followed by DeBondt and Thaler (1985) in order to examine the impact of mean reversion, the approach followed by Jegadeesh and Titman (1993) in order to exploit continuation, and the approach followed by Ang and Chen (2006) to exploit downside-risk, with the major difference being that these approaches are nonparametric whereas ours is explicitly parametric. For a discussion of similar parametric approaches see Jegadeesh (1990) and Balvers, Wu, and Gilliland (2000).

To be more specific, note that is not straightforward to implement traditional nonparametric approaches design a trading strategy including downside risk, momentum and mean reversion effects. One could, for instance, construct a portfolio of firms with a combination of high returns in the previous 1-3 month, or 3-12 month periods, and low returns in the previous 3-5 year periods, and buy this portfolio. One problem with this strategy is that we do not have any guidance concerning what the holding period should be – 1-3 months, or 3-12 months, or 3-5 years? More importantly, how should an investor weigh the importance of downside risk, momentum and mean reversion? As discussed above, we assume that we can decompose stock returns into permanent and transitory components. Our decomposition assumes that transitory price components are stock-specific, and include three parts - a downside risk premium, a momentum premium, and a mean reversion premium. The assumption that cross-stock price index shocks are transitory allows us to construct an expected returns indicator that naturally combines the three premia into a single indicator. Namely, one invests in the asset or portfolio of assets with the highest indicator, at each point in time (while shorting the assets with the lowest indicator).

3.3 Data and estimation

Our data on returns consists of 25 U.S. stock portfolios formed according to the same criteria as those used in Fama and French (1992,1993). These data are value-weighted returns for the intersections of five size portfolios and five book-to-market equity (B/M) portfolios on the New York Stock Exchange, the American Stock Exchange, and the NASDAQ. The portfolios are constructed at the end of June, and market equity is market capitalization at the end of June. The ratio B/M is book equity at the last fiscal year end of the prior calendar year, divided by market equity at the end of December of the prior year. This procedure is repeated for every calendar year from July 1963 to December 2004. We convert the discrete stock returns into continuous return rates, producing a time series spanning the third quarter of 1963 to the fourth quarter of 2004. Thus, we have 498 observations for each of the 25 portfolios. Table 3.1 reports summary statistics for the 25 size and book-to-market portfolios. The average monthly returns for the industry portfolios range from

0.71% to 1.66% resulting in an annualized spread of 11.4%. The large number of firms in the industries indicates that these portfolios are well diversified. An F-test of whether the mean returns differ across industries is not rejected, suggesting that there is cross-sectional variation in the industry sample means. We take value weighted CRSP Index as our proxy for the market portfolio.

We employ a maximum likelihood estimation procedure to estimate our baseline three component model. The model parameters to be estimated in Eq.(3.5), i.e. in the following equation:

$$r_t^i - r_t^w = -(1-\delta^i)(x_{t-1}^i - \mu^i) + \sum_{j=1}^{J} \rho_j^i (x_t^i - x_{t-1}^i) + \beta_{t-1}^i (r_{t-1}^i - r_{t-1}^w) + \eta_t^i$$

are δ^i, ρ_j^i, μ^i and β_t^i.To improve efficiency and avoid multicollinearity problems we follow Balvers, Wu (2006) and set $\rho_j^i = \rho_j$,$\delta^i = \delta$ and $\beta_t^i = \beta_t$. Accordingly, we examine a momentum trading strategy of buying the portfolio with the highest conditional risk-adjusted expected return and short-selling the portfolio with the lowest conditional risk-adjusted expected return based on Eq.(3.5), using parameters estimated from prior daily data. The approach ensures the ex-ante nature of our trading experiments. As in Balvers and Wu (2006), we start the forecast period at 1/3 of the sample, (i.e. January 1980), and apply recursive estimation to update parameter estimates as we roll the sample forward in time, prior to each new days' trading.

3.4 Empirical results

3.4.1 Cross-sectional parameter estimation results

Table 3.2 reports estimates of excess returns for the 25 Fama-French portfolios. The regressors include a mean reversion factor, a momentum factor, and a downside risk factor, taken from our above model decomposition. There are also regressors correpsonding to two Fama-French factors, namely size and book-to-market. Notice in Panel A of the table 3.2 that the downside risk factor is significant at a 5% level in all combinations (bracketed values are t-statistics), suggesting that downside risk helps to improve forecasting accuracy. Of note is that we sort portfolios by month, for the past 6 months (i.e. $J = 6$). As further evidence of the usefulness of the downside risk factor, note that the adjusted R^2 increases from 0.016 (Model 2) to 0.024 (Model 1), when the downside risk factor is added to the other two factors. In this sense, we obtain an increase in predictability when we augment the Balvers and Wu (2006) model to include downside risk. To compare our three factor model with and without the addition of the Fama-French factors, we added size and book-to-market factors into our original models. Panel B of the table 3.2 depicts the results of this set of regressions. Interestingly, adjusted R^2 values increase dramatically for all models. On the other hand, adjusted R^2 values for models with lagged Fama-French factors do not increase, as shown in panel C of the table 3.2. Furthermore, increasing the number of lags of the Fama-French factors does not improve model fit. This confirms that Fama-French factors do not help to predict stock returns.

Note that our momentum models are based on the assumption that $\rho_j^i = \rho$, $\delta^i = \delta$ and $\beta_t^i = \beta_t$. We test this hypothesis by estimating 25 portfolios separately using Eq. (3.5) and calculating parameter means and standard deviations. Results are provided in the panel D, where it can be seen that the mean of the constant, mean reversion, momentum and downside risk factors are quite close to the parameters estimated in Panel A; but standard deviations are quite large. Additionally the average value of the estimated mean-reversion parameter deviates substantially from the estimated values given in Panel A. In this sense, the results of Panels A-C of Table 3.2 are meant only as roughly indicative of the usefulness of the different factors.

Jegadeesh and Titman (1993) find that the size factor and book-to-market factor cannot explain the momentum effect; and their result is further confirmed by Fama and French (1993, 1996). Lewellen (2002) also argues that momentum can't be attributed to firm or industry-specific returns, since the size and B/M portfolios are well diversified. These studies are based on non-parametric settings. Our approach differs from these authors, as we examine momentum using a parametric setup, and investigate the relation between our three factors and the Fama-French factors. Figure 3.1 plots estimated downside risk, momentum, and mean reversion parameters for the 25 portfolios. As expected, the parameters for each 5 portfolios follow a pattern determined by the book-to-market factor. While within each pattern (5 portfolios sorted by size), the estimated parameters change according to the portfolio size. This pattern of estimated parameters prompts us to consider trading strategies based on the underlying characteristics of the data sample. In particular, we sort the data in two ways. First, we sort according to portfolio size, and then we sort according to book-to-market value. We compare trading returns from “small size" portfolios relative to those from “big size" portfolios, and high book-to-market relative to low book-to-market values, to assess whether these features of a portfolio have an impact on average returns. Contrary to what has been found by Jegadeesh and Titman (1993), Fama and French (1993, 1996), and Lewellen (2002), our trading results (discussed below) support the hypothesis that Fama-French factors affect the momentum profits, when the data are considered using these categorizations.

3.4.2 Cross-sectional trading strategy results

In order to facilitate comparison with existing strategies and models, including the pure momentum trading strategy considered by Jegadeesh and Titman (JT: 1993) and Lewellen (2002), the pure downside risk model of Ang and Chen (2006), and the combination trading strategy of Balvers, Wu (2006), we implement our trading strategy based on equation (3.5) both in the long run and in short run. In the long run, we allow for 12 possible momentum lags and a maximum 18-month holding period, while the maximum sorting period and holding period are 7 months and 6 months, respectively, in the short run. We display four special cases based on Eq. (3.5). Namely, the pure momentum model of Jegadeesh and Titman (1993), the combination mean reversion-momentum model, the combination downside risk-momentum model, and the combination downside risk-momentum-mean reversion strategy. We consider standard variations in the sorting and holding periods in order to assess which period and which factor is more significant in generating excess returns. Following the approach proposed by Jegadeesh (1990, 1993), we skip the first month after the sorting period, since the mean reversion effect is more significant than the momentum effect for very short sorting periods. Finally, we assign portfolio choices for period $t+1$ (based on expected returns for time $t+1$ given information at time t) to time $t+2$, etc.

Pure momentum trading strategies

When we set $\rho_j^i = \rho_j, \delta^i = 1$, and $\beta_t^i = 0$, equation (3.5) is the pure momentum model, and thus excess realized returns over the previous J sorting periods are equally weighted in determining expected returns. In order to compare our results with those of Balvers and Wu (2006), we also define the portfolio with the highest expected return as the “Max1” portfolio, and the portfolio with the lowest expected return as the “Min1” portfolio. The strategy of buying Max1 and shorting Min1, and holding this portfolio for K periods is referred to as "$Max1 - Min1$" and is listed under the appropriate value for K (similarly "Max3" and "Min3" refer to the strategy of holding the equally-weighted average of three portfolios with, respectively, the highest and lowest expected returns).

Results for the period January 1980–December 2004 are displayed in Table 3.3a. These results broadly agree with those of JT (1993) for U.S. equities. Excess returns per gross dollar invested (net dollar investment is zero, but we calculate returns using one dollar invested in the long position and one dollar invested in the short position, so that when compared with JT, our results should be multiplied by two) for the Max1–Min1 and Max3–Min3 portfolios are positive for all cases originally considered by JT (1993). It is worth noting that our results differ from Jegadeesh and Titman (1993) in two aspects, however. One is that our momentum returns are significant at a 1% level in all cases, while Jegadeesh and Titman (1993) find some significance below 10%. This supports the notion that Fama-French portfolios demonstrate strong momentum, as found by Lewellen (2002). Another difference is that we find relatively lower momentum profits of about 6% (annually) lower than those found by JT (1993). For example, when $J = 12$ and $K = 3$, Jegadeesh and Titman (1993) achieve maximum monthly returns from the "buy-sell" strategy of 1.31% , while we achieve returns of 0.782% (0.391% times two). One possible reason for this finding is that we are using Fama-French portfolios, which are well diversified. There are no extremely high returns in the sorting period, and there are no big differences between the highest and lowest returns. Lewellen (2002) also finds similar lower returns for portfolios sorted by size and book-to-market - he finds returns of 0.542%, 0.381%, 0.438%, 0.357% and 0.150% for $J = 12$ and $K = 3, 5, 7, 9$, and 11, respectively. His size- and book-to-market sorted portfolios are pretty clearly also well diversified. Consistent with the findings of JT (2001), excess returns for longer holding periods ($K > 9$) fall (e.g. 0.344% ($K = 6$) and 0.230% ($K = 15$)), but are still significant as K increases to 18. Additionally, increasing the sorting period, J, beyond 12 months increases returns, as expected. Of note is that momentum effects are more significant when holding "strong" portfolios than when selling "weak" portfolios. This suggests that the strategy of buying portfolios with the highest expected returns and shorting portfolios with the lowest expected returns usually generates less profits than strategies based upon only buying the portfolios with the highest expected returns (i.e. $max1 - min1$ produces less profits than does $max1-$ $max3$).

In the following discussion, we refer to a great extent to tables that appear in the paper.

However, as our analysis generated a great number of additional tables, a full set of all tables are contained in a separate not for publication appendix that is available upon request from the authors.

Combination momentum and mean reversion trading strategies

We now examine the strategy that encompasses both pure momentum and pure mean reversion cases ($\rho^i_j = \rho$, for all i, and j) - namely the case where we have one momentum parameter and one mean reversion parameter ($\delta^i = \delta$ for all i), and there is no downside risk ($\beta^i_t = 0$). In particular, Table 3.3b summarizes our trading strategy return findings based on Eq. (3.5), with the aforementioned parameter restrictions. Excess returns are positive in all cases, consistent with the findings of Balvers and Wu (2006). Additionally, the combination strategy outperforms the pure momentum strategy. In particular, for 87 out of 144 holding period K and sorting period J permutations, the combination strategy beats the pure momentum strategy. These instances are denoted by bold font. Of note that the combination strategy outperforms the pure momentum strategy for relatively short sorting periods (J=3,6,9) and relatively short holding periods (K=3,6,9,12). Additionally, as sorting period J increases, combination returns increase, as in the pure momentum strategy case. On the other hand, as holding period K increases, combination returns first increase, usually achieving their peaks at around $J = 6$ and $K = 9$, and then decrease. Of final note is that Balvers and Wu (2006) achieve much larger excess returns than we do because they apply their combination strategies to 18 developed country stock market indices, and return spreads across these indices are relatively large, when compared with our U.S. data.

Combination momentum and downside risk strategies

When we consider a combination strategy based on Eq. (3.5) with one momentum parameter and one downside risk parameter, excess returns are positive in all cases. (See not for publication appendix for tabulated results.) However, there are only 2 cases for which the combination strategy outperforms the pure momentum strategy, illustrating that our new factor-downside risk doesn't work well in pseudo real time trading, at least when K $\geq$ 3, as reported in the tabulated results. However, note in Table 3.3c that this strategy does actually yield improved excess returns when one considers the very short holding periods.

Combination momentum, mean reversion and downside risk strategies

In summary, our trading results based on relative long sorting periods ($J = 3, 6, 9, 12, 15, 18$) and holding periods ($K = 3, 6, 9, 12, 15, 18$), do not support the new factor – downside risk. As a robustness check of this finding, we compare performance when the sorting period is set at $J = 2, 3, 4, 5, 6, 7$, and the holding period is set at $K = 1, 2, 3, 4, 5, 6$. Results are provided in Table 3.3d as well as in our not for publication appendix; and these results are quite different from those based on the use of longer horizons. In particular, momentum and mean reversion trading strategies beat pure momentum strategies in almost all cases. Additionally, momentum and downside risk combination trading strategies yield higher returns than pure momentum trading strategies, when the sorting period and holding period are short ($J < 3, K < 6$). Finally (see Table 3d), the combination strategy based on the use of momentum, mean reversion and downside risk dominates the pure momentum strategy when $K < 3$ (results not shown here), the momentum, mean reversion combination strategy when $K < 3$ (for all cases that are in bold font in Table 3d), and the momentum, downside risk combination strategy when $K < 3$ (compare Tables 3.3c and 3.3d). These facts coincide with the notion the downside risk factor does affect premia, but only in short run trading horizons.

Size and book-to-market effects on trading strategy performance

Given the findings discussed above, we further examine the effect that macro factors including size and book-to-market have on trading strategies.

Turning first to portfolio size, we divide our 25 Fama-French portfolios into two categories: one for small size, which includes the smallest 12 portfolios out of the 25 Fama-French portfolios; one for big size, which includes the biggest 12 portfolios out of the 25 Fama-French portfolios. We trade the two size-based portfolios according to the pure momentum strategy, the momentum and downside risk strategy, the mean-reversion and momentum strategy, and the combination of mean reversion, momentum and downside risk strategy in both long run and short run.

Of note when considering small sized portfolios is that in 39 out of 144 cases, momentum and downside risk combination strategies "beat" pure momentum strategies (see Table

3.4a). Moreover, in one half of the cases considered, mean-reversion and momentum combination strategies outperform pure momentum strategies. Of note is those case where the momentum plus downside risk strategy dominates are generally not the cases where the momentum mean reversion strategy dominates. Finally, in 39 out of 144 cases, mean reversion, momentum and downside risk combination strategies have higher excess returns than any other strategy (see Table 3.4b). These “wins" are usually generated for the largest three values of J, as is the case when comparing momentum plus downside risk strategies with momentum strategies. In the short run (i.e. $J <= 7, K <= 6$), only mean-reversion and momentum combination strategies outperform pure momentum strategies.

Of note when considering big sized portfolios is that there are 100 out of 144 cases that the momentum and downside risk combination strategies outperform the pure momentum strategies, and 90 out of 144 cases where the combination of mean reversion, momentum and downside risk strategies have higher excess returns than the mean-reversion and momentum combination strategies, when considering cases where $K, J = 3, 6, 9, 12, 15, 18$. See Tables 3.4c and 3.4d for further details. This evidence support the notion that downside risk plays a relatively more important role in big sized portfolios.

Turning our attention to book-to-market value, we separate our 25 Fama-French portfolios into two categories: one for low book-to-market value, which includes the lowest 10 portfolios, and one for high book-to-market value, which includes the highest 10 portfolios. Interestingly, in these experiments, the only strategy that frequently outperforms the pure momentum strategy is the combination of mean reversion, momentum and downside risk strategy, which wins in 76 out of 144 cases, when considering low value book-to-market portfolios, for the larger values of K and J (see Table 3.5a). Turning now to Table 3.5b, when considering lower values of K and J and high value book-to-market portfolios, combination momentum and downside risk strategies have higher excess returns than pure momentum strategies in more than one half of the cases considered.

All of our findings with respect to size and book-to-market stategies are summarized in the following chart. Complete details are available in the not for publication appendix.

Chart 1: Size and Book-to-Market Trading Strategy Comparison

Trading Strategies Being Compared	Sorting / Holding Period	Small Size	Big Size	low B/M	high B/M
	Number of Cases (out of 144) where one strategy beats another strategy				
Cases Where Momentum and Downside Risk Strategy Beats Pure Momentum Strategy					
	Long run	39	100	14	45
	Short run	28	43	27	96
Cases Where Momentum and Mean Reversion Strategy Beats Pure Momentum Strategy					
	Long run	72	44	0	3
	Short run	113	108	14	9
Cases Where 3-Factor Strategy Beats Momentum and Mean Reversion Strategy					
	Long run	39	90	76	62
	Short run	18	26	28	113

* Notes: All entries denote the number of cases (out of a total of 144 cases) where one trading strategy beats another trading strategy. "Long run" denotes experiments where sorting periods are J = 3,6,9,12,15,18 and holding periods are K = 3,6,9,12,15,18. "Short run" denotes experiments where sorting period are J = 2,3,4,5,6,7 and holding periods are K =1,2,3,4,5,6.

Inspection of the entries in this table suggest that mean reversion and momentum combination strategies perform much better in size sorted portfolios, but poorly in book-to-market sorted portfolios. Moreover, the momentum effect is more significant in book-to-market portfolios than it is in size-sorted portfolios. In other words, the risk premium from mean-reversion is very small compared to the momentum premium. One possible reason for this finding is that book-to-market portfolios are more sensitive to relatively short horizon innovations. Thus, short-horizon downside risk might compensate for the weakness of long-horizon mean reversion effects. One key result of our analysis is that our 3-factor trading strategy that includes downside risk works extremely well with high book-to-market portfolios. One reason for this is that mean reversion and momentum effects are effectively "separated" in book-to-market portfolios, so we can't improve trading by jointly considering them.

Overall, our results support the notion that downside risk helps to explain the equity premium, as well as book-to-market and portfolio size premia.

3.4.3 Causality test results

In this section, we carry out an empirical investigation of nonlinear Granger causality, using the testing approach of Corradi and Swanson (2002,2005). One aspect of the test proposed by these authors that we implement is that it can equivalently be interpreted as an out-of-sample Granger causality test that is robust to generic nonlinear misspecification, and also as a predictive accuracy test, whereby a "smaller" model is first posited, and then one evaluates whether a "bigger" model yields improved predictions. We construct the test statistics according to the procedure outlined in the not for publication appendix to this paper. In summary, the test is based on constructing ex-ante predictions of a series, and then assessing whether the associated prediction errors are correlated with some *additional variable*, in which case the additional variable is shown to improve the predictive accuracy of the original prediction model. Equivalently, in this case, ones can say that there is out-of-sample (non)linear Granger causality from the *additional variable* to the variable being predicted. More specifically, define a "benchmark" model as:

$$y_t = \theta_{1,1}^{\dagger} + \theta_{1,2}^{\dagger} y_{t-1} + u_{1,t}, \tag{3.8}$$

where $\theta_1^{\dagger} = (\theta_{1,1}^{\dagger}, \theta_{1,2}^{\dagger})' = \arg\min_{\theta_1 \in \Theta_1} E(q_1(y_t - \theta_{1,1} - \theta_{1,2} y_{t-1}))$, and y_t is a scalar random variable. Further, define a generic "alternative" model as:

$$y_t = \theta_{2,1}^{\dagger}(\gamma) + \theta_{2,2}^{\dagger}(\gamma) y_{t-1} + \theta_{2,3}^{\dagger}(\gamma) w(Z^{t-1}, \gamma) + u_{2,t}(\gamma), \tag{3.9}$$

where $\theta_2^{\dagger}(\gamma) = (\theta_{2,1}^{\dagger}(\gamma), \theta_{2,2}^{\dagger}(\gamma), \theta_{2,3}^{\dagger}(\gamma))' = \arg\min_{\theta_2 \in \Theta_2} E(q_1(y_t - \theta_{2,1} - \theta_{2,2} y_{t-1} - \theta_{2,3} w(Z^{t-1}, \gamma)))$ and $\gamma \in \Gamma$, Γ is a compact subset of R^d, for some finite of d. Here, $w(Z^{t-1}, \gamma)$ is generically comprehensive function, like Bierens's exponential, a logistic, or a cumulative distribution function, and Z^{t-1} is a function of lags of y as well as lags of some *additional variable*, x. For example, in this paper, we define:

$$w(z^{t-1}, \gamma) = \exp\left(\sum_{i=1}^{2} (\gamma_i \tan^{-1}((z_{i,t-1} - \overline{z}_i)/2\widehat{\sigma}_{z_i}))\right) \tag{3.10}$$

with

$$\begin{aligned} z_{1,t-1} &= x_{t-1} \\ z_{2,t-1} &= y_{t-1} \end{aligned}$$

and γ_1, γ_2 scalars. The hypotheses of interest are:

$$H_0 : E(g(u_{1,t+1}) - g(u_{2,t+1}(\gamma))) = 0 \text{ versus } H_A : E(g(u_{1,t+1}) - g(u_{2,t+1}(\gamma))) > 0.$$

where $g(.)$ is a loss function, assumed to be quadratic in our setup, H_0 is the null of equal predictive accuracy, and H_A corresponds to the case where the alternative model outperforms the benchmark model. Following Corradi and Swanson (2002), the test statistic for testing this hypothesis is:

$$M_P = \int_{\Gamma} m_P(\gamma)^2 \phi(\gamma) d\gamma, \tag{3.11}$$

where $m_p(\gamma) = \frac{1}{P^{1/2}} \sum_{t=R}^{T-1} g\prime(u_{1,t+1}) w(Z^{t-1}, \gamma)$ and where $\int_{\Gamma} \phi(\gamma) d\gamma = 1$, $\phi(\gamma) \geq 0$, with $\phi(\gamma)$ absolutely continuous with respect to Lebesgue measure. Corradi and Swanson (2005) outline bootstrap methodology used to calculate critical values from the limiting distribution under the null hypothesis of this test statistic.

In our implementation of this test, we construct tests statistics using 1-step ahead forecasts formed via recursively estimated models. The beginning date for the in-sample period is 1963:7. The prediction periods considered are 1984:1-2003:12 and 1990:1-2003:12 . We consider 3 pairs of models. First, we test the model with MRV_t^i and CMC_t^i as explanatory variables. Namely,

$$R_t^i = MRV_t^i + CMC_t^i + \eta_t^i$$

against:

$$R_t^i = MRV_t^i + MOM_t^i + CMC_t^i + \eta_t^i$$

Second, we test the model:

$$R_t^i = MRV_t^i + \eta_t^i$$

against a model which includes momentum as an extra explanatory variable. Namely,

$$R_t^i = MRV_t^i + MOM_t^i + \eta_t^i$$

Finally, we test a model with only MRV_t^i and MOM_t^i as explanatory variables

$$R_t^i = MRV_t^i + MOM_t^i + \eta_t^i$$

against a model which includes downside risk as an extra explanatory variable.

$$R_t^i = MRV_t^i + MOM_t^i + CMC_t^i + \eta_t^i$$

In addition to the above test, we implement a variety of other out-of-sample test statistics including the out of sample F and Diebold-Mariano statistics. A complete summary of the tests that we implement (as well as test results) is given in a table contained in our not for publication appendix. Interestingly, and regardless of the pair of models being tested, we find almost no evidence that our "larger" alternative models are superior to the benchmark "smaller" models, when assuming a quadratic predictive error loss function. This finding is interesting, as it suggests that while we have accumulated a substantial amount of evidence concerning the excess returns available when following trading strategies that include downside risk, there is actually very little to choose between the models based upon the comparison of out-of-sample mean square forecast error, via the use of the various predictive accuracy tests that we have constructed. While this finding does not suggest that our earlier findings are non-robust, it does suggest that careful analysis of our trading strategies using actual profitability measures rather than average excess return measures may be useful, inasmuch as use of a profitability loss function may yield different findings from the quadratic loss function used in our 1-step ahead predictability analysis reported in this subsection. Further examination of this aspect of our analysis is left to future research.

3.5 Concluding Remarks

In this paper we evaluate a downside risk factor, in the context of pseudo real time trading. Our main focus is the assessing whether downside risk augmented trading strategies capture additional excess returns, relative to strategies that implement momentum and mean reversion factors. Our proposed strategy is neither purely contrarian, nor purely momentum-based, nor purely downside risk based. Instead, we use combinations of two or all of these factors to form a single indicator. Investing in the U.S. stock market with the highest indicator generally generates an annual excess return of 5.4% over the 20-year "out-of-sample" period that we consider. Individually, all of our combination strategy formulations yield significant excess returns. Interestingly, we find that mean reversion and momentum effect are "separated" in book-to-market portfolios, so that we cannot improve trading by jointly considering them, in such cases. However, the addition of a downside risk factor to trading strategies almost always yields increased excess returns, particularly for small sized portfolios and high book-to-market portfolios. In such cases, we generate significant risk premia, relative to strategies that combine only momentum and mean reversion factors. Finally, we carry out an ex-ante prediction analysis in order to assess, via the use of mean square forecast error loss, whether there is anything to choose between various different models that we consider in our trading strategy experiments. Interestingly, our findings point to little statistical difference, in a mean square forecast error sense, between the different models, suggesting that one may need to carry out direct ex-ante profitability analysis in order to reconcile our predictive time series results with our cross sectional trading strategy and excess return analysis.

Table 3.1: Cross- section evidence: 25 Fama - French portfolios

size	**B/M**	**returns**		**excess returns**	
		mean	std	mean	std
Small	Low	0.391	8.316	-0.455	5.414
	2	1.061	7.018	0.215	4.401
	3	1.178	6.023	0.332	3.563
	4	1.402	5.594	0.556	3.381
	High	1.487	5.884	0.641	3.689
2	Low	0.607	7.565	-0.239	4.304
	2	0.956	6.121	0.11	3.145
	3	1.254	5.376	0.408	2.74
	4	1.316	5.169	0.47	2.762
	High	1.381	5.728	0.535	3.275
3	Low	0.674	6.922	-0.172	3.562
	2	1.062	5.523	0.216	2.389
	3	1.091	4.933	0.245	2.326
	4	1.234	4.725	0.388	2.478
	High	1.374	5.406	0.528	3.042
4	Low	0.824	6.084	-0.022	2.572
	2	0.861	5.198	0.015	1.988
	3	1.105	4.857	0.259	2.138
	4	1.23	4.622	0.384	2.335
	High	1.235	5.323	0.389	2.955
Big	Low	0.782	4.797	-0.064	1.705
	2	0.853	4.57	0.007	1.697
	3	0.887	4.315	0.041	2.155
	4	0.961	4.209	0.115	2.607
	High	0.955	4.783	0.109	3.14

* Notes:Table 3.1 presents descriptive statistics (in percentages) for the 25 characteristic sorted quintile portfolios. Value- weighted returns and log dividend growth rates are presented for portfolios formed on market capitalization (Size), and book-to-market ratio (B/M). The data are sampled at the quarterly frequency, and cover the 3rd quarter 1963 through 4th quarter 2004.

Table 3.2: Basic Analysis for whole sample size (25 Fama - French portfolios)

NO	Model	Dependent Variable	Constant	Mean Reversion	Momentum	Downside Risk	SMB	HML	R^2
Panel A: Excess Returns on Mean-reversion, Momentum and Downside risk, 1963:9-2004:12 (monthly)									
1	RMMD	$r_t^i - r_t^w$	0.002(0.848)	0.033(0.180)	0.022(1.845)	0.089(1.967)			0.024
2	RMM	$r_t^i - r_t^w$	0.002(0.872)	0.051(0.280)	0.024(2.003)				0.016
3	RMD	$r_t^i - r_t^w$	0.002(1.253)		0.022(1.933)	0.090(1.979)			0.024
4	RMR	$r_t^i - r_t^w$	0.002(0.923)	0.135(0.751)					0.008
5	RM	$r_t^i - r_t^w$	0.002(1.371)		0.025(2.122)				0.016
6	RD	$r_t^i - r_t^w$	0.002(1.722)			0.098(2.164)			0.017
Panel B: Excess Returns on Mean-reversion, Momentum, Downside risk and Fama French factors, 1963:9-2004:12 (monthly)									
1	RMMD	$r_t^i - r_t^w$	-0.002(-0.950)	0.113(0.707)	0.011(1.072)	0.035(0.805)	0.356(12.235)	0.259(6.441)	0.262
2	RMM	$r_t^i - r_t^w$	-0.002(-0.950)	0.120(0.757)	0.012(1.138)		0.357(12.525)	0.261(6.510)	0.261
3	RMD	$r_t^i - r_t^w$	-0.001(-0.643)		0.013(1.263)	0.037(0.929)	0.354(12.345)	0.258(6.417)	0.261
4	RMR	$r_t^i - r_t^w$	-0.002(-0.945)	0.162(1.041)			0.360(12.648)	0.266(6.631)	0.259
5	RM	$r_t^i - r_t^w$	-0.001(-0.613)		0.014(1.344)		0.357(12.498)	0.261(6.499)	0.260
6	RD	$r_t^i - r_t^w$	-0.001(-0.409)			0.041(1.032)	0.356(12.445)	0.263(6.541)	0.259
Panel C: Excess Returns on Mean-reversion, Momentum, Downside risk and lagged Fama French factors, 1963:9-2004:12 (monthly)									
1	RMMD	$r_t^i - r_t^w$	0.002(0.825)	0.031(0.167)	0.022(1.842)	0.095(1805)	-0.008(-0.235)	0.007(0.141)	0.025
2	RMM	$r_t^i - r_t^w$	0.001(0.706)	0.053(0.290)	0.023(1.914)		0.025(0.755)	0.316(0.682)	0.018
3	RMD	$r_t^i - r_t^w$	0.002(1.203)		0.022(1.933)	0.095(1.829)	-0.009(-0.244)	0.007(0.138)	0.025
4	RMR	$r_t^i - r_t^w$	0.001(0.723)	0.133(0.741)			0.030(0.911)	0.038(0.825)	0.011
5	RM	$r_t^i - r_t^w$	0.002(1.141)		0.024(2.022)		0.025(0.750)	0.032(0.682)	0.018
6	RD	$r_t^i - r_t^w$	0.002(1.622)			0.101(1.932)	-0.006(-0.167)	0.012(0.248)	0.017
Panel D: Test the assumption that $\rho_j^i = \rho^i, \delta^i = \delta$ and $\beta_t^i = \beta^i$.									
1	RMMD	$r_t^i - r_t^w$	0.002(0.001)	-0.066(0.132)	0.019(0.017)	0.070(0.048)			
2	RMM	$r_t^i - r_t^w$	0.002(0.002)	-0.059(0.127)	0.020(0.017)				
3	RMD	$r_t^i - r_t^w$	0.002(0.001)		0.018(0.016)	0.070(0.048)			
4	RMR	$r_t^i - r_t^w$	0.003(0.003)	-0.024(0.132)					
5	RM	$r_t^i - r_t^w$	0.002(0.002)		0.020(0.017)				
6	RD	$r_t^i - r_t^w$	0.003(0.002)			0.079(0.046)			

* Notes: This table reports estimates from OLS regressions of stock returns on lagged variables named at the head of a colum. All returns use the value-weighted 25 Fama-French returns. The repressors are as follows: mean reversion factor, Downside risk factor and Momentum factor are from model decomposition. Momentum portfolios is formed in past 12 months, that is J=12. r_t is the return rate, r^w is the CRSP value weighted return. r^{vw} is the value weighted 25 Fame - French portfolio return, which are formed on market capitalization (Size). r^f is the 3-month T-bill return. "lag" denotes a one-period lag of the independent variables; cay_t is taken from Sidney Ludvigson's homepage; $C_{leverage}$ is the consumption leverage. The critical value for 1% significant level is 2.58; The critical value for 5% significant level is 1.96; The critical value for 10% significant level is 1.64.

Table 3.3a: Performance of portfolios with trading strategy: Pure momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.034	0.258	0.182	2.165	0.209	2.697	0.152	2.332	0.098	1.705	0.101	1.835
Max 1-Min1	0.047	0.471	0.192	2.782	0.218	3.563	0.162	3.131	0.103	2.171	0.105	2.456
Max3	0.129	1.293	0.215	3.092	0.242	3.899	0.211	3.992	0.169	3.567	0.153	3.333
Max3-Min3	0.086	1.147	0.162	3.078	0.179	3.986	0.148	3.834	0.113	3.172	0.105	3.339
J=6												
Max 1	0.265	2.013	0.316	3.642	0.26	3.385	0.173	2.611	0.167	2.86	0.15	2.691
Max 1-Min1	0.35	3.353	0.367	5.614	0.287	4.904	0.196	3.837	0.167	3.648	0.172	4.08
Max3	0.343	3.063	0.334	4.725	0.315	5.24	0.254	4.835	0.209	4.407	0.18	3.897
Max3-Min3	0.287	3.393	0.266	5.393	0.242	5.78	0.18	4.602	0.142	4.095	0.125	3.857
J=9												
Max 1	0.377	2.987	0.371	4.239	0.279	3.428	0.219	3.229	0.187	3.107	0.161	2.905
Max 1-Min1	0.396	4.049	0.359	5.107	0.274	4.308	0.221	4.239	0.188	3.949	0.189	4.317
Max3	0.371	3.681	0.359	4.839	0.282	4.574	0.222	4.151	0.177	3.699	0.158	3.598
Max3-Min3	0.321	4.167	0.282	5.407	0.226	5.146	0.173	4.53	0.136	3.833	0.128	3.934
J=12												
Max 1	0.411	3.225	0.375	4.172	0.299	3.757	0.252	3.771	0.204	3.475	0.165	3.061
Max 1-Min1	0.391	3.865	0.344	4.848	0.288	4.719	0.254	4.97	0.23	4.816	0.238	5.449
Max3	0.35	3.16	0.308	4.148	0.274	4.303	0.198	3.587	0.162	3.273	0.144	3.169
Max3-Min3	0.296	3.543	0.236	4.468	0.213	4.638	0.158	4.073	0.136	3.681	0.127	3.759
J=15												
Max 1	0.369	3.09	0.358	4.526	0.294	3.953	0.235	3.786	0.199	3.559	0.165	3.086
Max 1-Min1	0.374	3.743	0.345	5.347	0.301	5.297	0.252	5.062	0.244	5.204	0.235	5.388
Max3	0.294	2.881	0.258	3.655	0.225	3.731	0.183	3.474	0.15	3.178	0.137	3.156
Max3-Min3	0.243	3.092	0.191	3.647	0.174	3.87	0.142	3.487	0.126	3.38	0.12	3.487
J=18												
Max 1	0.453	4.199	0.373	4.64	0.316	4.427	0.275	4.421	0.233	4.146	0.189	3.636
Max 1-Min1	0.427	4.978	0.324	5.071	0.258	4.412	0.244	4.846	0.232	5.073	0.236	5.558
Max3	0.288	2.953	0.254	3.604	0.238	3.858	0.188	3.447	0.158	3.168	0.143	3.142
Max3-Min3	0.217	2.875	0.186	3.528	0.17	3.553	0.148	3.564	0.13	3.331	0.125	3.48

* Notes: All entries are return rate based on sorting period J and holding period K. we define the portfolio with the highest expected return as the "Max1" portfolio, and the portfolio with the lowest expected return as the "Min1" portfolio. The strategy of buying Max1 and shorting Min1, and holding this portfolio for K periods is referred to as "$Max1 - Min1$" and is listed under the appropriate value for K.

Table 3.3b: Performance of portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.209**	1.602	**0.289**	3.315	**0.285**	3.5	**0.252**	3.629	**0.188**	3.038	**0.16**	2.751
Max 1-Min1	**0.208**	2.182	**0.300**	4.431	**0.306**	5.014	**0.266**	5.208	**0.206**	4.285	**0.192**	4.56
Max3	**0.241**	2.4	**0.308**	4.249	**0.311**	4.777	**0.283**	5.054	**0.23**	4.487	**0.205**	4.169
Max3-Min3	**0.169**	2.332	**0.237**	4.6	**0.234**	5.319	**0.2**	5.409	**0.157**	4.46	**0.142**	4.57
J=6												
Max 1	**0.251**	1.869	**0.318**	3.453	**0.29**	3.596	**0.197**	2.829	**0.171**	2.737	0.134	2.268
Max 1-Min1	**0.356**	3.411	**0.364**	5.525	**0.316**	5.564	**0.217**	4.302	**0.17**	3.677	0.157	3.621
Max3	**0.361**	3.422	**0.383**	5.414	**0.366**	5.994	**0.296**	5.504	**0.235**	4.714	**0.198**	4.108
Max3-Min3	**0.318**	3.924	**0.301**	6.236	**0.273**	6.729	**0.205**	5.373	**0.158**	4.523	**0.133**	4.044
J=9												
Max 1	**0.452**	3.579	**0.416**	4.654	**0.347**	4.239	**0.252**	3.663	0.178	2.834	0.134	2.329
Max 1-Min1	**0.494**	4.999	**0.407**	5.897	**0.324**	5.241	**0.253**	5.001	**0.203**	4.245	**0.197**	4.5
Max3	**0.386**	3.934	**0.386**	5.401	**0.319**	5.1	**0.24**	4.397	**0.196**	3.889	**0.176**	3.802
Max3-Min3	**0.344**	4.67	**0.309**	6.279	**0.254**	5.871	**0.193**	5.176	**0.16**	4.594	**0.152**	4.76
J=12												
Max 1	**0.412**	3.157	0.374	4.124	0.298	3.738	0.25	3.763	**0.214**	3.639	**0.179**	3.311
Max 1-Min1	0.369	3.54	0.337	4.674	0.279	4.509	0.249	4.833	0.222	4.633	0.233	5.267
Max3	**0.357**	3.257	**0.315**	4.241	0.271	4.192	0.192	3.462	**0.166**	3.367	0.139	3.072
Max3-Min3	0.275	3.398	0.231	4.365	0.205	4.467	0.146	3.708	0.126	3.376	0.108	3.115
J=15												
Max 1	**0.376**	2.917	**0.361**	4.275	0.289	3.747	**0.242**	3.702	0.188	3.183	0.146	2.586
Max 1-Min1	**0.413**	3.98	**0.364**	5.349	0.297	5.059	0.251	4.864	0.226	4.761	0.213	4.82
Max3	**0.321**	3.146	**0.275**	3.787	0.225	3.569	0.17	3.127	0.137	2.783	0.119	2.641
Max3-Min3	0.24	3.067	**0.199**	3.75	0.174	3.823	0.135	3.327	0.11	2.875	0.095	2.653
J=18												
Max 1	0.428	3.504	**0.391**	4.599	**0.338**	4.458	**0.3**	4.653	**0.260**	4.516	**0.211**	3.962
Max 1-Min1	0.426	4.589	**0.342**	5.238	**0.284**	4.807	**0.271**	5.406	**0.242**	5.251	0.233	5.396
Max3	0.265	2.689	0.226	3.124	0.195	3.082	0.159	2.855	0.134	2.649	0.115	2.483
Max3-Min3	0.179	2.387	0.15	2.824	0.132	2.728	0.111	2.58	0.092	2.281	0.082	2.173

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table 3.3c: Performance of portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.278**	1.247	**0.099**	0.577	0.017	0.125	-0.002	-0.02	0	0.002	0.025	0.276
Max 1-Min1	**0.327**	1.84	0.177	1.352	0.098	1.028	0.103	1.213	0.108	1.428	0.112	1.571
Max3	**0.315**	1.785	0.136	1.059	0.105	1.048	0.119	1.331	0.1	1.332	0.113	1.638
Max3-Min3	**0.219**	1.576	0.091	0.924	0.063	0.866	0.077	1.161	0.071	1.247	0.079	1.546
J=3												
Max 1	**0.213**	0.964	**0.055**	0.325	0.018	0.138	0.032	0.293	0.018	0.192	0.032	0.357
Max 1-Min1	**0.304**	1.726	**0.154**	1.184	**0.109**	1.137	0.117	1.387	0.116	1.54	0.108	1.518
Max3	**0.324**	1.842	**0.161**	1.256	**0.142**	1.409	0.147	1.639	0.137	1.831	0.127	1.848
Max3-Min3	**0.24**	1.744	**0.108**	1.085	0.083	1.122	0.091	1.327	0.087	1.507	0.081	1.541
J=4												
Max 1	**0.332**	1.489	**0.13**	0.767	0.03	0.236	0.023	0.214	0.007	0.074	0.034	0.374
Max 1-Min1	**0.348**	1.979	**0.163**	1.279	0.087	0.932	0.103	1.227	0.101	1.348	0.102	1.433
Max3	**0.356**	2.007	**0.177**	1.376	0.135	1.358	0.163	1.841	0.152	2.067	0.155	2.3
Max3-Min3	**0.247**	1.785	**0.123**	1.225	0.084	1.115	0.108	1.572	0.104	1.814	0.102	1.965
J=5												
Max 1	**0.19**	0.845	0.036	0.214	0.035	0.266	0.036	0.333	0.03	0.304	0.059	0.639
Max 1-Min1	**0.288**	1.64	0.148	1.162	0.112	1.187	0.135	1.599	0.133	1.762	0.134	1.885
Max3	**0.337**	1.879	0.171	1.335	0.143	1.418	0.168	1.88	0.155	2.089	0.164	2.409
Max3-Min3	**0.239**	1.701	0.117	1.158	0.094	1.231	0.122	1.764	0.113	1.956	0.112	2.15
J=6												
Max 1	**0.300**	1.348	0.061	0.353	0.118	0.909	0.081	0.752	0.068	0.721	0.08	0.931
Max 1-Min1	**0.390**	2.262	0.181	1.363	0.2	2.092	0.206	2.531	0.195	2.71	0.206	3.084
Max3	**0.402**	2.239	0.239	1.842	0.223	2.243	0.238	2.725	0.226	3.094	0.241	3.571
Max3-Min3	**0.291**	2.078	0.188	1.862	0.182	2.416	0.207	3.081	0.2	3.645	0.21	4.254
J=7												
Max 1	0.217	0.99	0.032	0.185	0.044	0.336	0.037	0.339	0.021	0.215	0.048	0.554
Max 1-Min1	0.315	1.809	0.154	1.162	0.161	1.703	0.178	2.214	0.162	2.249	0.172	2.605
Max3	0.393	2.202	0.275	2.146	0.255	2.577	0.258	3.015	0.244	3.313	0.262	3.864
Max3-Min3	0.292	2.109	0.199	1.995	0.198	2.661	0.222	3.363	0.208	3.792	0.213	4.303

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table 3.3d: Performance of portfolios with strategy: Mean reversion, momentum and downside risk (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.379**	1.744	0.204	1.206	0.154	1.183	0.137	1.257	0.14	1.455	0.153	1.756
Max 1-Min1	**0.407**	2.372	0.229	1.779	0.193	2.038	0.19	2.284	0.202	2.752	0.21	3.104
Max3	**0.393**	2.267	**0.273**	2.168	**0.235**	2.368	**0.227**	2.604	**0.227**	2.997	0.248	3.509
Max3-Min3	**0.312**	2.311	**0.205**	2.128	**0.169**	2.367	**0.179**	2.789	0.176	3.195	0.186	3.713
J=3												
Max 1	**0.281**	1.325	**0.188**	1.138	0.145	1.146	0.153	1.463	0.132	1.416	0.146	1.717
Max 1-Min1	**0.399**	2.318	**0.274**	2.106	**0.213**	2.24	0.211	2.54	0.214	2.907	0.209	3.124
Max3	**0.405**	2.375	0.256	2.066	0.193	1.977	0.188	2.219	0.189	2.556	0.206	2.974
Max3-Min3	**0.299**	2.23	0.163	1.697	0.143	2.028	0.158	2.483	0.153	2.823	0.16	3.201
J=4												
Max 1	**0.361**	1.646	**0.189**	1.116	0.172	1.334	0.157	1.452	0.131	1.352	0.153	1.722
Max 1-Min1	**0.416**	2.41	**0.246**	1.912	**0.217**	2.291	0.22	2.645	0.22	2.949	0.225	3.289
Max3	**0.407**	2.345	**0.25**	1.972	0.2	2.032	0.195	2.266	0.194	2.592	0.22	3.121
Max3-Min3	**0.311**	2.271	**0.175**	1.785	0.145	2.006	0.16	2.447	0.156	2.802	0.172	3.373
J=5												
Max 1	**0.333**	1.549	**0.17**	1.011	0.17	1.312	0.178	1.647	0.148	1.529	0.176	2.013
Max 1-Min1	**0.394**	2.293	0.219	1.698	0.199	2.1	0.222	2.669	0.219	2.956	0.226	3.365
Max3	**0.378**	2.147	0.239	1.881	0.196	2.001	0.2	2.332	0.204	2.709	0.229	3.236
Max3-Min3	**0.274**	1.978	0.166	1.687	0.145	1.999	0.168	2.587	0.169	3.046	0.179	3.556
J=6												
Max 1	**0.449**	2.021	0.172	0.985	0.225	1.715	0.193	1.748	0.164	1.699	0.165	1.901
Max 1-Min1	0.448	2.555	0.245	1.836	0.271	2.79	0.282	3.388	0.269	3.711	0.266	4.009
Max3	**0.415**	2.321	0.261	2.002	0.247	2.467	0.26	2.954	0.245	3.23	0.271	3.849
Max3-Min3	0.312	2.238	0.208	2.071	0.203	2.744	0.225	3.434	0.214	3.953	0.225	4.71
J=7												
Max 1	**0.328**	1.527	0.106	0.618	0.136	1.053	0.143	1.319	0.119	1.244	0.154	1.787
Max 1-Min1	0.416	2.375	0.231	1.727	0.236	2.428	0.261	3.179	0.245	3.372	0.256	3.894
Max3	0.407	2.272	0.299	2.313	0.286	2.837	0.279	3.159	0.262	3.447	0.28	3.948
Max3-Min3	0.288	2.086	0.214	2.146	0.216	2.919	0.236	3.594	0.219	4.032	0.228	4.693

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy(in short run).

Table 3.4a: Performance of small size portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.252**	1.865	**0.293**	3.298	**0.336**	4.116	**0.270**	3.755	**0.213**	3.314	**0.197**	3.207
Max 1-Min1	**0.281**	3.542	**0.339**	5.756	**0.362**	6.548	**0.314**	6.356	**0.267**	5.644	**0.255**	5.886
Max3	**0.353**	3.028	**0.367**	4.525	**0.374**	5.268	**0.343**	5.491	**0.296**	5.259	**0.271**	5.033
Max3-Min3	**0.249**	3.949	**0.271**	6.022	**0.278**	6.751	**0.256**	6.766	**0.219**	6.102	**0.205**	6.277
J=6												
Max 1	**0.338**	2.317	0.353	3.685	**0.341**	4.045	**0.287**	3.813	**0.252**	3.738	**0.204**	3.185
Max 1-Min1	0.375	4.324	0.362	5.935	**0.326**	5.863	**0.268**	5.199	**0.238**	4.847	**0.207**	4.602
Max3	**0.377**	3.148	**0.39**	4.612	**0.368**	5.039	**0.314**	4.906	**0.263**	4.56	**0.225**	4.033
Max3-Min3	0.302	4.54	0.29	6.337	**0.267**	6.58	**0.211**	5.527	**0.175**	4.845	0.145	4.31
J=9												
Max 1	**0.353**	2.563	**0.348**	3.601	**0.329**	3.932	**0.284**	3.898	**0.224**	3.381	**0.185**	3.029
Max 1-Min1	**0.382**	4.718	**0.343**	5.558	**0.304**	5.305	**0.258**	4.984	**0.204**	4.161	**0.179**	3.95
Max3	**0.337**	2.767	**0.351**	4.194	**0.328**	4.64	**0.277**	4.466	**0.227**	4.065	**0.201**	3.908
Max3-Min3	**0.287**	4.487	**0.268**	5.785	**0.219**	5.257	**0.177**	4.633	**0.14**	3.908	**0.121**	3.619
J=12												
Max 1	**0.313**	2.084	**0.31**	3.042	**0.267**	3.108	**0.186**	2.468	**0.128**	1.916	**0.08**	1.31
Max 1-Min1	0.273	2.977	0.241	3.649	0.178	3.077	0.125	2.372	0.077	1.566	0.062	1.351
Max3	0.343	2.625	0.305	3.443	0.266	3.592	0.205	3.151	0.15	2.599	0.114	2.159
Max3-Min3	0.212	3.091	0.171	3.598	0.138	3.253	0.091	2.324	0.053	1.415	0.029	0.821
J=15												
Max 1	0.302	2.144	0.306	3.011	0.254	2.92	0.181	2.394	0.12	1.798	0.067	1.086
Max 1-Min1	0.267	3.116	0.233	3.64	0.173	3.039	0.122	2.354	0.087	1.783	0.05	1.112
Max3	0.335	2.706	0.298	3.428	0.247	3.363	0.192	2.984	0.141	2.452	0.108	2.067
Max3-Min3	0.216	3.353	0.156	3.429	0.122	2.951	0.082	2.109	0.055	1.488	0.031	0.885
J=18												
Max 1	0.274	1.858	0.256	2.484	0.221	2.581	0.162	2.17	0.108	1.632	0.053	0.89
Max 1-Min1	0.215	2.448	0.178	2.796	0.138	2.443	0.108	2.077	0.063	1.279	0.034	0.749
Max3	0.281	2.214	0.251	2.787	0.202	2.7	0.143	2.193	0.088	1.517	0.056	1.081
Max3-Min3	0.155	2.374	0.114	2.33	0.079	1.809	0.049	1.209	0.01	0.27	-0.01	-0.289

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table 3.4b: Performance of small size portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.29**	2.147	0.203	2.226	0.182	2.206	0.161	2.194	0.095	1.516	0.083	1.361
Max 1-Min1	0.273	3.358	0.215	3.687	0.198	3.62	0.19	3.909	0.136	3.044	0.127	3
Max3	0.287	2.43	0.28	3.499	0.261	3.79	0.25	4.133	0.209	3.889	0.197	3.807
Max3-Min3	0.175	3.039	0.175	4.307	0.162	4.345	0.162	4.733	0.129	4.041	0.124	4.097
J=6												
Max 1	0.188	1.375	0.206	2.228	0.207	2.492	0.163	2.205	0.1	1.582	0.086	1.4
Max 1-Min1	0.219	2.727	0.229	3.98	0.211	3.916	0.187	3.897	0.135	3.061	0.125	2.949
Max3	0.337	2.84	0.335	4.119	0.32	4.63	0.286	4.654	0.236	4.343	0.219	4.205
Max3-Min3	0.22	3.822	0.228	5.555	0.218	5.899	0.192	5.564	0.153	4.669	0.14	4.567
J=9												
Max 1	0.23	1.657	0.188	2.033	0.203	2.436	0.165	2.226	0.099	1.564	0.082	1.36
Max 1-Min1	0.288	3.546	0.245	4.259	0.232	4.295	0.209	4.3	0.147	3.307	0.124	2.897
Max3	0.304	2.573	0.267	3.395	0.261	3.861	0.245	4.094	0.2	3.754	0.191	3.722
Max3-Min3	0.195	3.334	0.18	4.579	0.169	4.623	0.164	4.754	0.126	3.931	0.118	3.87
J=12												
Max 1	**0.324**	2.271	0.249	2.645	0.229	2.744	0.175	2.326	0.104	1.635	0.08	1.314
Max 1-Min1	**0.319**	3.812	**0.279**	4.642	**0.233**	4.197	**0.194**	3.865	**0.133**	2.829	**0.113**	2.564
Max3	0.298	2.385	0.282	3.367	0.266	3.716	**0.223**	3.468	**0.173**	3.062	**0.153**	2.903
Max3-Min3	**0.221**	3.496	**0.21**	4.854	**0.176**	4.612	**0.144**	4.02	**0.098**	2.884	**0.086**	2.713
J=15												
Max 1	0.284	1.976	0.221	2.359	0.209	2.464	0.153	2.015	0.088	1.331	0.062	0.988
Max 1-Min1	**0.276**	3.237	**0.248**	4.229	**0.214**	3.885	**0.183**	3.711	**0.133**	2.855	**0.105**	2.356
Max3	0.308	2.56	0.276	3.415	**0.253**	3.648	**0.227**	3.645	**0.179**	3.248	**0.158**	3.038
Max3-Min3	0.207	3.374	**0.191**	4.581	**0.165**	4.366	**0.145**	4.121	**0.105**	3.116	**0.09**	2.881
J=18												
Max 1	0.254	1.727	0.195	2.003	0.182	2.12	0.138	1.814	0.075	1.122	0.05	0.807
Max 1-Min1	**0.252**	2.893	**0.228**	3.754	**0.195**	3.507	**0.167**	3.329	**0.11**	2.34	**0.077**	1.702
Max3	**0.297**	2.448	**0.265**	3.279	**0.245**	3.508	**0.217**	3.485	**0.174**	3.118	**0.15**	2.901
Max3-Min3	**0.189**	3.118	**0.17**	4.074	**0.156**	4.078	**0.136**	3.835	**0.096**	2.856	**0.077**	2.441

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table 3.4c: Performance of big size portfolios with strategy: Momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.204**	2.159	**0.135**	1.966	**0.141**	2.504	**0.149**	2.968	**0.136**	2.944	**0.14**	3.224
Max 1-Min1	0.135	1.827	0.086	1.631	0.08	1.947	0.068	1.913	0.048	1.472	0.031	1.017
Max3	**0.219**	3.423	**0.154**	3.041	**0.171**	3.995	**0.166**	4.588	**0.15**	4.52	**0.145**	4.63
Max3-Min3	**0.086**	1.973	**0.047**	1.416	**0.057**	2.05	**0.047**	1.954	**0.028**	1.241	**0.019**	0.947
J=6												
Max 1	**0.251**	2.586	**0.219**	3.145	**0.216**	3.774	**0.2**	4.197	**0.172**	3.91	**0.161**	3.895
Max 1-Min1	0.129	1.657	0.115	2.175	0.121	2.777	0.094	2.53	0.056	1.653	0.032	1.014
Max3	**0.235**	3.721	**0.211**	4.326	**0.232**	5.685	**0.211**	6.089	**0.184**	5.568	**0.175**	5.64
Max3-Min3	**0.122**	2.734	**0.096**	3.005	**0.099**	3.654	**0.08**	3.361	**0.047**	2.096	**0.036**	1.722
J=9												
Max 1	0.186	1.947	0.19	2.706	**0.211**	3.717	**0.206**	4.254	**0.169**	3.798	**0.166**	4.011
Max 1-Min1	0.1	1.351	0.106	2.034	0.124	2.899	0.103	2.787	0.063	1.898	0.04	1.277
Max3	**0.245**	3.818	**0.215**	4.2	**0.226**	5.367	**0.204**	5.79	**0.182**	5.426	**0.173**	5.39
Max3-Min3	**0.12**	2.69	**0.091**	2.702	**0.098**	3.489	**0.079**	3.315	**0.046**	2.095	**0.035**	1.689
J=12												
Max 1	**0.362**	3.822	**0.309**	4.432	**0.267**	4.698	**0.239**	4.95	**0.199**	4.594	**0.16**	4.006
Max 1-Min1	0.201	2.716	0.144	2.82	0.124	3.103	0.095	2.646	0.042	1.295	0.006	0.197
Max3	**0.244**	4.185	**0.213**	4.725	**0.2**	5.05	**0.181**	5.236	**0.16**	4.805	**0.145**	4.728
Max3-Min3	**0.123**	2.817	**0.086**	2.712	**0.075**	3.019	**0.051**	2.267	**0.022**	1.059	**0.008**	0.396
J=15												
Max 1	**0.295**	3.052	**0.247**	3.642	**0.234**	4.12	**0.21**	4.324	**0.172**	3.989	**0.159**	4.076
Max 1-Min1	0.15	1.981	0.122	2.423	0.115	2.82	0.09	2.574	0.052	1.645	0.035	1.174
Max3	**0.222**	3.564	**0.191**	3.786	**0.2**	4.587	**0.184**	5.081	**0.161**	4.741	**0.148**	4.695
Max3-Min3	**0.118**	2.673	**0.083**	2.563	**0.079**	2.942	**0.058**	2.513	**0.029**	1.327	**0.014**	0.675
J=18												
Max 1	**0.274**	2.944	**0.201**	3.017	**0.191**	3.455	**0.191**	4.098	**0.156**	3.679	**0.15**	3.861
Max 1-Min1	0.121	1.639	0.092	1.796	0.088	2.134	0.064	1.779	0.031	0.964	0.013	0.437
Max3	**0.248**	4.017	**0.206**	4.141	**0.21**	4.882	**0.193**	5.409	**0.165**	4.908	**0.152**	4.881
Max3-Min3	0.135	3.065	0.091	2.805	0.079	2.857	0.057	2.344	0.024	1.083	0.014	0.668

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table 3.4d: Performance of big size portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.237**	2.454	**0.219**	3.147	**0.208**	3.575	**0.195**	3.664	**0.186**	3.81	**0.189**	4.184
Max 1-Min1	**0.134**	1.879	**0.123**	2.417	**0.112**	2.817	**0.097**	2.743	**0.078**	2.439	**0.059**	1.943
Max3	0.236	3.252	0.207	3.613	0.208	4.229	0.196	4.588	0.186	4.735	0.181	4.975
Max3-Min3	0.097	2.138	0.073	2.137	0.07	2.326	0.055	2.087	0.035	1.434	0.029	1.312
J=6												
Max 1	0.293	2.895	0.264	3.686	0.258	4.353	0.223	4.349	0.205	4.415	0.199	4.593
Max 1-Min1	0.148	1.891	0.142	2.723	**0.138**	3.246	**0.101**	2.736	**0.07**	2.058	**0.052**	1.657
Max3	0.265	3.834	0.221	3.997	0.21	4.412	0.184	4.456	0.163	4.241	0.154	4.226
Max3-Min3	0.116	2.584	0.093	2.879	**0.086**	3.058	**0.06**	2.459	**0.03**	1.321	**0.017**	0.802
J=9												
Max 1	0.19	1.942	0.211	2.941	0.215	3.601	0.192	3.643	0.171	3.589	**0.166**	3.814
Max 1-Min1	0.077	1.049	0.094	1.838	**0.104**	2.438	**0.081**	2.224	**0.055**	1.67	**0.034**	1.103
Max3	0.295	4.043	0.24	4.182	**0.234**	4.708	**0.21**	4.891	**0.193**	4.86	**0.187**	5.001
Max3-Min3	0.131	2.884	**0.092**	2.664	**0.093**	3.092	**0.072**	2.772	**0.045**	1.888	**0.036**	1.606
J=12												
Max 1	0.343	3.527	0.278	3.956	0.265	4.412	0.212	4.065	0.186	3.997	0.167	3.88
Max 1-Min1	0.202	2.787	**0.149**	3.177	**0.138**	3.524	**0.09**	2.573	**0.048**	1.488	**0.02**	0.673
Max3	**0.282**	4.442	0.219	4.34	**0.203**	4.57	**0.181**	4.688	**0.153**	4.245	**0.141**	4.21
Max3-Min3	0.118	2.671	0.064	2.025	**0.058**	2.333	**0.037**	1.603	**0.007**	0.299	**−0.005**	-0.264
J=15												
Max 1	0.297	3.033	0.252	3.609	**0.242**	4.101	0.197	3.752	0.159	3.401	0.154	3.657
Max 1-Min1	0.136	1.863	**0.127**	2.631	**0.118**	2.986	**0.073**	2.097	**0.034**	1.055	**0.02**	0.667
Max3	**0.294**	4.202	**0.239**	4.182	**0.222**	4.435	**0.196**	4.639	**0.173**	4.44	**0.16**	4.414
Max3-Min3	**0.142**	3.126	**0.088**	2.544	**0.079**	2.761	**0.053**	2.111	**0.025**	1.073	**0.015**	0.656
J=18												
Max 1	0.28	2.943	**0.251**	3.694	**0.238**	4.149	**0.205**	4.093	**0.173**	3.868	**0.167**	4.072
Max 1-Min1	**0.137**	1.879	**0.127**	2.549	**0.114**	2.762	**0.069**	1.956	**0.035**	1.072	**0.013**	0.43
Max3	**0.294**	4.308	**0.233**	4.147	**0.223**	4.541	**0.196**	4.759	**0.172**	4.497	**0.157**	4.447
Max3-Min3	**0.134**	3.001	**0.086**	2.571	**0.073**	2.534	**0.049**	1.912	**0.018**	0.742	**0.007**	0.301

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table 3.5a: Performance of low book-to-market portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	-0.052	-0.411	-0.02	-0.24	-0.028	-0.392	-0.026	-0.392	-0.053	-0.957	-0.045	-0.859
Max 1-Min1	0.055	0.624	0.127	2.068	0.116	2.245	0.106	2.29	0.077	1.875	0.076	2.018
Max3	-0.027	-0.275	0.009	0.136	-0.002	-0.032	**−0.001**	-0.026	**−0.02**	-0.503	**−0.024**	-0.629
Max3-Min3	**0.041**	0.72	**0.085**	2.159	**0.075**	2.185	**0.067**	2.22	**0.046**	1.67	**0.044**	1.749
J=6												
Max 1	-0.089	-0.726	-0.029	-0.343	-0.037	-0.506	-0.037	-0.561	-0.05	-0.933	-0.048	-0.929
Max 1-Min1	0.066	0.753	0.153	2.48	0.114	2.196	**0.098**	2.106	**0.072**	1.762	0.072	1.891
Max3	-0.043	-0.428	0.03	0.425	0.012	0.213	-0.009	-0.184	-0.027	-0.644	-0.027	-0.829
Max3-Min3	0.011	0.178	0.089	2.091	0.074	2.004	**0.051**	1.588	0.032	1.079	0.037	1.381
J=9												
Max 1	-0.024	-0.194	0.002	0.026	**−0.022**	-0.301	**−0.046**	-0.737	-0.057	-1.083	-0.048	-0.974
Max 1-Min1	0.098	1.197	0.149	2.405	**0.118**	2.296	**0.085**	1.84	**0.065**	1.558	**0.068**	1.821
Max3	0	0.003	0.027	0.391	**0.007**	0.129	**−0.015**	-0.3	-0.034	-0.843	-0.035	-0.902
Max3-Min3	0.047	0.772	0.098	2.334	**0.075**	2.076	**0.054**	1.714	**0.034**	1.186	**0.038**	1.475
J=12												
Max 1	**0.003**	0.027	**0.014**	0.166	**0.004**	0.056	**−0.027**	-0.433	-0.02	-0.379	-0.003	-0.054
Max 1-Min1	**0.121**	1.497	**0.158**	2.566	**0.118**	2.271	**0.078**	1.682	**0.069**	1.6	**0.081**	2.123
Max3	0.014	0.135	**0.047**	0.675	**0.034**	0.611	**0.001**	0.019	-0.017	-0.437	-0.019	-0.51
Max3-Min3	**0.052**	0.823	**0.101**	2.29	**0.09**	2.482	**0.062**	1.956	**0.046**	1.568	**0.048**	1.85
J=15												
Max 1	**−0.046**	-0.382	-0.02	-0.24	**−0.016**	-0.22	-0.04	-0.66	-0.034	-0.629	-0.024	-0.478
Max 1-Min1	**0.08**	0.994	**0.12**	2.052	**0.102**	1.949	**0.066**	1.419	**0.055**	1.292	**0.067**	1.747
Max3	-0.002	-0.017	**0.039**	0.573	**0.027**	0.477	0.007	0.141	-0.015	-0.359	-0.022	-0.564
Max3-Min3	**0.044**	0.699	**0.097**	2.217	**0.079**	2.159	**0.06**	1.887	**0.04**	1.386	**0.041**	1.555
J=18												
Max 1	**0.044**	0.361	**0.048**	0.58	0.045	0.639	0.012	0.193	0.004	0.081	0.011	0.23
Max 1-Min1	**0.158**	1.953	**0.185**	2.942	**0.16**	3.037	**0.117**	2.491	**0.09**	2.134	**0.094**	2.487
Max3	**0**	-0.003	**0.046**	0.675	**0.052**	0.936	0.024	0.499	0	-0.005	-0.005	-0.12
Max3-Min3	**0.044**	0.708	**0.099**	2.276	**0.096**	2.533	**0.072**	2.242	**0.051**	1.718	**0.053**	1.986

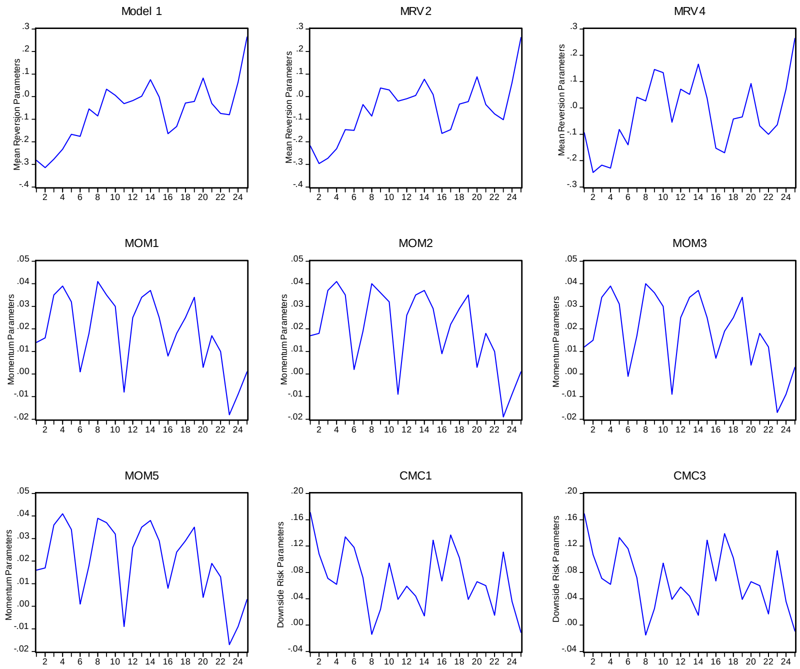
* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table 3.5b: Performance of high book-to-market portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.537**	3.194	**0.354**	2.729	**0.349**	3.072	**0.368**	3.817	**0.382**	4.315	**0.383**	4.765
Max 1-Min1	**0.254**	2.249	**0.14**	1.597	**0.093**	1.365	**0.093**	1.631	**0.092**	1.821	**0.086**	1.886
Max3	**0.547**	3.717	**0.406**	3.849	**0.369**	3.942	**0.366**	4.546	**0.39**	5.285	**0.382**	5.52
Max3-Min3	**0.175**	2.256	**0.085**	1.594	**0.047**	1.061	**0.042**	1.157	**0.059**	1.821	**0.056**	1.892
J=3												
Max 1	**0.558**	3.102	**0.39**	2.959	**0.324**	2.891	**0.332**	3.455	**0.359**	4.174	**0.342**	4.3
Max 1-Min1	**0.24**	2.05	**0.13**	1.594	**0.083**	1.299	**0.085**	1.515	**0.094**	1.888	**0.08**	1.735
Max3	**0.544**	3.697	**0.422**	3.874	**0.354**	3.721	**0.344**	4.209	**0.366**	4.963	**0.363**	5.312
Max3-Min3	**0.2**	2.537	**0.094**	1.673	**0.041**	0.912	**0.032**	0.88	**0.037**	1.116	**0.032**	1.068
J=4												
Max 1	**0.534**	3.059	**0.385**	2.94	**0.332**	2.867	0.354	3.595	**0.394**	4.393	**0.396**	4.755
Max 1-Min1	**0.175**	1.547	**0.101**	1.194	**0.049**	0.739	0.069	1.213	**0.099**	1.972	**0.097**	2.066
Max3	**0.529**	3.574	**0.414**	3.849	0.372	3.94	0.372	4.586	0.391	5.373	0.384	5.595
Max3-Min3	**0.17**	2.162	**0.08**	1.419	**0.046**	1.007	0.047	1.242	0.059	1.758	0.052	1.722
J=5												
Max 1	**0.478**	2.734	**0.355**	2.733	**0.348**	3.048	**0.381**	3.938	**0.424**	4.764	**0.407**	4.889
Max 1-Min1	**0.153**	1.347	0.053	0.62	0.051	0.74	**0.073**	1.263	**0.109**	2.125	**0.098**	2.094
Max3	**0.512**	3.466	**0.395**	3.742	0.366	3.945	0.371	4.618	0.386	5.315	0.382	5.577
Max3-Min3	**0.152**	1.964	**0.069**	1.25	0.04	0.887	0.044	1.132	0.056	1.635	0.051	1.651
J=6												
Max 1	**0.526**	3.153	**0.376**	2.991	**0.351**	3.278	**0.375**	4.031	**0.371**	4.276	0.395	4.884
Max 1-Min1	**0.22**	1.959	0.098	1.135	0.066	1.002	0.076	1.376	0.084	1.706	0.092	2.089
Max3	**0.468**	3.248	**0.387**	3.684	0.371	4.085	0.379	4.718	0.392	5.366	0.409	5.888
Max3-Min3	**0.113**	1.5	0.04	0.712	0.029	0.642	0.048	1.236	0.069	2.023	0.081	2.641
J=7												
Max 1	**0.591**	3.538	**0.394**	3.2	**0.379**	3.501	**0.396**	4.193	**0.405**	4.606	0.409	5.006
Max 1-Min1	**0.206**	1.829	0.071	0.841	0.058	0.884	0.062	1.14	0.084	1.706	0.085	1.961
Max3	**0.498**	3.382	**0.402**	3.753	0.383	4.176	0.386	4.759	0.412	5.556	0.428	6.063
Max3-Min3	**0.15**	1.924	**0.065**	1.136	0.048	1.094	0.058	1.523	0.078	2.291	0.09	2.904

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Figure 3.1 Mean Reversion, Momentum and Downside risk parameter estimates for 25 Fama-French Portfolios



Note: We test the assumption that Mean Reversion, Momentum and Downside risk parameters are same for 25 Fama-French Portfolios

Chapter 4

Further Evidence on Empirical Linkages Between Macroeconomic Factors and Stock Market Returns

4.1 Introduction

In financial economics, the literature exploring empirical linkages between macroeconomic variables and financial markets is rich. One important group of papers from this literature is Lettau and Ludvigson (2001a,b), who study the role of fluctuations in the aggregate consumption-wealth ratio for predicting stock returns. In particular, they explore the impact on cross sectional returns of including the log consumption-wealth ratio as another conditioning variable into the consumption CAPM model, and argue that the ratio helps to explain the difference in returns between low-book-to-market and high-book-to-market portfolios. Another interesting "macroeconomic factor" analysis is that carried out by Bansal, Dittmar and Lundblad (2005), who show that cross-sectional differences in a certain consumption leverage parameter can explain about 50% of the variations in risk premia across 30 portfolios, including 10 momentum, 10 size, and 10 book-to-market sorted portfolios. They argue that their consumption leverage model can justify a large percentage of observed value, momentum, and size risk premium spreads. For an excellent and up to date discussion on these and related papers, the reader is referred to Timmermann (2008), and the references cited in there.

In this paper we re-examine variants of the consumption CAPM model discussed in Lettau and Ludvigson (2001a,b), and the consumption leverage model discussed in Bansal, Dittmar and Lundblad (2005). In particular, we examine the predictive content of a consumption leverage variable discussed in Bansal, Dittmar and Lundblad (2005) and the so-called "cay" variable discused in Lettau and Ludvigson (2001a,b), using the 25 size and book-to-market sorted Fama- French portfolios. Our evaluation focuses on the use of a large variety of state-of-the-art ex-ante predictive accuracy tests as well as more standard in-sample regression diagnostics. We observe substantive shifts in the dynamics of our "macroeconomic factor models", which have noteworthy effects on the predictive content of the factors when used to predict both real returns and excess returns.

The rest of the paper is organized as follows. Section 2 outlines the methodology used in the paper, and Section 3 discusses the data used and presents our empirical results. Concluding remarks are gathered in Section 5. A "not for publication" appendix includes descriptions of the tests used, and additional tabulated results.

4.2 Methodology

Persistence in expected dividend growth rates is an important source of volatility in price-dividend ratios, as documented in Barsky and DeLong (1993) and Bansal and Lundblad (2002). Thus, dividend growth rates may also be expected to be an important determinant for predicting asset returns. Additionally, consumption growth rates are related to expected future asset returns, in consumer budget constraints. Following closely the approach used Bansal, Dittmar and Lundblad (2005), we calculate the covariance between dividend and consumption growth rates. This is our consumption leverage variable. More specifically, we calculate consumption leverage by measuring the exposure of a portfolio's dividend stream to consumption in the time-series, using the following model:

$$g_{i,t} = \varphi_i x_t + \eta_{i,t}, \tag{4.1}$$

where $g_{i,t} = \log D_{i,t} - \log D_{i,t-1}$ is the ex-post dividend growth rate, $D_{i,t}$ is the dividend, φ_i measures the covariance between portfolio dividend and consumption growth rates, x_t, and $\eta_{i,t}$ is an error term. Our consumption leverage measure, φ_i, is hence the regression coefficient (OLS slope coefficient) from this regression. One of our main objectives in this note is to explore how much of the cross-sectional differences observed in expected returns can be explained by this measure. In particular, we investigate the explanatory power of consumption leverage using the 25 size and book-to-market sorted Fama- French portfolios. These assets are well diversified and form the basis of common risk factors used to explain differences in risk premia between other assets (see Fama and French (1993)). Table 4.2 shows that portfolios with high (low) consumption leverage are portfolios with high (low) average returns. In other words, portfolios with high sensitivity to aggregate consumption growth are those that have high average risk premia. This in turn suggests that we can relate consumption leverage innovations to stock return innovations. Our consumption leverage model is thus:

$$r_{t+1} = \alpha + \gamma\varphi_t + \varepsilon_t \tag{4.2}$$

where r_{t+1} is the (excess) return rate, φ_t is the consumption leverage, and ε_t is an error term. In our empirical analysis, when we constructing return forecasts, we also consider the overall performance of the 25 Fama-French portfolios with respect to consumption leverage. We adjust the 25 Fama-French portfolios by their market capitalization.

$$weight_{i,t} = size_{i,t} / \sum_{j=1}^{25} size_{i,t}, \quad g_t = \sum_{j=1}^{25} weight_{i,t} g_{i,t}$$

Thus, we calculate the overall dividend growth rate for value-weighted 25 Fama-French portfolio by using individual dividend growth rates and weights calculated using the above formula. To get the consumption leverage for overall portfolios we run the regression given as equation (4.1).

Now, note also that Lettau and Ludvigson (2001a) state that the cointegration residuals among log consumption, log asset wealth and log current labor income variables helps to predict U.S. quarterly stock market returns and the cross-section of average returns. They construct their so-called cay_t series from log consumption, log asset wealth and log current labor income and consider the following model (see details in Lettau and Ludvigson (2001a,b):

$$r_{t+1} = \alpha + \beta cay_t + \epsilon_t, \tag{4.3}$$

where r_{t+1} is the (excess) return rate and ϵ_t is an error term. We construct cay_t in the same manner as Lettau and Ludvigson.

In addition to examining the predictive content of various variants of the above two models both with and without lag dynamics, we also add consumption leverage to equation (4.3). Thus, we also consider variants of the following model:

$$r_{t+1} = \gamma + \delta cay_t + \gamma\varphi_t + \xi_t \tag{4.4}$$

where ξ_t is an error term. This model is an alternative linear factor model to the (C)CAPM examined in Lettau and Ludvigson (2001b) and the factor model in Bansal, Dittmar and

Lundblad (2005), and is likewise used to explain the cross-section of expected returns from the Fama and French size and book-to-market portfolios.

4.3 Empirical Results

4.3.1 Data

Our data on returns consists of 25 U.S. stock portfolios formed according to the same criteria as those used in Fama and French (1992,1993). These data are value-weighted returns for the intersections of five size portfolios and five book-to-market equity (B/M) portfolios on the New York Stock Exchange, the American Stock Exchange, and the NASDAQ. The portfolios are constructed at the end of June, and market equity is market capitalization at the end of June. The ratio B/M is book equity at the last fiscal year end of the prior calendar year, divided by market equity at the end of December of the prior year. This procedure is repeated for every calendar year from July 1963 to December 2004. We convert the discrete stock returns into continuous return rates, producing a time series spanning the third quarter of 1963 to the fourth quarter of 2004. Thus, we have 498 observations for each of the 25 portfolios. Table 4.2 reports summary statistics for the 25 size and book-to-market portfolios. The average monthly returns for the industry portfolios range from 0.71% to 1.66% resulting in an annualized spread of 11.4%. The large number of firms in the industries indicates that these portfolios are well diversified. An F-test of whether the mean returns differ across industries is not rejected, suggesting that there is cross-sectional variation in the industry sample means. We take value weighted CRSP Index as our proxy for the market portfolio.

4.3.2 In-sample regression results

The summary statistics provided in Table 4.2 illustrate that portfolios with high (low) consumption leverage, φ_t, are portfolios with high (low) average returns. That is, portfolios with high sensitivity to aggregate consumption growth are those that have high average risk premia. It also worth noting that capitalization-sorted portfolios also demonstrate this pattern with respect to consumption leverage, with the estimated leverage coefficients on small firms exceeding those associated with large firms. Given the fact that low book-to-market portfolios generally have larger leverage coefficients than high book-to-market portfolios, we see that dividend growth rates of low book-to-market portfolios have a closer relationship with the smoothed consumption growth rate.

Panels A and B of Table 4.3 provide an initial snapshot of the real and excess return forecasting performance implied by our macroeconomic factor regression models. All models are linear, and explanatory variables include one lag of the dependent variable, *cay* and consumption leverage. Panel C includes results from fitting random walk models to our return variables. The third row of Panel A shows that the forecasting power of a regression of returns on "own" lags and on the lag of $\widehat{cay}$ is very good. This model predicts 6.1% of next quarter's variation in real returns. For the 25 size and book-to-market sorted portfolios adjusted returns, regressions of real returns on own lags, the lag of $\widehat{cay}$, and consumption leverage produce only a slightly better result (the adjusted R^2 is 0.076). If we regress real returns on own lags and on one lag of consumption leverage, the adjusted R^2 is 0.011, as expected given the previous result. By contrast, regressions of real returns on only the lag of consumption leverage yield negligible the adjusted R^2 values (as shown in Panel C of the table 4.3). These results are little affected when lagged real returns are included. When we run regressions on excess returns, model fit is not as good as those discussed above, although the qualitative findings are the same. To further test the significance level of consumption leverage, we regress CRSP returns on above models. Results are provided in Panels D and E of Table 4.3, and it is seen that consumption leverage is only marginally significant in the returns regressions, resulting only in very small increases to adjusted R^2 values.

4.3.3 Parameter evolution

In order to examine the robustness of the findings reported above, and as justification for our use of the ex-ante prediction methods reported on in the sequel, we plot recursive and rolling estimates of parameters from the various regression models, where "rolling" estimates are based upon regressions constructed using windows of 10 years of data. Our initial in-sample estimation period is 1964:1-1983:4, and the prediction period considered spans the rest of our sample, namely 1984:1-2004:4. Figure 4.1 plots the sequences of estimated coefficients from our regression models. All graphs demonstrate that the coefficients for *cay* change significantly over time. Based on examination of these figures, we experimented with different sub-samples, and we found two sub-samples that illustrate clearly that parameter estimates can radically change over time. In particular, we split the whole sample (1963:3-2004:4) into two subsamples: 1963:3-1975:4 and 1978:1- 2004:4. Two years of data from

1976-1978 were omitted because there was pretty clearly an inflection point in the evolution of parameter estimates over this period. Table 4.4 summarizes results based upon evaluation of these subsamples. Consider the subsample from 1963:3-1975:4, as compared with results from our whole sample regressions. First, the values of *lag* and consumption leverage increase dramatically and become statistically significant at standard significance levels. Second, the R^2 value is abnormally high in the sub-sample, especially for the cay models, for which values are over 0.20 (while Lettau and Ludvigson (2001a,b) find R^2 values of around 0.080-0.090). Finally, the coefficient estimate associated with the *cay* variable is around 4, which is much larger than that for our second subsample from 1978:1- 2004:4.

Now, consider the subsample from 1978:1- 2004:4, when compared with results from our whole sample regressions. Note first that the *lag* of returns and the consumption leverage parameters change signs. Also, there are dramatic changes in the magnitudes of the estimated parameters. Moreover, adjusted R^2 values decrease to half of values obtained using the whole sample. Given the above results pointing to the clear change in importance of the *cay* variable in different subsamples, we also carried out a likelihood ratio test for single structural break and multiple structural breaks (Bai, 1999). Figure 2 plots the p-values associated with the likelihood ratio test for single structural break. Interestingly, the test does not reject the null hypothesis that there is no break point in the estimated coefficient for *cay* using a 5% significant level, although the null is rejected at a 15% significant level at multiple different time periods. Moreover a multiple break-point version of the same test (Bai, 1999) does reject the null of no structural change in the parameter. Thus, in summary, we have rather strong evidence that the predictive performance of the *cay* variable might be expected to differ over time..

4.3.4 Ex-ante test results

In order to further assess the stability and usefulness of our regression models, we carried out a number of ex-ante predictive accuracy tests. The tests were constructed using predictions and prediction errors constructed recursively using the estimation procedures discussed above. All tests were designed to allow us to “select” between the following two models:

$$r_t = \alpha + \beta r_{t-1} + \delta cay_{t-1}$$

$$r_t = \alpha + \beta r_{t-1} + \delta cay_{t-1} + \gamma \varphi_{t-1}$$

The null hypothesis is that of equal predictive accuracy, while the alternative is that the "bigger" model that includes our consumption leverage variable yields true ex-ante predictions that are statistically superior to those from the "smaller" model. In this sense, test rejections imply that consumption leverage has marginal predictive content for returns. These prediction based tests are quite different from the usual in-sample regression analysis done to evaluate such models, and hence the results might differ from those reported in the previous subsections. The particular tests that we implement are summarized in the following chart.

Table 4.1: Predictive Accuracy Test Statistics

F – The standard Wald version of the in-sample F-test is calculated using the entire sample of T observations. In particular, we use: $F = T\left(\sum_{t=1}^{T}\widehat{u}_{1,t}^2 - \sum_{t=1}^{T}\widehat{u}_{2,t}^2)/\sum_{t=1}^{T}\widehat{u}_{2,t}^2\right)$, where $\widehat{u}_{1,t}$ and $\widehat{u}_{2,t}$ are the in-sample residuals associated with least squares estimation of the smaller and bigger models, respectively, and where T denotes the sample size.

CM – The Clark and McCracken (2004) test is an out-of-sample encompassing test (see also Harvey, Leybourne and Newbold (1997), and is defined as follows: $CM = (P-h+1)^{1/2}\frac{\frac{1}{P-h+1}\sum_{t=R}^{T-h}\widehat{c}_{t+h}}{\frac{1}{P-h+1}\sum_{j=-\overline{j}}^{\overline{j}}\sum_{t=R+j}^{T-h}K\left(\frac{j}{M}\right)(\widehat{c}_{t+h}-\overline{c})(\widehat{c}_{t+h-j}-\overline{c})}$, where $\widehat{c}_{t+h} = \widehat{u}_{1,t+h}\left(\widehat{u}_{1,t+h} - \widehat{u}_{2,t+h}\right)$, $\overline{c} = \frac{1}{P-h+1}\sum_{t=R}^{T-\tau}\widehat{c}_{t+h}$, $K(\cdot)$ is a kernel (such as the Bartlett kernel), and $0 \le K\left(\frac{j}{M}\right) \le 1$, with $K(0) = 1$, and $M = o(P^{1/2})$. Additionally, h is the forecast horizon, P is the out-of-sample prediction period, and $\widehat{u}_{1,t+1}$ and $\widehat{u}_{2,t+1}$ are the out-of-sample residuals associated with least squares estimation of the smaller and bigger models, respectively. Note finally, that $\overline{j}$ does not grow with the sample size.

DM – The mean square error version of the Diebold and Mariano (1995) test is a predictive accuracy test, and is defined as follows: $DM = \sqrt{P}\frac{\frac{1}{P}\sum_{t=R}^{T}\widehat{d}_{t+h}}{\frac{1}{P-h+1}\sum_{j=-\overline{j}}^{\overline{j}}\sum_{t=R+j}^{T-h}K\left(\frac{j}{M}\right)(\widehat{d}_{t+h}-\overline{d})(\widehat{d}_{t+h-j}-\overline{d})}$, where $\widehat{d}_{t+h} = \widehat{\epsilon}_{t+h}^2 - \widehat{u}_{t+h}^2$, and $\overline{d} = \frac{1}{P-h+1}\sum_{t=R}^{T-\tau}\widehat{d}_{t+h}$.

CS – The so-called Corradi and Swanson (2002,2005) test is a generically comprehensive out-of-sample encompassing test, and is defined as follows: $M_P = \int_\Gamma |m_P(\gamma)|\phi(\gamma)d\gamma$, where $m_P(\gamma) = \frac{1}{\sqrt{P}}\sum_{t=R}^{T-1}g'(\widehat{u}_{1,t+1})w(Z^t,\gamma)$, and where $\int_\Gamma \phi(\gamma)d\gamma = 1$, $\phi(\gamma) \ge 0$, with $\phi(\gamma)$ absolutely continuous with respect to Lebesgue measure, Γ is a compact subset of $\Re^d$, for some finite d, and g' is the derivative of the loss function used for predictive evaluation, with respect to its argument. Additionally, $w(Z^t,\gamma)$ is a generically comprehensive function as discussed above and in Corradi and Swanson (2002), and Z^t is a vector of variables of interest.

CCS – The so-called Chao, Corradi and Swanson (2001) test is a simplified version of CS which is not designed to have power against generic nonlinear alternatives, and is defined as follows: $CCS = \frac{1}{\sqrt{P}}\sum_{t=R}^{T-1}\widehat{u}_{1,t+1}Z^t$.

Evidence from our predictive accuracy tests, reported in Table 4.5, quite clearly points to an almost universal failure to reject the null hypothesis of equal predictive accuracy.

Given that at least one of the tests (i.e. the CS test) is robust to generic nonlinearity, we have evidence that there is no (non)linear ex-ante Granger causality from consumption leverage to returns. Put differently, consumption leverage appears to have little marginal predictive power for stock returns.

4.3.5 Ex-ante prediction results

The tests discussed above suggest that including consumption leverage as an extra explanatory factor does not help in prediction. In order to shed more light onto this finding, we also report results from various prediction experiments. For this set of experiments, our initial in-sample estimation period is 1964:1-1973:4, and various prediction periods beginning in 1974:1 are reported (we report only on a select set of prediction periods - a full set of tabulated results are available upon request from the authors). Results are gathered in Table 4.6, in which mean square forecast errors (MSFEs) are tabulated. All results are based on the construction of 1-step ahead predictions. The minimum MSFEs are emphasized in bold font. A number of conclusions emerge, upon examination of the tabulated results. First, note that the model with one lag of returns and *cay* (model 13 of Table 4.6) yields lower MSFEs for all prediction periods from 1974 - 1984. However, for subsequent prediction periods, the model with only *cay* (model 14 of Table 4.6) yields lower MSFEs, and this holds for most of the remaining predictive periods through the end of our sample. This feature may due to the structural break of coefficient of *cay* in the sample. Neverthless, we have yet further evidence that the *cay* variable is quite useful, in a predictive context. Second, predicted returns via models with only *cay* in them become more accurate over time, as evidenced by the fact that MSFEs are much bigger for early subsamples. This finding is consistent with the notion that returns in general are becoming more predictible, or that *cay* is becoming a more “potent" predictor. In either case, we again have evidence as to the dominance of the *cay* variable for predicting returns. Finally, there is clearly very little evidence of predictive content for our consumption leverage variable, as documented by the fact that all models including consumption leverage have much higher MSFEs than the models without consumption leverage. Note also that our findings are qualitatively the same, regardless of whether real or excess returns are predicted, and regardless of whether recursive or rolling estimation methods are used in the construction of our prediction models.

4.4 Concluding remarks

In this paper, we compare the forecasting performance of a snumber of macroeconomic factor models, including the "*cay*" model discussed in Lettau and Ludvigson (2001a, 2001b) and the consumption leverage model discussed in Bansal, Dittmar and Lundblad (2005). We find little evidence of consumption leverage effects when constructing in-sample and out-of-sample tests and prediction experiments, and strong evidence as to the importance of the *cay* variable. We also find substantive evidence of structural breaks in the evolution of coefficients in models that include the *cay* variable, although this does not seem to adversely impact on our strong findings concerning the predictive content of this variable for real and excess stock returns.

Table 4.2: Cross- section evidence: 25 Fama - French portfolios

size	B/M	returns		Dividend growth rate		consumption leverage
		mean	stand deviation	mean	stand deviation	
Small	Low	2.527	16.839	-0.221	17.184	-1.303
	2	2.498	14.264	3.765	14.167	5.934
	3	4.138	12.522	3.742	12.447	5.080
	4	4.284	11.922	4.253	11.841	4.570
	High	4.924	12.989	4.762	12.918	5.591
2	Low	5.265	14.873	2.623	14.770	6.295
	2	2.857	12.451	3.088	12.337	4.937
	3	3.597	10.942	3.664	10.854	5.025
	4	4.365	10.698	3.651	10.579	4.347
	High	4.507	11.532	4.016	11.434	5.103
3	Low	4.772	13.500	2.555	13.396	6.150
	2	2.869	10.966	3.164	10.865	5.116
	3	3.746	9.775	2.902	9.683	4.584
	4	3.749	9.760	3.169	9.658	4.578
	High	4.171	10.796	3.755	10.709	4.629
4	Low	4.687	12.121	2.754	12.050	4.974
	2	3.153	10.095	2.367	10.017	3.774
	3	3.042	9.213	2.839	9.120	4.189
	4	3.703	9.226	3.022	9.128	4.592
	High	4.101	10.373	3.201	10.248	3.661
Big	Low	4.242	9.323	2.196	9.246	5.150
	2	2.776	8.413	2.038	8.361	2.901
	3	2.898	7.484	1.894	7.420	2.234
	4	2.945	7.565	1.960	7.492	2.987
	High	3.164	8.578	1.989	8.441	2.999

* Notes:Table 4.2 presents descriptive statistics (in percentages) for the 25 characteristic sorted quintile portfolios. Value- weighted returns and log dividend growth rates are presented for portfolios formed on market capitalization (Size), and book-to-market ratio (B/M). The data are sampled at the quarterly frequency, and cover the 3rd quarter 1963 through 4th quarter 2004.

Table 4.3: Regression analysis for the period 1963-2004

NO	Model	Dependent Variable	Constant	Lag(t-stat)	$\widehat{cay}_t$(t-stat)	$C_{leverage}$ (t-stat)	R^2
		Panel A: Returns on *cay* and Consumption leverage, 1963:3-2004:4 (quarterly)					
1	FFRCL	r_t^{vw}	0.030(4.956)		1.440(3.380)	5.74E-05(1.62)	0.076
2	FFRLCL	r_t^{vw}	0.029(4.457)	0.028(0.377)	1.448(3.400)	5.84E-05(1.64)	0.077
3	FFRC	r_t^{vw}	0.032(5.285)		1.381(3.226)		0.061
4	FFRL	r_t^{vw}	0.030(4.795)			4.71E-05(1.29)	0.011
		Panel B: Excess returns on *cay* and Consumption leverage, 1963:3-2004:4 (quarterly)					
5	FFERCL	$r_t^{vw} - r_t^f$	0.015(2.258)		1.453(3.375)	5.41E-05(1.51)	0.074
6	FFERLCL	$r_t^{vw} - r_t^f$	0.014(1.992)	0.034(0.472)	1.463(3.391)	5.54E-05(1.54)	0.075
7	FFERC	$r_t^{vw} - r_t^f$	0.016(2.581)		1.398(3.26)		0.061
8	FFERL	$r_t^{vw} - r_t^f$	0.015(2.278)			4.37E-05(1.19)	0.009
		Panel C: Random walk, 1963:3-2004:4 (quarterly)					
9	RW	r_t^w		0.134(1.72)			-0.111
10	ERW	$r_t^w - r_t^f$		0.053(0.673)			-0.024
		Panel D: CRSP real returns 1963:3-2004:4 (quarterly)					
11	RLCL	r_t^w	0.027(4.23)	0.048(0.628)	1.486(3.648)	-6.93E-05(-1.48)	0.076
12	RCL	r_t^w	0.029(4.754)		1.470(3.421)	-6.45E-05(-1.39)	0.073
13	RLC	r_t^w	0.029(4.424)	0.030(0.388)	1.423(3.291)		0063
14	RC	r_t^w	0.029(4.825)		1.400(3.271)		0.062
15	RL	r_t^w	0.029(4.575)			-4.56E-05(-0.96)	0.006
		Panel E: CRSP excess returns 1963:3-2004:4 (quarterly)					
16	ERLCL	$r_t^w - r_t^f$	0.012(1.972)	0.055(0.072	1.502(3.468)	-6.80E-05(-1.44)	0.075
17	ERCL	$r_t^w - r_t^f$	0.013(2.126)		1.484(3.541)	-6.24E-05(-1.34)	0.072
18	ERLC	$r_t^w - r_t^f$	0.013(2.108)	003704850	1.423(3.297)		0063
19	ERC	$r_t^w - r_t^f$	0.014(2.212)		1.415(3.271)		0.062
20	ERL	$r_t^w - r_t^f$	0.013(2.046)			-4.33E-05(-0.90)	0.005

* Notes: This table reports estimates from OLS regressions of stock returns on lagged variables named at the head of a colum. All returns use the value-weighted 25 Fama-French returns. The repressors are as follows: r_t is the return rate, r^w is the CRSP value weighted return. r^{vw} is the value weighted 25 Fame - French portfolio return, which are formed on market capitalization (Size). r^f is the 3-month T-bill return. "lag" denotes a one-period lag of the independent variables; cay_t is taken from Sidney Ludvigson's homepage; $C_{leverage}$ is the consumption leverage. The critical value for 1% significant level is 2.58; The critical value for 5% significant level is 1.96; The critical value for 10% significant level is 1.64. Regressions use data from third quarter of 1963 to forth quarter of 2004.

Table 4.4: Regression analysis for two sub-samples

NO	Model	Dependent Variable	Constant	Lag(t-stat)	$\widehat{cay}_t$(t-stat)	$C_{leverage}$ (t-stat)	R^2
Panel A: Whole sample 1963:3-2004:4 (quarterly)							
CRSP real returns							
11	RLCL	r_t^w	0.027(4.23)	0.048(0.628)	1.486(3.648)	-6.93E-05(-1.48)	0.076
12	RCL	r_t^w	0.029(4.754)		1.470(3.421)	-6.45E-05(-1.39)	0.073
13	RLC	r_t^w	0.029(4.424)	0.030(0.388)	1.423(3.291)		0063
14	RC	r_t^w	0.029(4.825)		1.400(3.271)		0.062
15	RL	r_t^w	0.029(4.575)			-4.56E-05(-0.96)	0.006
CRSP excess returns							
16	ERLCL	$r_t^w - r_t^f$	0.012(1.972)	0.055(0.072	1.502(3.468)	-6.80E-05(-1.44)	0.075
17	ERCL	$r_t^w - r_t^f$	0.013(2.126)		1.484(3.541)	-6.24E-05(-1.34)	0.072
18	ERLC	$r_t^w - r_t^f$	0.013(2.108)	003704850	1.423(3.297)		0063
19	ERC	$r_t^w - r_t^f$	0.014(2.212)		1.415(3.271)		0.062
20	ERL	$r_t^w - r_t^f$	0.013(2.046)			-4.33E-05(-0.90)	0.005
Panel B: First subsample 1963:3-1975:4 (quarterly)							
CRSP real returns							
11	RLCL	r_t^w	0.043(3.04)	0.191(1.47)	4.01(3.63)	-1.12E-04(-2.08))	0.256
12	RCL	r_t^w	0.045(3.12)		3.85(3.43)	-1.00E-04(-1.84)	0.223
13	RLC	r_t^w	0.045(3.03)	0.148(1.11)	3.66(3.22)		0.189
14	RC	r_t^w	0.046(3.13)		3.57(3.10)		0.168
15	RL	r_t^w	0.017(1.26)			-0.74E-04(-1.24)	0.032
CRSP excess returns							
16	ERLCL	$r_t^w - r_t^f$	0.032(2.24)	0.21(1.64)	4.11(3.68)	-1.12E-04(-2.05))	0.262
17	ERCL	$r_t^w - r_t^f$	0.032(2.17)		3.94(3.45)	0.97E-04(-1.77)	0.221
18	ERLC	$r_t^w - r_t^f$	0.034(2.27)	0.168(1.26)	3.76(3.27)		0.197
19	ERC	$r_t^w - r_t^f$	0.033(2.21)		3.66(3.14)		0.170
20	ERL	$r_t^w - r_t^f$	0.003(0.20)			0.70E-04(-1.15)	0.027
Panel C: Second subsample 1978:1-2004:4 (quarterly)							
CRSP real returns							
11	RLCL	r_t^w	0.034(4.04)	-0.044(0.44)	0.91(1.83)	2.82E-05(0.26)	0.037
12	RCL	r_t^w	0.032(4.24)		0.92(1.87)	-1.84E-05(-0.17)	0.035
13	RLC	r_t^w	0.033(4.03)	-0.038(-0.39)	0.92(1.86)		0.037
14	RC	r_t^w	0.032(4.25)		0.93(1.89)		0.035
15	RL	r_t^w	0.035(4.60)			3.05E-05(0.28)	0.003
CRSP excess returns							
16	ERLCL	$r_t^w - r_t^f$	0.016(2.04)	-0.04(-0.41)	0.95(1.90)	3.1E-05(0.28)	0.038
17	ERCL	$r_t^w - r_t^f$	0.015(2.10)		0.96(1.94)	2.16E-05(0.20)	0.036
18	ERLC	$r_t^w - r_t^f$	0.016(2.08)	-0.035(-0.36)	0.96(1.92)		0.037
19	ERC	$r_t^w - r_t^f$	0.015(2.01)		0.97(1.95)		0.036
20	ERL	$r_t^w - r_t^f$	0.018(2.36)			3.42E-05(0.31)	0.001

* See notes to Table 4.3.

Table 4.5: Tests for the marginal predictive content of consumption leverage

Bootstrap Method	Block Length l	Test Statistics	Prediction Period Begins 1984: 1 5%	Prediction Period Begins 1984: 1 10%	Prediction Period Begins 1990: 1 5%	Prediction Period Begins 1990: 1 10%
			Panel A: CS and CCS test			
Recur Block Bootsrap	2	CS Test	No Reject	Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	Reject
	10		No Reject	No Reject	No Reject	Reject
BB, no PEE, no adj	2	CS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Block Bootstrap	2	CS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Recur Block Bootsrap	2	CCS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
			Panel B: F test, DM test and CM test, assume $\pi = 0$			
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	No Reject	No Reject	No Reject	No Reject
			Panel C: F test, DM test and CM test, assume $\pi > 0$			
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	No Reject	No Reject	No Reject	No Reject

* Notes: All entries are rejection of the null hypothesis of equal predictive accuracy based on 5% and 10% nominal size critical values constructed using the bootstrap approaches discussed above, where l denotes the block length, and empirical bootstrap distributions are constructed using 100 bootstrap statistics. In particular, "Recur Block Bootstrap" is the bootstrap developed in CS(2005) , "BB, no PEE, no adj" is a naive block bootstrap where no parameter estimation error is assumed, and no recentering (i.e. adjustment) is done in parameter estimation or bootstrap statistic construction, and "Standard Block Bootstrap" is the usual block bootstrap that allows for parameter estimation error, but does not recenter parameter estimates or bootstrap statistics. In all experiments, the ex ante forecast period is of length P, which is set equal to $(1/2)T$, where T is the sample size. All models are estimated recursively, so that parameter estimates are updated before each new prediction is constructed. "Reject" means that we reject the null hypothesis of equal predictive accuracy of the two models; "No Reject" means that we don't reject the null hypothesis of equal predictive accuracy of the two models; See Table 1 and Section 4 for further details. small model includes constant, lag and Cay; big model includes constant, lag, Cay and consumption leverage.

Table 4.6: Recursive mean square forecast errors of macro factor models

Panel A: Real returns						
Begin Year	Model 9	Model 11	Model 12	Model 13	Model 14	Model 15
	RW	RLCL	RCL	RLC	RC	RL
1975	0.0062	**0.0061**	0.0062	**0.0061**	0.0065	0.0075
1978	0.0062	0.0061	0.0061	**0.006**	0.0061	0.007
1981	0.0063	**0.0061**	0.0062	**0.0061**	**0.0061**	0.0071
1984	0.0061	0.006	0.0061	**0.0059**	0.006	0.0071
1987	0.0064	0.0062	0.0063	0.0062	**0.006**	0.0071
1990	0.0059	0.0057	0.0058	0.0057	**0.0053**	0.0063
1993	0.0056	0.0055	0.0056	0.0055	**0.0054**	0.0065

Panel B: Excess returns						
Begin Year	Model 10	Model 16	Model 17	Model 18	Model 19	Model 20
	ERW	ERLCL	ERCL	ERLC	ERC	ERL
1975	0.0063	**0.0062**	0.0063	**0.0062**	0.0066	0.0068
1978	0.0063	**0.0061**	0.0062	**0.0061**	0.0062	0.0064
1981	0.0064	0.0063	0.0063	**0.0062**	0.0063	0.0065
1984	0.0061	**0.0059**	0.0061	**0.0059**	0.006	0.0064
1987	0.0064	0.0062	0.0063	0.0061	**0.006**	0.0065
1990	0.0058	0.0056	0.0058	0.0056	**0.0053**	0.0058
1993	0.0056	0.0054	0.0056	0.0055	**0.0054**	0.0059

Panel C: Real returns						
Begin Year	Model 9	Model 11	Model 12	Model 13	Model 14	Model 15
	RW	RLCL	RCL	RLC	RC	RL
1975	0.0066	0.0063	0.0063	**0.0061**	0.0064	0.0075
1978	0.0057	0.0055	0.0054	**0.0053**	0.0054	0.0062
1981	0.0053	**0.0051**	0.0053	0.0052	**0.0051**	0.0061
1984	0.0064	**0.0062**	0.0064	**0.0062**	0.0063	0.0075
1987	0.0079	**0.0076**	0.0079	**0.0076**	0.0079	0.0086
1990	0.0084	**0.0076**	0.0084	0.0078	0.0084	0.008
1993	0.0036	0.0035	0.0037	0.0037	**0.0030**	0.0053

Panel B: Excess returns						
Begin Year	Model 10	Model 16	Model 17	Model 18	Model 19	Model 20
	ERW	ERLCL	ERCL	ERLC	ERC	ERL
1975	0.0066	0.0063	0.0062	**0.0060**	0.0064	0.0067
1978	0.0057	0.0054	0.0054	**0.0052**	0.0054	0.0055
1981	0.0052	**0.0050**	0.0052	0.0051	0.0051	0.0055
1984	0.0064	**0.0061**	0.0063	0.0062	0.0063	0.0068
1987	0.0079	**0.0076**	0.0078	**0.0076**	0.0078	0.0079
1990	0.0083	**0.0075**	0.0082	0.0077	0.0083	0.0079
1993	0.0042	0.0041	0.0043	0.0042	**0.0034**	0.0053

* Notes: All entries are MSFE based on rolling estimate for macro-factor based models (See Table 3 for further details). In reporting MSFEs, results are given for all perids beginning with 1974:1, 1975:1, ..., 1994:1. The length for the rolling estimate is 10 years. In each period, 1-step ahead predictions are constructed throughout the rest of each sub-sample, ending in 2004:4. Bold entries are the minimum MSFE in the same estimating period.

Figure 4.1: Recursive and rolling estimate of Cay

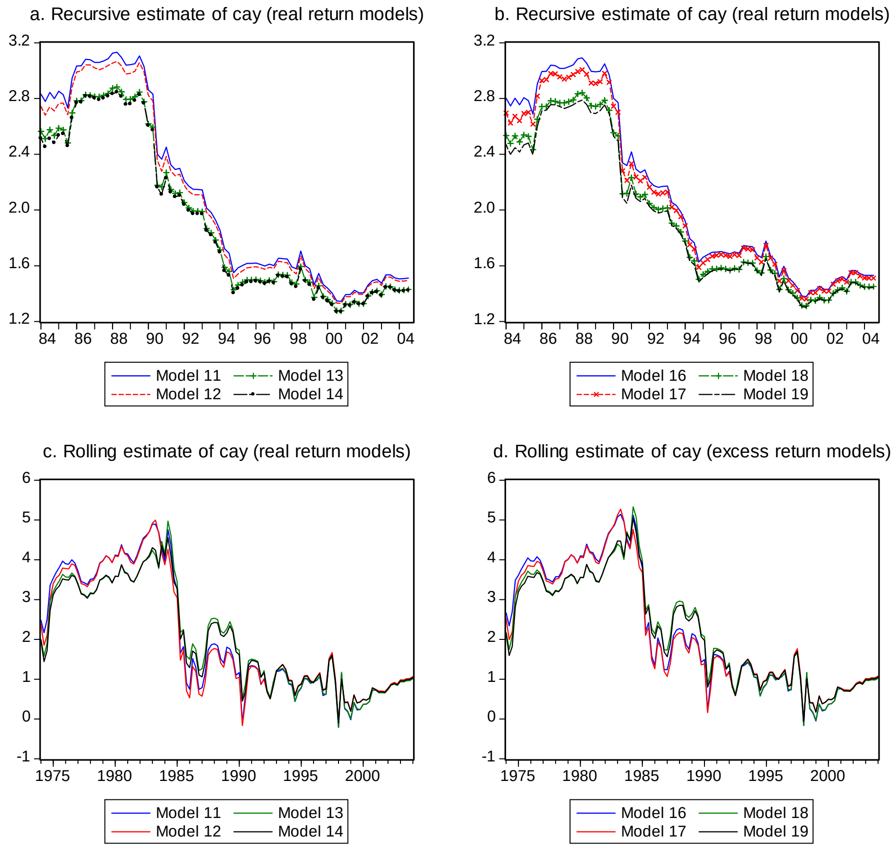
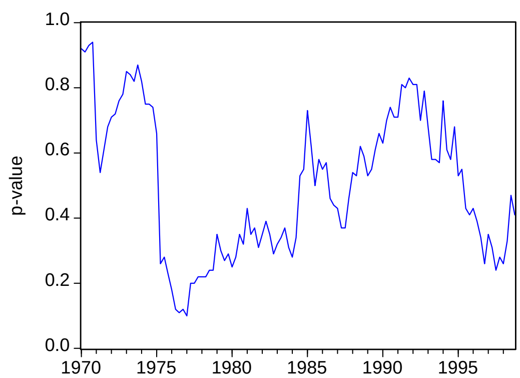


Figure 4.2: Likelihood ratio tests for single structural break for cay



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Appendix

The CS test and recursive block bootstrap

Corradi and Swanson (2002) introduce a test draw on both the consistent specification and predictive ability testing literatures in order to propose a test for predictive accuracy which is consistent against generic nonlinear alternatives, which is designed for comparing nested models, and which allows for dynamic misspecification of all models being evaluated. The objective of the approach is to test whether there exists any unknown alternative model that has better predictive accuracy than a given benchmark model, for a given loss function. The main difference between the CS test and other tests, like discussed in Clark and McCracken (2001,2004), Giacomini and White(2003) is that the CS test is consistent against generic (non)linear alternatives and not only against a fixed alternative.

Corradi and Swanson (2002) start with a simple example in which the benchmark model is an autoregressive model and we want to check whether a more accurate forecasting model can be constructed by including possibly unknown (non)linear functions of the past of the process. In fact, the benchmark model can be any (non)linear model. One important feature of this application is that the same loss function is used for in-sample estimation and out-of-sample prediction.

Define the benchmark model as:

$$y_t = \theta^{\dagger}_{1,1} + \theta^{\dagger}_{1,2} y_{t-1} + u_{1,t}, \tag{A1}$$

where $\theta^{\dagger}_1 = (\theta^{\dagger}_{1,1}, \theta^{\dagger}_{1,2})' = \arg\min_{\theta_1 \in \Theta_1} E(q_1(y_t - \theta_{1,1} - \theta_{1,2} y_{t-1}))$, y_t is a scalar.

We further define the generic alternative model as:

$$y_t = \theta^{\dagger}_{2,1}(\gamma) + \theta^{\dagger}_{2,2}(\gamma) y_{t-1} + \theta^{\dagger}_{2,3}(\gamma) w(Z^{t-1}, \gamma) + u_{2,t}(\gamma), \tag{A2}$$

where $\theta^{\dagger}_2(\gamma) = (\theta^{\dagger}_{2,1}(\gamma), \theta^{\dagger}_{2,2}(\gamma), \theta^{\dagger}_{2,3}(\gamma))' = \arg\min_{\theta_2 \in \Theta_2} E(q_1(y_t - \theta_{2,1} - \theta_{2,2} y_{t-1} - \theta_{2,3} w(Z^{t-1}, \gamma)))$ and $\gamma \in \Gamma$, Γ is a compact subset of R^d, for some finite of d. The presence of $w(Z^{t-1}, \gamma)$

is generically comprehensive function, like Bierens's exponential, a logistic, or a cumulative distribution function.

Further define

$$w(z^{t-1},\gamma) = \exp(\sum_{i=1}^{2}(\gamma_i \tan^{-1}((z_{i,t-1} - \overline{z}_i)/2\widehat{\sigma}_{z_i}))) \tag{A3}$$

with

$$\begin{aligned} z_{1,t-1} &= x_{t-1} \\ z_{2,t-1} &= y_{t-1} \end{aligned}$$

and γ_1, γ_2 scalars.

The hypotheses of interest are:

$H_0 : E(g(u_{1,t+1}) - g(u_{2,t+1}(\gamma))) = 0$ versus $H_A : E(g(u_{1,t+1}) - g(u_{2,t+1}(\gamma))) > 0$

where $g(.)$ is the loss function. H_0 means equal predictive accuracy, while H_A corresponds to the case where the alternative model outperforms the reference model. In fact, the benchmark model is nested within the alternative model, the null model can never outperform the alternative.

Given the definition of $\theta_2^{\dagger}(\gamma)$ and define $g\prime$ as the derivative of the loss function with respect to its argument. Thus, we can restate $H_0$and H_A as:

$$H_0 : E(g\prime(u_{1,t+1})w(Z^{t-1},\gamma)) = 0 \; versus \; H_A : E(g\prime(u_{1,t+1})w(Z^{t-1},\gamma)) \neq 0 \tag{A4}$$

for $\forall\gamma \in \Gamma$, except for a subset with zero Lebesque meansure. Finally, define the forecast error as $\widehat{u}_{1,t+1} = y_{t+1} - (1 \;\; y_t)\widehat{\theta}_{1,t}$. Following CS (2002), the test statistics is:

$$M_P = \int_{\Gamma} m_P(\gamma)^2 \phi(\gamma) d\gamma \tag{A5}$$

where

$m_p(\gamma) = \frac{1}{P^{1/2}} \sum_{t=R}^{T-1} g\prime(u_{1,t+1})w(Z^{t-1},\gamma)$ and where $\int_{\Gamma} \phi(\gamma)d\gamma = 1$, $\phi(\gamma) \geq 0$, with $\phi(\gamma)$ absolutely continuous with respect to Lebesgue measure.

We carry out a series of bootstrap experiments to get the critical values of CS test for a variety of models. Namely: (i) the "Recur Block Bootstrap", which is the block bootstrap for recursive m-estimators discussed in CS(2005b), which estimate $\widehat{\theta}_{1,t}$ using first R observations and then $R+1$ observations, and so on, until the last estimator is constructed using whole sample. It focus on one-step ahead prediction. At each replication, draw b blocks (with replacement) of length l from the sample $W_t = (y_t, Z^{t-1})$, where $bl = T - s$. Thus, the first block is equal to $W_{i+1}, ..., W_{i+l}$, for some $i = s-1, ..., T-l+1$, with probability $1/(T-s-l+1)$, the second block is equal to $W_{i+1}, ..., W_{i+l}$, again for some $i = s-1, ..., T-l+1$, with probability $1/(T-s-l+1)$, and so on, for all blocks, where the block length grows with the sample size at an appropriate rate. More formally, let I_k, $k = 1, ..., b$ be *iid* discrete uniform random variables on $[s-1, s, ..., T-l+1]$. Then, the resampled series, $W_t^* = (y_t^*, Z^{*,t-1})$, is such that $W_1^*, W_2^*, ..., W_l^*, W_{l+1}^*, ..., W_T^* = W_{I_1+1}, W_{I_1+2}, ..., W_{I_1+l}, W_{I_2}, ..., W_{I_b+l}$, and so a resampled series consists of b blocks that are discrete *iid* uniform random variables, conditional on the sample. We define the bootstrap estimator, $\widehat{\theta}^*_{1,t}$, to be the direct analog of $\widehat{\theta}_{1,t}$.We assume there exists bias in the estimation, so we have the bootstrap score centered around $\frac{1}{T-s}\sum_{k=s}^{T-1} \nabla_\theta q(y_k, Z^{k-1}, \widehat{\theta}_t)$. Hence, define a new bootstrap estimator, $\widetilde{\theta}^*_t$, as:

$$\widetilde{\theta}^*_t = \arg\min_{\theta\in\Theta} \frac{1}{t}\sum_{j=s}^{t}\left(q(y_j^*, Z^{*,j-1}, \theta) - \theta'\left(\frac{1}{T}\sum_{k=s}^{T-1}\nabla_\theta q(y_k, Z^{k-1}, \widehat{\theta}_t)\right)\right), \tag{A6}$$

$R \le t \le T-1$; (ii) "Block Bootstrap, no PEE, no adjust" is a strawman block bootstrap used for comparison purposes, where it is assumed that there is no parameter estimation error (PEE), so that $\widehat{\theta}_{1,t}$ is used in place of $\widetilde{\theta}^*_{1,t}$ in the construction of M_P^*, and the term $\frac{1}{T}\sum_{i=1}^{T-1} g'\left(y_{i+1} - \begin{pmatrix} 1 & y_i \end{pmatrix}\widehat{\theta}_{1,t}\right) w(Z^i, \gamma)$ in m_P^* is replaced with $g'\left(y_{t+1} - \begin{pmatrix} 1 & y_t \end{pmatrix}\widehat{\theta}_{1,t}\right) w(Z^t, \gamma)$ (i.e. there is no bootstrap statistic adjustment, thus conforming with the usual case when the standard block bootstrap is used); (iii) "Standard Block Bootstrap" is the standard block bootstrap (i.e. this bootstrap is the same as that outlined in (ii), except that $\widehat{\theta}_{1,t}$ is replaced with $\widehat{\theta}^*_{1,t}$.

The parametric bootstrap begins with the estimation of a specific model for x_t and y_t and resample the residuals as if they were *iid*. Then the pseudo time series $x_t^*$and $y_t^*$are constructed using estimated parameters and resampled residuals, and using the original model structure. At this point, $x_t^*$and y_t^* are used to construct bootstrap statistics exactly as the original statistics, except that prediction errors and variables are replaced with their bootstrapped counterparts.

We follow Corradi and Swanson(2005b) to examine: (i) the standard in-sample F-test; (ii) the encompassing test due to Clark and McCracken (CM: 2004) and Harvey, Leybourne and Newbold (1997); (iii) the Diebold and Mariano (DM: 1995) test; (iv) a version of the M_P encompassing test defined and discussed above (called the CS test in the sequel); and (v) a linear version of the CS test due to Chao, Corradi and Swanson (CCS: 2001).

To be more specific, we also consider other out-of-sample tests like the CM test, DM test of the Diebold and Mariano (1995) and CCS test. Complete details of all tests are given in Table 1.

Corradi and Swanson(2005b) point out that the CS test tends to be undersized and to have lower power than the CM, DM, and CCS tests in presence of highly dependent observations, but it is able to reject in certain contexts where a variety of the other tests examined here fail to reject.

In all experiments, we set $w(z^{t-1}, \gamma) = \exp(\sum_{i=1}^{2}(\gamma_i \tan^{-1}((z_{i,t-1} - \overline{z}_i)/2\widehat{\sigma}_{z_i})))$, with $z_{1,t-1} = x_{t-1}$, $z_{2,t-1} = y_{t-1}$, and γ_1, γ_2 scalars. Define $\Gamma = [0.0, 5.0] \times [0.0, 5.0]$, consider a grid that is defined by increments of size 0.5. If there are more than two variables in z^{t-1}, we will set Γ more dimensions. All bootstrap critical values are constructed using 100 simulated statistics.

The Reality Check

In this section, we employ the White (2000) reality check developed by CS (2005b) to the case of nonvanishing parameter estimation error. They show that the estimators properly mimics the contribution of parameter estimation error to the covariance kernel of the limiting distribution of the original reality check test when applying the block bootstrap for recursive estimation.

Let the forecast error be $u_{i,t+1} = y_{t+1} - \kappa_i(Z^t, \theta_i^\dagger)$, and let $\widehat{u}_{i,t+1} = y_{t+1} - \kappa_i(Z^t, \widehat{\theta}_{i,t})$, where $\kappa_i(Z^t, \widehat{\theta}_{i,t})$ is the estimated conditional mean function under model i. Also, assume that the set of regressors may vary across different models, so that Z^t is meant to denote the collection of all potential regressors. Define the statistic

$$S_P = \max_{k=2,\ldots,n} S_P(1, k),$$

where

$$S_P(1,k) = \frac{1}{\sqrt{P}} \sum_{t=R}^{T-1} \left(g(\widehat{u}_{1,t+1}) - g(\widehat{u}_{k,t+1})\right), \ k = 2, ..., n,$$

and where g is a given loss function. For a given loss function, the reality check tests the null hypothesis that a benchmark model (defined as model 1) performs equal to or better than all competitor models (i.e. models 2,...,n). The alternative is that at least one competitor performs better than the benchmark. Formally, the hypotheses are:

$$H_0 : \max_{k=2,\ldots,n} E\left(g(u_{1,t+1}) - g(u_{k,t+1})\right) \leq 0$$

and

$$H_A : \max_{k=2,\ldots,n} E\left(g(u_{1,t+1}) - g(u_{k,t+1})\right) > 0.$$

In order to derive the limiting distribution of S_P we should know that the maximum of a Gaussian process is not Gaussian in general, so that standard critical values cannot be used to conduct inference on S_P. Then we apply the block bootstrap for recursive m-estimators outlined in CS(2005b).

Define the bootstrap parameter estimator as:

$$\widetilde{\theta}^*_{i,t} = \arg\min_{\theta_i \in \Theta_i} \frac{1}{t} \sum_{j=s}^{t} \left(q_i(y^*_j, Z^{*,j-1}, \theta_i) - \theta_i' \left(\frac{1}{T} \sum_{h=s}^{T-1} \nabla_{\theta_i} q_i(y_h, Z^{h-1}, \widehat{\theta}_{i,t}) \right) \right), \tag{A7}$$

where $R \leq t \leq T-1$, $i = 1, ..., n$; and define the bootstrap statistic as:

$$S^*_P = \max_{k=2,\ldots,n} S^*_P(1,k),$$

where

$$\begin{aligned} S^*_P(1,k) \quad = \quad & \frac{1}{\sqrt{P}} \sum_{t=R}^{T-1} \Bigg[\Big(g(y^*_{t+1} - \kappa_1(Z^{*,t}, \widetilde{\theta}^*_{1,t})) - g(y^*_{t+1} - \kappa_k(Z^{*,t}, \widetilde{\theta}^*_{k,t})) \Big) \\ & - \left\{ \frac{1}{T} \sum_{j=s}^{T-1} \Big(g(y_{j+1} - \kappa_1(Z^j, \widehat{\theta}_{1,t})) - g(y_{j+1} - \kappa_k(Z^j, \widehat{\theta}_{k,t})) \Big) \right\} \Bigg]. \end{aligned} \tag{A8}$$

Note that bootstrap statistic above is the difference between the statistic computed over the sample observations and over the bootstrap observations. That is, following the usual approach to bootstrap statistic construction, one might have expected that the appropriate bootstrap statistic would be:

$$\begin{aligned} \overline{S}^*_P(1,k) \quad = \quad & \frac{1}{\sqrt{P}} \sum_{t=R}^{T-1} \Bigg[\Big(g(y^*_{t+1} - \kappa_1(Z^{*,t}, \widetilde{\theta}^*_{1,t})) - g(y^*_{t+1} - \kappa_k(Z^{*,t}, \widetilde{\theta}^*_{k,t})) \Big) \\ & - \Big(g(y_{t+1} - \kappa_1(Z^t, \widehat{\theta}_{1,t})) - g(y_{t+1} - \kappa_k(Z^t, \widehat{\theta}_{k,t})) \Big) \Bigg]. \end{aligned} \tag{A9}$$

Instead, as can be seen by inspection of $S_P^*(1,k)$, the bootstrap (resampled) component is constructed only over the last P observations, while the sample component is constructed over all T observations. Detailed proof is provided in CS(2005b).

In application, Corradi and Swanson (2005b) show that the block bootstrap for recursive m-estimators can be readily adapted in order to provide asymptotically valid critical values that are robust to parameter estimation error as well as model misspecification. In addition, the bootstrap statistics are very easy to construct, as no complicated adjustment terms involving possibly higher order derivatives need be included

A Distribution Comparison test

In this section we briefly discuss the distributional accuracy test discussed in Corradi and Swanson (2005b) (CS), which shall be used in our subsequent empirical analysis. Assume that our objective is to compare the joint distribution of the actual data with the joint distribution of the simulated series. First we fix a given model as the "benchmark" model, against which all " alternative" models are compared. The comparison is done using a distribution than does the benchmark model. "Accuracy" is measured in terms of square error. The limiting distribution of the statistic is a functional over a Gaussian process with a covariance kernel that reflects the contribution of parameter estimation error. Let $r_t, t = 1, ..., T$ denote actual historical stock return rate and let $r_{j,t}, t = 1, ..., S$, denote the stock return series simulated under model j, where S denotes the simulated sample length. Parameters are estimated using the T available historical observations. Let $Y_t = \{r_t\}$ and $Y_{j,n}(\widehat{\theta}_{j,T}) = \{r_{j,t}(\widehat{\theta}_{j,T})\}$. Let $F_0(u;\theta_0)$ denote the distribution of Y_t evaluated at u and $F_j(u;\theta_j^\dagger)$ denote the distribution of $Y_{j,n}(\theta_j^\dagger)$, where $\theta_j^\dagger$is the probability limit of $\widehat{\theta}_{j,T}$, taken as $T \longrightarrow \infty$, and where $u \in U \subset \Re^2$, possibly unbounded. Accuracy is measured in terms of the squared (approximation) error associated with model $j, j = 1, ..., m$, defined as a (weighted) average over U of $E\left(\left(F_j(u;\theta_j^\dagger) - F_0(u;\theta_0)\right)^2\right)$. Thus, the rule is to choose Model 1 over Model 2, say, if

$$\int_U E\left(\left(F_1(u;\theta_1^\dagger) - F_0(u;\theta_0)\right)^2\right)\phi(u)du < \int_U E\left(\left(F_2(u;\theta_2^\dagger) - F_0(u;\theta_0)\right)^2\right)\phi(u)du$$

where $\int_U \phi(u)du = 1$ and $\phi(u) \geq 0$ for all $u \in U \subset \Re^2$. For any evaluation point, this measure defines a norm and is a typical goodness of fit measure.

The hypotheses of interest are:

$$H_0: \max_{j=2,\ldots,m} \int_U E\left(\left(F_0(u;\theta_0) - F_1(u;\theta_1^\dagger)\right)^2 - \left(F_0(u;\theta_0) - F_j(u;\theta_j^\dagger)\right)^2\right)\phi(u)du \leq 0$$

$$H_A: \max_{j=2,\ldots,m} \int_U E\left(\left(F_0(u;\theta_0) - F_1(u;\theta_1^\dagger)\right)^2 - \left(F_0(u;\theta_0) - F_j(u;\theta_j^\dagger)\right)^2\right)\phi(u)du > 0$$

Thus, under H_0, no model can provide a better approximation than model 1. In order to test H_0 versus H_A, the relevant test statistic is $\sqrt{T}Z_{T,S}$, where:

$$Z_{T,S} = \max_{j=2,\ldots,m} \int_U Z_{j,T,S}(u)\phi(u)du \tag{A10}$$

and

$$\begin{aligned} Z_{j,T,S}(u) &= \frac{1}{T}\sum_{t=1}^{T}(1\{Y_t \leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{1,n}(\widehat{\theta}_{1,T}) \leq u\})^2 \\ -\frac{1}{T}\sum_{t=1}^{T}(1\{Y_t &\leq u\} - \frac{1}{S}\sum_{n=1}^{S} 1\{Y_{j,n}(\widehat{\theta}_{j,T}) \leq u\})^2 \end{aligned}$$

We use bootstrap experiments to get the critical values for the test.

Not for Publication Appendix to the third chapter "Further Empirical Evidence on Momentum, Mean Reversion, Downside Risk, and Excess Returns"

Table A1: Test Statistic Mnemonics

F – The standard Wald version of the in-sample F-test is calculated using the entire sample of T observations. In particular, we use: $F = T\left(\sum_{t=1}^{T}\widehat{u}_{1,t}^2 - \sum_{t=1}^{T}\widehat{u}_{2,t}^2)/\sum_{t=1}^{T}\widehat{u}_{2,t}^2\right)$, where $\widehat{u}_{1,t}$ and $\widehat{u}_{2,t}$ are the in-sample residuals associated with least squares estimation of the smaller and bigger models, respectively, and where T denotes the sample size.

CM – The Clark and McCracken (2004) test is an out-of-sample encompassing test (see also Harvey, Leybourne and Newbold (1997), and is defined as follows: $CM = (P-h+1)^{1/2}\frac{\frac{1}{P-h+1}\sum_{t=R}^{T-h}\widehat{c}_{t+h}}{\frac{1}{P-h+1}\sum_{j=-\bar{j}}^{\bar{j}}\sum_{t=R+j}^{T-h}K\left(\frac{j}{M}\right)(\widehat{c}_{t+h}-\bar{c})(\widehat{c}_{t+h-j}-\bar{c})}$, where $\widehat{c}_{t+h} = \widehat{u}_{1,t+h}\left(\widehat{u}_{1,t+h} - \widehat{u}_{2,t+h}\right)$, $\bar{c} = \frac{1}{P-h+1}\sum_{t=R}^{T-\tau}\widehat{c}_{t+h}$, $K(\cdot)$ is a kernel (such as the Bartlett kernel), and $0 \leq K\left(\frac{j}{M}\right) \leq 1$, with $K(0) = 1$, and $M = o(P^{1/2})$. Additionally, h is the forecast horizon, P is the out-of-sample prediction period, and $\widehat{u}_{1,t+1}$ and $\widehat{u}_{2,t+1}$ are the out-of-sample residuals associated with least squares estimation of the smaller and bigger models, respectively. Note finally, that $\bar{j}$ does not grow with the sample size.

DM – The mean square error version of the Diebold and Mariano (1995) test is a predictive accuracy test, and is defined as follows: $DM = \sqrt{P}\frac{\frac{1}{P}\sum_{t=R}^{T}\widehat{d}_{t+h}}{\frac{1}{P-h+1}\sum_{j=-\bar{j}}^{\bar{j}}\sum_{t=R+j}^{T-h}K\left(\frac{j}{M}\right)(\widehat{d}_{t+h}-\bar{d})(\widehat{d}_{t+h-j}-\bar{d})}$, where $\widehat{d}_{t+h} = \widehat{\epsilon}_{t+h}^2 - \widehat{u}_{t+h}^2$, and $\bar{d} = \frac{1}{P-h+1}\sum_{t=R}^{T-\tau}\widehat{d}_{t+h}$.

CS – The so-called Corradi and Swanson (2002) test is a generically comprehensive out-of-sample encompassing test, and is defined as follows: $M_P = \int_\Gamma |m_P(\gamma)|\phi(\gamma)d\gamma$, where $m_P(\gamma) = \frac{1}{\sqrt{P}}\sum_{t=R}^{T-1}g'(\widehat{u}_{1,t+1})w(Z^t,\gamma)$, and where $\int_\Gamma \phi(\gamma)d\gamma = 1$, $\phi(\gamma) \geq 0$, with $\phi(\gamma)$ absolutely continuous with respect to Lebesgue measure, Γ is a compact subset of $\Re^d$, for some finite d, and g' is the derivative of the loss function used for predictive evaluation, with respect to its argument. Additionally, $w(Z^t,\gamma)$ is a generically comprehensive function as discussed above and in Corradi and Swanson (2002), and Z^t is a vector of variables of interest.

CCS – The so-called Chao, Corradi and Swanson (2001) test is a simplified version of CS which is not designed to have power against generic nonlinear alternatives, and is defined as follows: $CCS = \frac{1}{\sqrt{P}}\sum_{t=R}^{T-1}\widehat{u}_{1,t+1}Z^t$.

Table A2: Cross- section evidence: 25 Fama - French portfolios

size	B/M	returns		excess returns	
		mean	std	mean	std
Small	Low	0.391	8.316	-0.455	5.414
	2	1.061	7.018	0.215	4.401
	3	1.178	6.023	0.332	3.563
	4	1.402	5.594	0.556	3.381
	High	1.487	5.884	0.641	3.689
2	Low	0.607	7.565	-0.239	4.304
	2	0.956	6.121	0.11	3.145
	3	1.254	5.376	0.408	2.74
	4	1.316	5.169	0.47	2.762
	High	1.381	5.728	0.535	3.275
3	Low	0.674	6.922	-0.172	3.562
	2	1.062	5.523	0.216	2.389
	3	1.091	4.933	0.245	2.326
	4	1.234	4.725	0.388	2.478
	High	1.374	5.406	0.528	3.042
4	Low	0.824	6.084	-0.022	2.572
	2	0.861	5.198	0.015	1.988
	3	1.105	4.857	0.259	2.138
	4	1.23	4.622	0.384	2.335
	High	1.235	5.323	0.389	2.955
Big	Low	0.782	4.797	-0.064	1.705
	2	0.853	4.57	0.007	1.697
	3	0.887	4.315	0.041	2.155
	4	0.961	4.209	0.115	2.607
	High	0.955	4.783	0.109	3.14

* Notes:Table 2 presents descriptive statistics (in percentages) for the 25 characteristic sorted quintile portfolios. Value- weighted returns and log dividend growth rates are presented for portfolios formed on market capitalization (Size), and book-to-market ratio (B/M). The data are sampled at the quarterly frequency, and cover the 3rd quarter 1963 through 4th quarter 2004.

Table A3: Basic Analysis for whole sample size (25 Fama - French portfolios)

NO	Model	Dependent Variable	Constant	Mean Reversion	Momentum	Downside Risk	SMB	HML	R^2
Panel A: Excess Returns on Mean-reversion, Momentum and Downside risk, 1963:9-2004:12 (monthly)									
1	RMMD	$r_t^i - r_t^w$	0.002(0.848)	0.033(0.180)	0.022(1.845)	0.089(1.967)			0.024
2	RMM	$r_t^i - r_t^w$	0.002(0.872)	0.051(0.280)	0.024(2.003)				0.016
3	RMD	$r_t^i - r_t^w$	0.002(1.253)		0.022(1.933)	0.090(1.979)			0.024
4	RMR	$r_t^i - r_t^w$	0.002(0.923)	0.135(0.751)					0.008
5	RM	$r_t^i - r_t^w$	0.002(1.371)		0.025(2.122)				0.016
6	RD	$r_t^i - r_t^w$	0.002(1.722)			0.098(2.164)			0.017
Panel B: Excess Returns on Mean-reversion, Momentum, Downside risk and Fama French factors, 1963:9-2004:12 (monthly)									
1	RMMD	$r_t^i - r_t^w$	-0.002(-0.950)	0.113(0.707)	0.011(1.072)	0.035(0.805)	0.356(12.235)	0.259(6.441)	0.262
2	RMM	$r_t^i - r_t^w$	-0.002(-0.950)	0.120(0.757)	0.012(1.138)		0.357(12.525)	0.261(6.510)	0.261
3	RMD	$r_t^i - r_t^w$	-0.001(-0.643)		0.013(1.263)	0.037(0.929)	0.354(12.345)	0.258(6.417)	0.261
4	RMR	$r_t^i - r_t^w$	-0.002(-0.945)	0.162(1.041)			0.360(12.648)	0.266(6.631)	0.259
5	RM	$r_t^i - r_t^w$	-0.001(-0.613)		0.014(1.344)		0.357(12.498)	0.261(6.499)	0.260
6	RD	$r_t^i - r_t^w$	-0.001(-0.409)			0.041(1.032)	0.356(12.445)	0.263(6.541)	0.259
Panel C: Excess Returns on Mean-reversion, Momentum, Downside risk and lagged Fama French factors, 1963:9-2004:12 (monthly)									
1	RMMD	$r_t^i - r_t^w$	0.002(0.825)	0.031(0.167)	0.022(1.842)	0.095(1805)	-0.008(-0.235)	0.007(0.141)	0.025
2	RMM	$r_t^i - r_t^w$	0.001(0.706)	0.053(0.290)	0.023(1.914)		0.025(0.755)	0.316(0.682)	0.018
3	RMD	$r_t^i - r_t^w$	0.002(1.203)		0.022(1.933)	0.095(1.829)	-0.009(-0.244)	0.007(0.138)	0.025
4	RMR	$r_t^i - r_t^w$	0.001(0.723)	0.133(0.741)			0.030(0.911)	0.038(0.825)	0.011
5	RM	$r_t^i - r_t^w$	0.002(1.141)		0.024(2.022)		0.025(0.750)	0.032(0.682)	0.018
6	RD	$r_t^i - r_t^w$	0.002(1.622)			0.101(1.932)	-0.006(-0.167)	0.012(0.248)	0.017
Panel D: Test the assumption that $\rho_j^i = \rho^i, \delta^i = \delta$ and $\beta_t^i = \beta^i$.									
1	RMMD	$r_t^i - r_t^w$	0.002(0.001)	-0.066(0.132)	0.019(0.017)	0.070(0.048)			
2	RMM	$r_t^i - r_t^w$	0.002(0.002)	-0.059(0.127)	0.020(0.017)				
3	RMD	$r_t^i - r_t^w$	0.002(0.001)		0.018(0.016)	0.070(0.048)			
4	RMR	$r_t^i - r_t^w$	0.003(0.003)	-0.024(0.132)					
5	RM	$r_t^i - r_t^w$	0.002(0.002)		0.020(0.017)				
6	RD	$r_t^i - r_t^w$	0.003(0.002)			0.079(0.046)			

Table A4: Tests for the Marginal Predictive Content of Momentum factor(1)

Bootstrap Method	Block Length	Test Statistics	Prediction Period Begins 1984: 1		Prediction Period Begins 1990: 1	
	l		5%	10%	5%	10%
Panel A: CS and CCS test						
Recur Block Bootsrap	2	CS Test	Reject	Reject	Reject	Reject
	5		Reject	Reject	Reject	Reject
	10		Reject	No Reject	Reject	Reject
BB, no PEE, no adj	2	CS Test	No Reject	Reject	No Reject	No Reject
	5		Reject	Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Block Bootstrap	2	CS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Recur Block Bootsrap	2	CCS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	Reject
	10		No Reject	No Reject	Reject	Reject
Panel B: F test, DM test and CM test, assume $\pi = 0$						
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	No Reject	No Reject	No Reject	No Reject
Panel C: F test, DM test and CM test, assume $\pi > 0$						
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	No Reject	No Reject	No Reject	No Reject

* Notes: All entries are rejection of the null hypothesis of equal predictive accuracy based on 5% and 10% nominal size critical values constructed using the bootstrap approaches discussed above, where l denotes the block length, and empirical bootstrap distributions are constructed using 100 bootstrap statistics. In particular, "Recur Block Bootstrap" is the bootstrap developed in CS(2005) , "BB, no PEE, no adj" is a naive block bootstrap where no parameter estimation error is assumed, and no recentering (i.e. adjustment) is done in parameter estimation or bootstrap statistic construction, and "Standard Block Bootstrap" is the usual block bootstrap that allows for parameter estimation error, but does not recenter parameter estimates or bootstrap statistics. In all experiments, the ex ante forecast period is of length P, which is set equal to $(1/2)T$, where T is the sample size. All models are estimated recursively, so that parameter estimates are updated before each new prediction is constructed. "Reject" means that we reject the null hypothesis of equal predictive accuracy of the two models; "No Reject" means that we don't reject the null hypothesis of equal predictive accuracy of the two models; See Table 1 and Section 4 for further details. small model includes constant, mean reversion and downside risk factors; big model includes constant, mean reversion, downside risk and momentum factors.

Table A5: Tests for the Marginal Predictive Content of Momentum factor(2)

Bootstrap Method	Block Length l	Test Statistics	Prediction Period Begins 1984: 1 5%	10%	Prediction Period Begins 1990: 1 5%	10%
Panel A: CS and CCS test						
Recur Block Bootsrap	2	CS Test	Reject	Reject	Reject	Reject
	5		Reject	Reject	Reject	Reject
	10		Reject	Reject	Reject	Reject
BB, no PEE, no adj	2	CS Test	No Reject	Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Block Bootstrap	2	CS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Recur Block Bootsrap	2	CCS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Panel B: F test, DM test and CM test, assume $\pi = 0$						
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	No Reject	No Reject	No Reject	No Reject
Panel C: F test, DM test and CM test, assume $\pi > 0$						
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	No Reject	No Reject	No Reject	No Reject

* Notes: All entries are rejection of the null hypothesis of equal predictive accuracy based on 5% and 10% nominal size critical values constructed using the bootstrap approaches discussed above, where l denotes the block length, and empirical bootstrap distributions are constructed using 100 bootstrap statistics. In particular, "Recur Block Bootstrap" is the bootstrap developed in CS(2005) , "BB, no PEE, no adj" is a naive block bootstrap where no parameter estimation error is assumed, and no recentering (i.e. adjustment) is done in parameter estimation or bootstrap statistic construction, and "Standard Block Bootstrap" is the usual block bootstrap that allows for parameter estimation error, but does not recenter parameter estimates or bootstrap statistics. In all experiments, the ex ante forecast period is of length P, which is set equal to $(1/2)T$, where T is the sample size. All models are estimated recursively, so that parameter estimates are updated before each new prediction is constructed. "Reject" means that we reject the null hypothesis of equal predictive accuracy of the two models; "No Reject" means that we don't reject the null hypothesis of equal predictive accuracy of the two models; See Table 1 and Section 4 for further details. small model includes constant and mean reversion factor; big model includes constant, mean reversion and momentum factors.

Table A6: Tests for the Marginal Predictive Content of Downside Risk

Bootstrap Method	Block Length	Test Statistics	Prediction Period Begins 1984: 1		Prediction Period Begins 1990: 1	
	l		5%	10%	5%	10%
Panel A: CS and CCS test						
Recur Block Bootsrap	2	CS Test	Reject	Reject	No Reject	No Reject
	5		Reject	Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
BB, no PEE, no adj	2	CS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Block Bootstrap	2	CS Test	No Reject	No Reject	No Reject	No Reject
	5		No Reject	No Reject	No Reject	No Reject
	10		No Reject	No Reject	No Reject	No Reject
Recur Block Bootsrap	2	CCS Test	Reject	Reject	No Reject	No Reject
	5		No Reject	Reject	No Reject	No Reject
	10		No Reject	Reject	No Reject	No Reject
Panel B: F test, DM test and CM test, assume $\pi = 0$						
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	Reject	Reject	Reject	Reject
Panel C: F test, DM test and CM test, assume $\pi > 0$						
		F test	No Reject	No Reject	No Reject	No Reject
		DM test	No Reject	No Reject	No Reject	No Reject
		CM test	Reject	Reject	Reject	Reject

* Notes: All entries are rejection of the null hypothesis of equal predictive accuracy based on 5% and 10% nominal size critical values constructed using the bootstrap approaches discussed above, where l denotes the block length, and empirical bootstrap distributions are constructed using 100 bootstrap statistics. In particular, “Recur Block Bootstrap" is the bootstrap developed in CS(2005) , “BB, no PEE, no adj" is a naive block bootstrap where no parameter estimation error is assumed, and no recentering (i.e. adjustment) is done in parameter estimation or bootstrap statistic construction, and “Standard Block Bootstrap" is the usual block bootstrap that allows for parameter estimation error, but does not recenter parameter estimates or bootstrap statistics. In all experiments, the ex ante forecast period is of length P, which is set equal to $(1/2)T$, where T is the sample size. All models are estimated recursively, so that parameter estimates are updated before each new prediction is constructed. “Reject" means that we reject the null hypothesis of equal predictive accuracy of the two models; “No Reject" means that we don't reject the null hypothesis of equal predictive accuracy of the two models; See Table 1 and Section 4 for further details. small model includes constant,mean reversion and momentumfactor; big model includes constant, mean reversion, momentum and downside risk factors.

Table A7a: Performance of portfolios with trading strategy: Pure momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.034	0.258	0.182	2.165	0.209	2.697	0.152	2.332	0.098	1.705	0.101	1.835
Max 1-Min1	0.047	0.471	0.192	2.782	0.218	3.563	0.162	3.131	0.103	2.171	0.105	2.456
Max3	0.129	1.293	0.215	3.092	0.242	3.899	0.211	3.992	0.169	3.567	0.153	3.333
Max3-Min3	0.086	1.147	0.162	3.078	0.179	3.986	0.148	3.834	0.113	3.172	0.105	3.339
J=6												
Max 1	0.265	2.013	0.316	3.642	0.26	3.385	0.173	2.611	0.167	2.86	0.15	2.691
Max 1-Min1	0.35	3.353	0.367	5.614	0.287	4.904	0.196	3.837	0.167	3.648	0.172	4.08
Max3	0.343	3.063	0.334	4.725	0.315	5.24	0.254	4.835	0.209	4.407	0.18	3.897
Max3-Min3	0.287	3.393	0.266	5.393	0.242	5.78	0.18	4.602	0.142	4.095	0.125	3.857
J=9												
Max 1	0.377	2.987	0.371	4.239	0.279	3.428	0.219	3.229	0.187	3.107	0.161	2.905
Max 1-Min1	0.396	4.049	0.359	5.107	0.274	4.308	0.221	4.239	0.188	3.949	0.189	4.317
Max3	0.371	3.681	0.359	4.839	0.282	4.574	0.222	4.151	0.177	3.699	0.158	3.598
Max3-Min3	0.321	4.167	0.282	5.407	0.226	5.146	0.173	4.53	0.136	3.833	0.128	3.934
J=12												
Max 1	0.411	3.225	0.375	4.172	0.299	3.757	0.252	3.771	0.204	3.475	0.165	3.061
Max 1-Min1	0.391	3.865	0.344	4.848	0.288	4.719	0.254	4.97	0.23	4.816	0.238	5.449
Max3	0.35	3.16	0.308	4.148	0.274	4.303	0.198	3.587	0.162	3.273	0.144	3.169
Max3-Min3	0.296	3.543	0.236	4.468	0.213	4.638	0.158	4.073	0.136	3.681	0.127	3.759
J=15												
Max 1	0.369	3.09	0.358	4.526	0.294	3.953	0.235	3.786	0.199	3.559	0.165	3.086
Max 1-Min1	0.374	3.743	0.345	5.347	0.301	5.297	0.252	5.062	0.244	5.204	0.235	5.388
Max3	0.294	2.881	0.258	3.655	0.225	3.731	0.183	3.474	0.15	3.178	0.137	3.156
Max3-Min3	0.243	3.092	0.191	3.647	0.174	3.87	0.142	3.487	0.126	3.38	0.12	3.487
J=18												
Max 1	0.453	4.199	0.373	4.64	0.316	4.427	0.275	4.421	0.233	4.146	0.189	3.636
Max 1-Min1	0.427	4.978	0.324	5.071	0.258	4.412	0.244	4.846	0.232	5.073	0.236	5.558
Max3	0.288	2.953	0.254	3.604	0.238	3.858	0.188	3.447	0.158	3.168	0.143	3.142
Max3-Min3	0.217	2.875	0.186	3.528	0.17	3.553	0.148	3.564	0.13	3.331	0.125	3.48

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A7b: Performance of portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.209**	1.602	**0.289**	3.315	**0.285**	3.5	**0.252**	3.629	**0.188**	3.038	**0.16**	2.751
Max 1-Min1	**0.208**	2.182	**0.300**	4.431	**0.306**	5.014	**0.266**	5.208	**0.206**	4.285	**0.192**	4.56
Max3	**0.241**	2.4	**0.308**	4.249	**0.311**	4.777	**0.283**	5.054	**0.23**	4.487	**0.205**	4.169
Max3-Min3	**0.169**	2.332	**0.237**	4.6	**0.234**	5.319	**0.2**	5.409	**0.157**	4.46	**0.142**	4.57
J=6												
Max 1	**0.251**	1.869	**0.318**	3.453	**0.29**	3.596	**0.197**	2.829	**0.171**	2.737	0.134	2.268
Max 1-Min1	**0.356**	3.411	**0.364**	5.525	**0.316**	5.564	**0.217**	4.302	**0.17**	3.677	0.157	3.621
Max3	**0.361**	3.422	**0.383**	5.414	**0.366**	5.994	**0.296**	5.504	**0.235**	4.714	**0.198**	4.108
Max3-Min3	**0.318**	3.924	**0.301**	6.236	**0.273**	6.729	**0.205**	5.373	**0.158**	4.523	**0.133**	4.044
J=9												
Max 1	**0.452**	3.579	**0.416**	4.654	**0.347**	4.239	**0.252**	3.663	0.178	2.834	0.134	2.329
Max 1-Min1	**0.494**	4.999	**0.407**	5.897	**0.324**	5.241	**0.253**	5.001	**0.203**	4.245	**0.197**	4.5
Max3	**0.386**	3.934	**0.386**	5.401	**0.319**	5.1	**0.24**	4.397	**0.196**	3.889	**0.176**	3.802
Max3-Min3	**0.344**	4.67	**0.309**	6.279	**0.254**	5.871	**0.193**	5.176	**0.16**	4.594	**0.152**	4.76
J=12												
Max 1	**0.412**	3.157	0.374	4.124	0.298	3.738	0.25	3.763	**0.214**	3.639	**0.179**	3.311
Max 1-Min1	0.369	3.54	0.337	4.674	0.279	4.509	0.249	4.833	0.222	4.633	0.233	5.267
Max3	**0.357**	3.257	**0.315**	4.241	0.271	4.192	0.192	3.462	**0.166**	3.367	0.139	3.072
Max3-Min3	0.275	3.398	0.231	4.365	0.205	4.467	0.146	3.708	0.126	3.376	0.108	3.115
J=15												
Max 1	**0.376**	2.917	**0.361**	4.275	0.289	3.747	**0.242**	3.702	0.188	3.183	0.146	2.586
Max 1-Min1	**0.413**	3.98	**0.364**	5.349	0.297	5.059	0.251	4.864	0.226	4.761	0.213	4.82
Max3	**0.321**	3.146	**0.275**	3.787	0.225	3.569	0.17	3.127	0.137	2.783	0.119	2.641
Max3-Min3	0.24	3.067	**0.199**	3.75	0.174	3.823	0.135	3.327	0.11	2.875	0.095	2.653
J=18												
Max 1	0.428	3.504	**0.391**	4.599	**0.338**	4.458	**0.3**	4.653	**0.260**	4.516	**0.211**	3.962
Max 1-Min1	0.426	4.589	**0.342**	5.238	**0.284**	4.807	**0.271**	5.406	**0.242**	5.251	0.233	5.396
Max3	0.265	2.689	0.226	3.124	0.195	3.082	0.159	2.855	0.134	2.649	0.115	2.483
Max3-Min3	0.179	2.387	0.15	2.824	0.132	2.728	0.111	2.58	0.092	2.281	0.082	2.173

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A7c: Performance of portfolios with strategy: Momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.018	0.138	0.032	0.357	0.059	0.766	0.065	0.957	0.001	0.025	0.002	0.035
Max 1-Min1	**0.109**	1.137	0.108	1.518	0.123	2.109	0.117	2.213	0.048	1.021	0.039	0.891
Max3	**0.142**	1.409	0.127	1.848	0.14	2.398	0.141	2.768	0.099	2.239	0.093	2.204
Max3-Min3	0.083	1.122	0.081	1.541	0.101	2.327	0.097	2.56	0.059	1.726	0.054	1.713
J=6												
Max 1	0.118	0.909	0.08	0.931	0.119	1.563	0.084	1.282	0.064	1.127	0.065	1.166
Max 1-Min1	0.200	2.092	0.206	3.084	0.213	3.662	0.182	3.578	0.137	2.996	0.128	3.03
Max3	0.223	2.243	0.241	3.571	0.26	4.493	0.224	4.487	0.172	3.894	0.156	3.717
Max3-Min3	0.182	2.416	0.21	4.254	0.208	4.969	0.173	4.677	0.123	3.643	0.113	3.66
J=9												
Max 1	0.111	0.871	0.086	0.942	0.096	1.249	0.072	1.103	0.044	0.764	0.041	0.767
Max 1-Min1	0.161	1.714	0.153	2.177	0.17	2.9	0.147	2.885	0.101	2.201	0.094	2.205
Max3	0.21	2.086	0.212	3.064	0.225	3.854	0.212	4.198	0.163	3.631	0.147	3.466
Max3-Min3	0.16	2.131	0.164	3.221	0.171	3.994	0.16	4.261	0.114	3.369	0.103	3.3
J=12												
Max 1	0.325	2.554	0.268	3.179	0.224	2.878	0.175	2.628	0.143	2.443	0.121	2.176
Max 1-Min1	0.332	3.452	0.301	4.453	0.252	4.124	0.221	4.294	0.178	3.739	0.177	4.088
Max3	0.298	2.896	0.296	4.184	0.277	4.51	0.241	4.642	0.197	4.244	0.177	4.02
Max3-Min3	0.244	3.146	0.257	5.027	0.231	5.211	0.196	5.328	0.151	4.336	0.141	4.474
J=15												
Max 1	0.272	2.1	0.209	2.471	0.195	2.539	0.15	2.26	0.101	1.751	0.067	1.228
Max 1-Min1	0.303	3.03	0.256	3.811	0.256	4.421	0.218	4.346	0.175	3.765	0.153	3.577
Max3	0.317	3.176	0.284	4.145	0.273	4.474	0.26	4.992	0.209	4.487	0.183	4.178
Max3-Min3	0.248	3.183	0.232	4.525	0.217	4.834	0.205	5.442	0.159	4.589	0.143	4.504
J=18												
Max 1	0.289	2.257	0.211	2.491	0.21	2.811	0.167	2.607	0.113	1.978	0.103	1.965
Max 1-Min1	0.298	2.987	0.265	3.868	0.269	4.453	0.237	4.69	0.183	3.903	0.174	4.068
Max3	0.302	2.98	0.284	4.134	0.276	4.679	0.254	4.982	0.202	4.439	0.181	4.22
Max3-Min3	0.241	3.133	0.235	4.644	0.227	5.119	0.209	5.529	0.159	4.556	0.144	4.417

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A7d: Performance of portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.145	1.146	0.146	1.717	0.121	1.606	0.124	1.849	0.067	1.174	0.054	0.961
Max 1-Min1	**0.213**	2.24	0.209	3.124	0.194	3.428	0.181	3.559	0.118	2.601	0.102	2.377
Max3	0.193	1.977	0.206	2.974	0.207	3.459	0.205	4.012	0.155	3.446	0.138	3.25
Max3-Min3	0.143	2.028	0.16	3.201	0.167	3.97	0.153	4.25	0.103	3.137	0.09	2.938
J=6												
Max 1	0.225	1.715	0.165	1.901	0.172	2.251	0.14	2.15	0.097	1.674	0.081	1.454
Max 1-Min1	0.271	2.79	0.266	4.009	0.248	4.321	0.208	4.154	0.152	3.292	0.141	3.296
Max3	0.247	2.467	0.271	3.849	0.273	4.524	0.249	4.743	0.182	3.93	0.157	3.551
Max3-Min3	0.203	2.744	0.225	4.71	0.219	5.333	0.187	5.137	0.128	3.788	0.114	3.616
J=9												
Max 1	0.231	1.787	0.201	2.29	0.19	2.485	0.156	2.397	0.105	1.831	0.077	1.407
Max 1-Min1	0.224	2.314	0.241	3.559	0.247	4.257	0.212	4.289	0.153	3.35	0.127	2.966
Max3	0.243	2.399	0.246	3.444	0.25	4.064	0.229	4.29	0.174	3.709	0.152	3.422
Max3-Min3	0.187	2.483	0.191	3.703	0.186	4.243	0.173	4.554	0.12	3.495	0.108	3.418
J=12												
Max 1	0.32	2.464	0.274	3.186	0.219	2.818	0.162	2.425	0.128	2.164	0.119	2.109
Max 1-Min1	0.332	3.401	0.319	4.611	0.25	4.067	0.207	4.045	0.165	3.461	0.163	3.698
Max3	0.309	3.046	0.309	4.446	0.281	4.572	0.234	4.514	0.186	4.024	0.164	3.738
Max3-Min3	0.261	3.445	0.261	5.287	0.234	5.527	0.195	5.407	0.148	4.313	0.131	4.146
J=15												
Max 1	0.274	2.094	0.219	2.544	0.219	2.795	0.158	2.351	0.107	1.826	0.081	1.441
Max 1-Min1	0.305	3.032	0.268	3.889	0.264	4.483	0.225	4.423	0.183	3.89	0.159	3.667
Max3	0.307	3.009	0.287	4.13	0.275	4.476	0.249	4.744	0.186	3.958	0.159	3.583
Max3-Min3	0.247	3.109	0.236	4.572	0.212	4.75	0.192	5.138	0.14	3.949	0.123	3.784
J=18												
Max 1	0.328	2.511	0.243	2.758	0.234	3.007	0.186	2.791	0.134	2.263	0.125	2.287
Max 1-Min1	0.325	3.276	0.289	4.233	0.273	4.548	0.242	4.779	0.188	3.916	0.172	3.896
Max3	0.29	2.774	0.27	3.799	0.255	4.138	0.231	4.374	0.18	3.842	0.154	3.489
Max3-Min3	0.224	2.876	0.215	4.103	0.198	4.247	0.183	4.649	0.137	3.732	0.116	3.357

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table A7e: Performance of portfolios with strategy: Pure Momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.261	1.197	0.085	0.549	0.03	0.238	0.088	0.823	0.149	1.54	0.149	1.681
Max 1-Min1	0.32	1.808	0.188	1.554	0.126	1.331	0.17	2.029	0.208	2.78	0.202	2.883
Max3	0.181	0.949	0.146	1.106	0.114	1.108	0.12	1.349	0.143	1.847	0.159	2.213
Max3-Min3	0.154	1.069	0.125	1.25	0.09	1.182	0.107	1.586	0.12	2.068	0.128	2.44
J=3												
Max 1	0.049	0.221	-0.012	-0.07	0.034	0.258	0.141	1.236	0.192	1.933	0.182	2.165
Max 1-Min1	0.127	0.71	0.037	0.297	0.047	0.471	0.143	1.619	0.19	2.389	0.192	2.782
Max3	0.157	0.844	0.111	0.839	0.129	1.293	0.164	1.946	0.198	2.566	0.215	3.092
Max3-Min3	0.124	0.878	0.076	0.761	0.086	1.147	0.127	1.959	0.148	2.514	0.162	3.078
J=4												
Max 1	0.111	0.492	0.061	0.382	0.136	1.064	0.203	1.841	0.223	2.348	0.223	2.66
Max 1-Min1	0.175	0.999	0.153	1.195	0.158	1.562	0.213	2.406	0.233	3.006	0.256	3.664
Max3	0.18	1.019	0.162	1.278	0.195	1.961	0.251	2.748	0.269	3.457	0.266	3.722
Max3-Min3	0.111	0.842	0.11	1.157	0.159	2.11	0.21	3.051	0.224	3.828	0.223	4.24
J=5												
Max 1	0.163	0.732	0.113	0.676	0.226	1.757	0.215	2.001	0.237	2.536	0.256	2.871
Max 1-Min1	0.322	1.812	0.265	2.01	0.297	2.839	0.293	3.366	0.326	4.377	0.335	4.831
Max3	0.26	1.443	0.245	1.887	0.299	2.882	0.312	3.529	0.323	4.096	0.327	4.56
Max3-Min3	0.225	1.622	0.212	2.13	0.258	3.227	0.26	3.823	0.262	4.499	0.263	5.006
J=6												
Max 1	0.197	0.849	0.242	1.411	0.265	2.013	0.284	2.546	0.293	3.068	0.316	3.642
Max 1-Min1	0.396	2.178	0.371	2.741	0.35	3.353	0.362	4.281	0.37	5.091	0.367	5.614
Max3	0.324	1.714	0.328	2.399	0.343	3.063	0.338	3.624	0.328	4.216	0.334	4.725
Max3-Min3	0.289	2.023	0.265	2.514	0.287	3.393	0.28	4.046	0.27	4.776	0.266	5.393
J=7												
Max 1	0.364	1.586	0.318	1.863	0.341	2.645	0.327	3.111	0.333	3.53	0.364	4.174
Max 1-Min1	0.438	2.495	0.384	2.909	0.396	3.97	0.382	4.717	0.382	5.372	0.382	5.925
Max3	0.401	2.142	0.387	2.914	0.389	3.71	0.377	4.343	0.376	4.892	0.38	5.374
Max3-Min3	0.332	2.34	0.324	3.1	0.332	4.096	0.319	4.834	0.308	5.4	0.302	5.961

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A7f: Performance of portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.278**	1.247	**0.099**	0.577	0.017	0.125	-0.002	-0.02	0	0.002	0.025	0.276
Max 1-Min1	**0.327**	1.84	0.177	1.352	0.098	1.028	0.103	1.213	0.108	1.428	0.112	1.571
Max3	**0.315**	1.785	0.136	1.059	0.105	1.048	0.119	1.331	0.1	1.332	0.113	1.638
Max3-Min3	**0.219**	1.576	0.091	0.924	0.063	0.866	0.077	1.161	0.071	1.247	0.079	1.546
J=3												
Max 1	**0.213**	0.964	**0.055**	0.325	0.018	0.138	0.032	0.293	0.018	0.192	0.032	0.357
Max 1-Min1	**0.304**	1.726	**0.154**	1.184	**0.109**	1.137	0.117	1.387	0.116	1.54	0.108	1.518
Max3	**0.324**	1.842	**0.161**	1.256	**0.142**	1.409	0.147	1.639	0.137	1.831	0.127	1.848
Max3-Min3	**0.24**	1.744	**0.108**	1.085	0.083	1.122	0.091	1.327	0.087	1.507	0.081	1.541
J=4												
Max 1	**0.332**	1.489	**0.13**	0.767	0.03	0.236	0.023	0.214	0.007	0.074	0.034	0.374
Max 1-Min1	**0.348**	1.979	**0.163**	1.279	0.087	0.932	0.103	1.227	0.101	1.348	0.102	1.433
Max3	**0.356**	2.007	**0.177**	1.376	0.135	1.358	0.163	1.841	0.152	2.067	0.155	2.3
Max3-Min3	**0.247**	1.785	**0.123**	1.225	0.084	1.115	0.108	1.572	0.104	1.814	0.102	1.965
J=5												
Max 1	**0.19**	0.845	0.036	0.214	0.035	0.266	0.036	0.333	0.03	0.304	0.059	0.639
Max 1-Min1	**0.288**	1.64	0.148	1.162	0.112	1.187	0.135	1.599	0.133	1.762	0.134	1.885
Max3	**0.337**	1.879	0.171	1.335	0.143	1.418	0.168	1.88	0.155	2.089	0.164	2.409
Max3-Min3	**0.239**	1.701	0.117	1.158	0.094	1.231	0.122	1.764	0.113	1.956	0.112	2.15
J=6												
Max 1	**0.300**	1.348	0.061	0.353	0.118	0.909	0.081	0.752	0.068	0.721	0.08	0.931
Max 1-Min1	**0.390**	2.262	0.181	1.363	0.2	2.092	0.206	2.531	0.195	2.71	0.206	3.084
Max3	**0.402**	2.239	0.239	1.842	0.223	2.243	0.238	2.725	0.226	3.094	0.241	3.571
Max3-Min3	**0.291**	2.078	0.188	1.862	0.182	2.416	0.207	3.081	0.2	3.645	0.21	4.254
J=7												
Max 1	0.217	0.99	0.032	0.185	0.044	0.336	0.037	0.339	0.021	0.215	0.048	0.554
Max 1-Min1	0.315	1.809	0.154	1.162	0.161	1.703	0.178	2.214	0.162	2.249	0.172	2.605
Max3	0.393	2.202	0.275	2.146	0.255	2.577	0.258	3.015	0.244	3.313	0.262	3.864
Max3-Min3	0.292	2.109	0.199	1.995	0.198	2.661	0.222	3.363	0.208	3.792	0.213	4.303

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A7g: Performance of portfolios with strategy: Mean reversion and momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.349**	1.631	**0.244**	1.581	**0.192**	1.513	**0.192**	1.817	**0.193**	2.063	**0.237**	2.708
Max 1-Min1	**0.342**	1.964	**0.281**	2.282	**0.221**	2.342	**0.253**	3.093	**0.256**	3.575	**0.266**	3.88
Max3	**0.335**	1.817	**0.259**	2.02	**0.224**	2.218	**0.217**	2.637	**0.219**	2.846	**0.249**	3.504
Max3-Min3	**0.271**	1.925	**0.201**	2.051	**0.166**	2.224	**0.178**	2.906	**0.19**	3.433	**0.197**	3.951
J=3												
Max 1	**0.257**	1.163	**0.171**	1.09	**0.209**	1.602	**0.27**	2.366	**0.294**	2.94	**0.289**	3.315
Max 1-Min1	**0.32**	1.844	**0.214**	1.781	**0.208**	2.182	**0.276**	3.205	**0.306**	3.946	**0.3**	4.431
Max3	**0.298**	1.567	**0.263**	1.983	**0.241**	2.4	**0.271**	3.227	**0.291**	3.686	**0.308**	4.249
Max3-Min3	**0.211**	1.506	**0.173**	1.755	**0.169**	2.332	**0.217**	3.532	**0.229**	3.995	**0.237**	4.6
J=4												
Max 1	**0.25**	1.149	**0.184**	1.199	**0.201**	1.567	**0.258**	2.332	**0.263**	2.779	**0.272**	3.067
Max 1-Min1	**0.252**	1.487	**0.195**	1.608	**0.179**	1.819	**0.233**	2.637	**0.246**	3.294	**0.265**	3.878
Max3	**0.199**	1.115	**0.238**	1.878	**0.252**	2.484	**0.286**	3.218	**0.297**	3.763	**0.315**	4.338
Max3-Min3	**0.112**	0.866	**0.153**	1.606	**0.187**	2.51	**0.22**	3.316	**0.233**	4.036	**0.239**	4.628
J=5												
Max 1	**0.305**	1.415	**0.167**	0.986	0.199	1.509	0.199	1.792	0.204	2.119	0.235	2.56
Max 1-Min1	**0.371**	2.161	**0.256**	1.933	0.279	2.696	0.275	3.19	0.289	3.956	0.31	4.569
Max3	**0.297**	1.652	**0.258**	2.007	0.297	2.852	0.301	3.449	0.316	3.929	0.337	4.469
Max3-Min3	**0.294**	2.122	**0.256**	2.504	**0.27**	3.375	**0.272**	4.182	**0.281**	4.863	**0.292**	5.504
J=6												
Max 1	**0.341**	1.441	**0.258**	1.499	0.251	1.869	0.267	2.421	0.287	2.87	**0.318**	3.453
Max 1-Min1	**0.455**	2.561	**0.388**	2.896	**0.356**	3.411	0.345	4.192	0.355	4.915	0.364	5.525
Max3	**0.365**	1.962	**0.358**	2.705	**0.361**	3.422	**0.368**	4.198	**0.367**	4.821	**0.383**	5.414
Max3-Min3	**0.319**	2.246	**0.301**	2.921	**0.318**	3.924	**0.313**	4.755	**0.299**	5.516	**0.301**	6.236
J=7												
Max 1	**0.298**	1.358	0.258	1.661	0.285	2.242	**0.33**	3.116	**0.337**	3.537	0.354	4.073
Max 1-Min1	**0.457**	2.616	**0.388**	3.092	0.384	3.897	**0.398**	4.895	**0.394**	5.507	**0.398**	6.146
Max3	**0.45**	2.388	**0.409**	3.106	**0.394**	3.748	0.377	4.437	**0.389**	5.038	**0.405**	5.615
Max3-Min3	**0.372**	2.608	**0.357**	3.443	**0.357**	4.41	**0.338**	5.263	**0.33**	5.904	0.333	6.713

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A7h: Performance of portfolios with strategy: Mean reversion, momentum and downside risk (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.379**	1.744	0.204	1.206	0.154	1.183	0.137	1.257	0.14	1.455	0.153	1.756
Max 1-Min1	**0.407**	2.372	0.229	1.779	0.193	2.038	0.19	2.284	0.202	2.752	0.21	3.104
Max3	**0.393**	2.267	**0.273**	2.168	**0.235**	2.368	**0.227**	2.604	**0.227**	2.997	0.248	3.509
Max3-Min3	**0.312**	2.311	**0.205**	2.128	**0.169**	2.367	**0.179**	2.789	0.176	3.195	0.186	3.713
J=3												
Max 1	**0.281**	1.325	**0.188**	1.138	0.145	1.146	0.153	1.463	0.132	1.416	0.146	1.717
Max 1-Min1	**0.399**	2.318	**0.274**	2.106	**0.213**	2.24	0.211	2.54	0.214	2.907	0.209	3.124
Max3	**0.405**	2.375	0.256	2.066	0.193	1.977	0.188	2.219	0.189	2.556	0.206	2.974
Max3-Min3	**0.299**	2.23	0.163	1.697	0.143	2.028	0.158	2.483	0.153	2.823	0.16	3.201
J=4												
Max 1	**0.361**	1.646	**0.189**	1.116	0.172	1.334	0.157	1.452	0.131	1.352	0.153	1.722
Max 1-Min1	**0.416**	2.41	**0.246**	1.912	**0.217**	2.291	0.22	2.645	0.22	2.949	0.225	3.289
Max3	**0.407**	2.345	**0.25**	1.972	0.2	2.032	0.195	2.266	0.194	2.592	0.22	3.121
Max3-Min3	**0.311**	2.271	**0.175**	1.785	0.145	2.006	0.16	2.447	0.156	2.802	0.172	3.373
J=5												
Max 1	**0.333**	1.549	**0.17**	1.011	0.17	1.312	0.178	1.647	0.148	1.529	0.176	2.013
Max 1-Min1	**0.394**	2.293	0.219	1.698	0.199	2.1	0.222	2.669	0.219	2.956	0.226	3.365
Max3	**0.378**	2.147	0.239	1.881	0.196	2.001	0.2	2.332	0.204	2.709	0.229	3.236
Max3-Min3	**0.274**	1.978	0.166	1.687	0.145	1.999	0.168	2.587	0.169	3.046	0.179	3.556
J=6												
Max 1	**0.449**	2.021	0.172	0.985	0.225	1.715	0.193	1.748	0.164	1.699	0.165	1.901
Max 1-Min1	0.448	2.555	0.245	1.836	0.271	2.79	0.282	3.388	0.269	3.711	0.266	4.009
Max3	**0.415**	2.321	0.261	2.002	0.247	2.467	0.26	2.954	0.245	3.23	0.271	3.849
Max3-Min3	0.312	2.238	0.208	2.071	0.203	2.744	0.225	3.434	0.214	3.953	0.225	4.71
J=7												
Max 1	**0.328**	1.527	0.106	0.618	0.136	1.053	0.143	1.319	0.119	1.244	0.154	1.787
Max 1-Min1	0.416	2.375	0.231	1.727	0.236	2.428	0.261	3.179	0.245	3.372	0.256	3.894
Max3	0.407	2.272	0.299	2.313	0.286	2.837	0.279	3.159	0.262	3.447	0.28	3.948
Max3-Min3	0.288	2.086	0.214	2.146	0.216	2.919	0.236	3.594	0.219	4.032	0.228	4.693

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy(in short run).

Table A8a: Performance of big size portfolios with trading strategy: Pure momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.143	1.52	0.185	2.742	0.219	3.826	0.179	3.597	0.152	3.343	0.161	3.78
Max 1-Min1	0.029	0.397	0.075	1.523	0.101	2.458	0.052	1.422	0.018	0.557	0.014	0.471
Max3	0.216	3.443	0.207	4.049	0.22	4.944	0.208	5.678	0.172	4.999	0.162	4.982
Max3-Min3	0.094	2.133	0.091	2.877	0.094	3.538	0.071	3.013	0.041	1.908	0.026	1.326
J=6												
Max 1	0.267	2.849	0.252	3.787	0.234	4.179	0.193	4.072	0.164	3.638	0.164	3.736
Max 1-Min1	0.164	2.245	0.139	2.974	0.109	2.69	0.054	1.528	0.012	0.35	0.004	0.11
Max3	0.257	3.983	0.263	5.328	0.252	6.459	0.214	6.089	0.178	5.184	0.166	5.016
Max3-Min3	0.12	2.689	0.112	3.774	0.093	3.698	0.058	2.559	0.031	1.503	0.02	1.001
J=9												
Max 1	0.463	5.093	0.406	5.933	0.331	5.844	0.258	5.223	0.222	4.91	0.2	4.974
Max 1-Min1	0.266	3.421	0.2	3.605	0.142	3.184	0.078	2.06	0.049	1.457	0.025	0.782
Max3	0.285	4.898	0.28	6.435	0.238	6.368	0.197	5.754	0.174	5.015	0.167	5.254
Max3-Min3	0.149	3.469	0.124	4.073	0.084	3.402	0.042	1.963	0.022	1.044	0.01	0.499
J=12												
Max 1	0.428	4.545	0.321	4.814	0.235	4.252	0.195	4.011	0.166	3.961	0.154	4.14
Max 1-Min1	0.223	2.97	0.129	2.419	0.06	1.396	0.034	0.92	0.008	0.249	-0.014	-0.438
Max3	0.289	5.032	0.26	6.144	0.225	6.192	0.188	5.549	0.167	5.065	0.159	5.36
Max3-Min3	0.133	2.963	0.093	3.107	0.065	2.63	0.029	1.265	0.012	0.523	0.001	0.03
J=15												
Max 1	0.36	4.026	0.279	4.666	0.222	4.243	0.208	4.589	0.176	4.401	0.163	4.53
Max 1-Min1	0.141	1.905	0.079	1.533	0.046	1.063	0.039	1.028	0.004	0.111	-0.015	-0.464
Max3	0.295	5.322	0.264	5.91	0.225	5.786	0.194	5.61	0.165	5.075	0.154	5.217
Max3-Min3	0.102	2.485	0.072	2.559	0.049	2.055	0.024	1.049	-0.001	-0.057	-0.01	-0.491
J=18												
Max 1	0.294	3.478	0.247	4.166	0.23	4.724	0.214	5.24	0.195	5.505	0.175	5.415
Max 1-Min1	0.09	1.381	0.045	0.909	0.047	1.129	0.029	0.785	0.002	0.062	-0.018	-0.556
Max3	0.269	4.9	0.224	5.043	0.199	5.249	0.165	4.909	0.149	4.74	0.141	5.018
Max3-Min3	0.07	1.727	0.041	1.395	0.031	1.2	0.006	0.236	-0.011	-0.453	-0.02	-0.921

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A8b: Performance of big size portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.122	1.272	0.137	1.945	0.166	2.673	0.14	2.532	0.123	2.409	0.135	2.779
Max 1-Min1	**0.053**	0.797	0.056	1.244	0.065	1.613	0.021	0.575	-0.005	-0.145	-0.007	-0.203
Max3	**0.311**	4.252	**0.286**	4.832	**0.250**	4.734	**0.231**	5.107	**0.206**	4.867	**0.199**	4.952
Max3-Min3	**0.110**	2.457	**0.109**	3.21	0.09	3.047	**0.073**	2.798	**0.049**	2.000	**0.040**	1.794
J=6												
Max 1	**0.327**	3.319	**0.288**	3.86	**0.270**	4.213	**0.231**	4.221	**0.206**	4.072	**0.204**	4.203
Max 1-Min1	**0.175**	2.511	**0.156**	3.519	**0.122**	3.161	**0.069**	1.956	**0.036**	1.075	**0.023**	0.709
Max3	**0.311**	4.281	**0.273**	4.789	0.238	5.099	0.201	4.799	0.175	4.388	0.16	4.122
Max3-Min3	**0.124**	2.862	0.107	3.542	0.082	3.158	0.043	1.815	0.022	0.956	0.011	0.489
J=9												
Max 1	0.366	3.845	0.307	4.275	0.248	4.077	0.211	3.985	0.177	3.648	0.159	3.615
Max 1-Min1	0.211	2.826	0.145	2.679	0.094	2.088	0.051	1.337	0.021	0.582	-0.001	-0.03
Max3	0.28	4.027	0.245	4.504	0.201	4.202	0.183	4.157	0.161	3.831	0.153	3.865
Max3-Min3	0.132	2.913	0.09	2.743	0.054	1.954	0.027	1.111	0.006	0.242	0.002	0.075
J=12												
Max 1	**0.455**	4.901	**0.339**	5.031	**0.280**	5.086	**0.237**	4.851	**0.196**	4.587	**0.176**	4.596
Max 1-Min1	0.22	2.984	0.126	2.433	**0.078**	1.897	**0.045**	1.267	0.007	0.209	**−0.012**	-0.394
Max3	0.28	4.683	0.219	4.585	0.172	4.001	0.144	3.614	0.125	3.332	0.114	3.386
Max3-Min3	0.123	2.799	0.069	2.252	0.037	1.444	0.005	0.185	-0.015	-0.617	-0.022	-1.009
J=15												
Max 1	0.356	3.935	0.277	4.406	**0.233**	4.376	0.208	4.354	0.174	4.009	0.159	4.058
Max 1-Min1	**0.148**	2.142	0.077	1.606	**0.053**	1.313	0.02	0.561	-0.012	-0.338	-0.027	-0.832
Max3	0.239	3.794	0.2	3.755	0.164	3.431	0.145	3.342	0.124	3.14	0.119	3.364
Max3-Min3	0.07	1.661	0.048	1.661	0.022	0.892	-0.002	-0.101	-0.025	-1.044	-0.028	-1.265
J=18												
Max 1	**0.321**	3.724	**0.250**	4.046	0.208	3.954	0.175	3.744	0.149	3.535	0.127	3.388
Max 1-Min1	**0.122**	1.914	**0.065**	1.418	0.03	0.758	0.003	0.084	-0.022	-0.652	-0.037	-1.148
Max3	0.259	4.246	0.18	3.51	0.142	3.109	0.122	2.976	0.111	2.915	0.101	2.975
Max3-Min3	**0.074**	1.823	0.023	0.777	-0.001	-0.049	-0.023	-0.897	-0.036	-1.404	-0.042	-1.77

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A8c: Performance of big size portfolios with strategy: Momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.204**	2.159	**0.135**	1.966	**0.141**	2.504	**0.149**	2.968	**0.136**	2.944	**0.14**	3.224
Max 1-Min1	0.135	1.827	0.086	1.631	0.08	1.947	0.068	1.913	0.048	1.472	0.031	1.017
Max3	**0.219**	3.423	**0.154**	3.041	**0.171**	3.995	**0.166**	4.588	**0.15**	4.52	**0.145**	4.63
Max3-Min3	**0.086**	1.973	**0.047**	1.416	**0.057**	2.05	**0.047**	1.954	**0.028**	1.241	**0.019**	0.947
J=6												
Max 1	**0.251**	2.586	**0.219**	3.145	**0.216**	3.774	**0.2**	4.197	**0.172**	3.91	**0.161**	3.895
Max 1-Min1	0.129	1.657	0.115	2.175	0.121	2.777	0.094	2.53	0.056	1.653	0.032	1.014
Max3	**0.235**	3.721	**0.211**	4.326	**0.232**	5.685	**0.211**	6.089	**0.184**	5.568	**0.175**	5.64
Max3-Min3	**0.122**	2.734	**0.096**	3.005	**0.099**	3.654	**0.08**	3.361	**0.047**	2.096	**0.036**	1.722
J=9												
Max 1	0.186	1.947	0.19	2.706	**0.211**	3.717	**0.206**	4.254	**0.169**	3.798	**0.166**	4.011
Max 1-Min1	0.1	1.351	0.106	2.034	0.124	2.899	0.103	2.787	0.063	1.898	0.04	1.277
Max3	**0.245**	3.818	**0.215**	4.2	**0.226**	5.367	**0.204**	5.79	**0.182**	5.426	**0.173**	5.39
Max3-Min3	**0.12**	2.69	**0.091**	2.702	**0.098**	3.489	**0.079**	3.315	**0.046**	2.095	**0.035**	1.689
J=12												
Max 1	**0.362**	3.822	**0.309**	4.432	**0.267**	4.698	**0.239**	4.95	**0.199**	4.594	**0.16**	4.006
Max 1-Min1	0.201	2.716	0.144	2.82	0.124	3.103	0.095	2.646	0.042	1.295	0.006	0.197
Max3	**0.244**	4.185	**0.213**	4.725	**0.2**	5.05	**0.181**	5.236	**0.16**	4.805	**0.145**	4.728
Max3-Min3	**0.123**	2.817	**0.086**	2.712	**0.075**	3.019	**0.051**	2.267	**0.022**	1.059	**0.008**	0.396
J=15												
Max 1	**0.295**	3.052	**0.247**	3.642	**0.234**	4.12	**0.21**	4.324	**0.172**	3.989	**0.159**	4.076
Max 1-Min1	0.15	1.981	0.122	2.423	0.115	2.82	0.09	2.574	0.052	1.645	0.035	1.174
Max3	**0.222**	3.564	**0.191**	3.786	**0.2**	4.587	**0.184**	5.081	**0.161**	4.741	**0.148**	4.695
Max3-Min3	**0.118**	2.673	**0.083**	2.563	**0.079**	2.942	**0.058**	2.513	**0.029**	1.327	**0.014**	0.675
J=18												
Max 1	**0.274**	2.944	**0.201**	3.017	**0.191**	3.455	**0.191**	4.098	**0.156**	3.679	**0.15**	3.861
Max 1-Min1	0.121	1.639	0.092	1.796	0.088	2.134	0.064	1.779	0.031	0.964	0.013	0.437
Max3	**0.248**	4.017	**0.206**	4.141	**0.21**	4.882	**0.193**	5.409	**0.165**	4.908	**0.152**	4.881
Max3-Min3	0.135	3.065	0.091	2.805	0.079	2.857	0.057	2.344	0.024	1.083	0.014	0.668

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A8d: Performance of big size portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.237**	2.454	**0.219**	3.147	**0.208**	3.575	**0.195**	3.664	**0.186**	3.81	**0.189**	4.184
Max 1-Min1	**0.134**	1.879	**0.123**	2.417	**0.112**	2.817	**0.097**	2.743	**0.078**	2.439	**0.059**	1.943
Max3	0.236	3.252	0.207	3.613	0.208	4.229	0.196	4.588	0.186	4.735	0.181	4.975
Max3-Min3	0.097	2.138	0.073	2.137	0.07	2.326	0.055	2.087	0.035	1.434	0.029	1.312
J=6												
Max 1	0.293	2.895	0.264	3.686	0.258	4.353	0.223	4.349	0.205	4.415	0.199	4.593
Max 1-Min1	0.148	1.891	0.142	2.723	**0.138**	3.246	**0.101**	2.736	**0.07**	2.058	**0.052**	1.657
Max3	0.265	3.834	0.221	3.997	0.21	4.412	0.184	4.456	0.163	4.241	0.154	4.226
Max3-Min3	0.116	2.584	0.093	2.879	**0.086**	3.058	**0.06**	2.459	**0.03**	1.321	**0.017**	0.802
J=9												
Max 1	0.19	1.942	0.211	2.941	0.215	3.601	0.192	3.643	0.171	3.589	**0.166**	3.814
Max 1-Min1	0.077	1.049	0.094	1.838	**0.104**	2.438	**0.081**	2.224	**0.055**	1.67	**0.034**	1.103
Max3	0.295	4.043	0.24	4.182	**0.234**	4.708	**0.21**	4.891	**0.193**	4.86	**0.187**	5.001
Max3-Min3	0.131	2.884	**0.092**	2.664	**0.093**	3.092	**0.072**	2.772	**0.045**	1.888	**0.036**	1.606
J=12												
Max 1	0.343	3.527	0.278	3.956	0.265	4.412	0.212	4.065	0.186	3.997	0.167	3.88
Max 1-Min1	0.202	2.787	**0.149**	3.177	**0.138**	3.524	**0.09**	2.573	**0.048**	1.488	**0.02**	0.673
Max3	**0.282**	4.442	0.219	4.34	**0.203**	4.57	**0.181**	4.688	**0.153**	4.245	**0.141**	4.21
Max3-Min3	0.118	2.671	0.064	2.025	**0.058**	2.333	**0.037**	1.603	**0.007**	0.299	**−0.005**	-0.264
J=15												
Max 1	0.297	3.033	0.252	3.609	**0.242**	4.101	0.197	3.752	0.159	3.401	0.154	3.657
Max 1-Min1	0.136	1.863	**0.127**	2.631	**0.118**	2.986	**0.073**	2.097	**0.034**	1.055	**0.02**	0.667
Max3	**0.294**	4.202	**0.239**	4.182	**0.222**	4.435	**0.196**	4.639	**0.173**	4.44	**0.16**	4.414
Max3-Min3	**0.142**	3.126	**0.088**	2.544	**0.079**	2.761	**0.053**	2.111	**0.025**	1.073	**0.015**	0.656
J=18												
Max 1	0.28	2.943	**0.251**	3.694	**0.238**	4.149	**0.205**	4.093	**0.173**	3.868	**0.167**	4.072
Max 1-Min1	**0.137**	1.879	**0.127**	2.549	**0.114**	2.762	**0.069**	1.956	**0.035**	1.072	**0.013**	0.43
Max3	**0.294**	4.308	**0.233**	4.147	**0.223**	4.541	**0.196**	4.759	**0.172**	4.497	**0.157**	4.447
Max3-Min3	**0.134**	3.001	**0.086**	2.571	**0.073**	2.534	**0.049**	1.912	**0.018**	0.742	**0.007**	0.301

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table A8e: Performance of big size portfolios with strategy: Pure Momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.202	1.281	0.207	1.877	0.205	2.118	0.218	2.54	0.238	3.127	0.223	3.263
Max 1-Min1	0.111	0.855	0.129	1.387	0.085	1.161	0.105	1.602	0.125	2.185	0.108	2.157
Max3	0.228	2.253	0.197	2.732	0.199	3.351	0.189	3.51	0.179	3.482	0.182	3.76
Max3-Min3	0.134	1.758	0.101	1.867	0.085	1.997	0.082	2.129	0.077	2.251	0.079	2.52
J=3												
Max 1	0.183	1.187	0.114	1.057	0.143	1.52	0.149	1.808	0.15	2.018	0.185	2.742
Max 1-Min1	0.072	0.575	0.005	0.052	0.029	0.397	0.052	0.884	0.061	1.095	0.075	1.523
Max3	0.229	2.398	0.19	2.653	0.216	3.443	0.214	3.612	0.211	3.806	0.207	4.049
Max3-Min3	0.115	1.555	0.08	1.473	0.094	2.133	0.093	2.36	0.091	2.55	0.091	2.877
J=4												
Max 1	0.216	1.335	0.239	2.075	0.246	2.465	0.27	3.054	0.274	3.52	0.296	4.119
Max 1-Min1	0.119	0.931	0.105	1.126	0.111	1.433	0.132	2.053	0.134	2.458	0.157	3.28
Max3	0.217	2.101	0.204	2.631	0.239	3.506	0.232	3.676	0.241	4.119	0.237	4.314
Max3-Min3	0.058	0.778	0.062	1.169	0.088	1.996	0.088	2.264	0.103	2.988	0.104	3.42
J=5												
Max 1	0.243	1.546	0.256	2.265	0.277	2.844	0.256	2.959	0.26	3.323	0.231	3.203
Max 1-Min1	0.141	1.077	0.14	1.454	0.146	1.827	0.137	2.095	0.155	2.841	0.149	3.005
Max3	0.261	2.489	0.245	3.078	0.249	3.653	0.245	4.058	0.252	4.518	0.256	4.861
Max3-Min3	0.115	1.53	0.108	1.954	0.111	2.475	0.108	2.782	0.113	3.371	0.114	3.724
J=6												
Max 1	0.232	1.506	0.26	2.368	0.267	2.849	0.246	3.091	0.245	3.393	0.252	3.787
Max 1-Min1	0.153	1.18	0.157	1.733	0.164	2.245	0.153	2.73	0.15	2.984	0.139	2.974
Max3	0.256	2.466	0.233	3.064	0.257	3.983	0.259	4.441	0.264	4.978	0.263	5.328
Max3-Min3	0.118	1.598	0.098	1.804	0.12	2.689	0.119	3.129	0.117	3.464	0.112	3.774
J=7												
Max 1	0.386	2.479	0.391	3.56	0.378	4.004	0.341	4.196	0.315	4.399	0.323	4.813
Max 1-Min1	0.204	1.54	0.21	2.287	0.204	2.805	0.188	3.008	0.162	2.963	0.152	3.209
Max3	0.238	2.403	0.243	3.317	0.251	4.023	0.256	4.473	0.255	5.013	0.26	5.64
Max3-Min3	0.103	1.373	0.109	2.001	0.116	2.695	0.116	3.061	0.109	3.349	0.109	3.744

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A8f: Performance of big size portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.237**	1.506	0.203	1.806	0.163	1.757	0.141	1.663	0.137	1.834	0.141	2.074
Max 1-Min1	0.093	0.724	0.072	0.766	0.055	0.766	0.065	0.988	0.063	1.102	0.058	1.166
Max3	0.217	2.149	**0.218**	2.998	**0.208**	3.319	0.182	3.187	**0.18**	3.484	0.176	3.565
Max3-Min3	0.107	1.427	**0.106**	1.997	**0.087**	2.038	0.07	1.753	0.068	1.911	0.065	2.026
J=3												
Max 1	**0.325**	2.052	**0.209**	1.741	**0.204**	2.159	0.148	1.726	0.137	1.822	0.135	1.966
Max 1-Min1	**0.184**	1.434	**0.124**	1.31	**0.135**	1.827	**0.108**	1.602	**0.094**	1.569	**0.086**	1.631
Max3	**0.241**	2.36	**0.233**	3.207	**0.219**	3.423	0.175	3.016	0.171	3.2	0.154	3.041
Max3-Min3	**0.117**	1.566	**0.096**	1.763	0.086	1.973	0.064	1.62	0.057	1.573	0.047	1.416
J=4												
Max 1	**0.332**	2.113	**0.244**	2.092	0.236	2.472	0.184	2.135	0.179	2.369	0.174	2.497
Max 1-Min1	**0.141**	1.126	0.1	1.072	0.094	1.275	0.094	1.377	0.091	1.509	0.09	1.686
Max3	**0.228**	2.227	**0.23**	3.043	0.221	3.453	0.192	3.249	0.191	3.577	0.184	3.62
Max3-Min3	**0.115**	1.528	**0.106**	1.942	**0.092**	2.128	0.074	1.857	0.068	1.883	0.065	1.989
J=5												
Max 1	**0.267**	1.702	0.233	2.044	0.185	1.96	0.178	2.078	0.17	2.268	0.172	2.521
Max 1-Min1	0.103	0.806	0.061	0.639	0.055	0.72	0.087	1.269	0.083	1.369	0.084	1.54
Max3	0.253	2.383	0.233	3.077	0.219	3.432	0.186	3.166	0.191	3.583	0.188	3.705
Max3-Min3	**0.142**	1.834	**0.112**	2.012	0.094	2.103	0.073	1.786	0.076	2.044	0.075	2.256
J=6												
Max 1	**0.376**	2.384	0.239	2.078	0.251	2.586	0.22	2.557	0.209	2.754	0.219	3.145
Max 1-Min1	**0.211**	1.667	0.113	1.17	0.129	1.657	0.126	1.868	0.116	1.958	0.115	2.175
Max3	**0.282**	2.687	**0.244**	3.23	0.235	3.721	0.204	3.561	0.209	4.115	0.211	4.326
Max3-Min3	**0.137**	1.827	**0.127**	2.347	**0.122**	2.734	0.1	2.515	0.098	2.73	0.096	3.005
J=7												
Max 1	0.367	2.318	0.226	1.962	0.26	2.713	0.193	2.262	0.183	2.417	0.205	2.946
Max 1-Min1	**0.246**	1.944	0.13	1.352	0.158	2.067	0.133	2.008	0.121	2.065	0.119	2.263
Max3	**0.256**	2.412	0.242	3.148	0.244	3.814	0.201	3.483	0.205	3.974	0.209	4.234
Max3-Min3	**0.108**	1.411	**0.116**	2.09	**0.121**	2.796	0.102	2.581	0.095	2.697	0.096	2.984

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A8g: Performance of big size portfolios with strategy: Mean reversion and momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.312**	1.942	**0.281**	2.375	**0.219**	2.131	**0.235**	2.584	0.225	2.767	0.22	2.965
Max 1-Min1	**0.155**	1.227	**0.143**	1.551	**0.122**	1.691	**0.134**	2.098	**0.134**	2.395	**0.127**	2.591
Max3	**0.301**	2.677	**0.284**	3.484	**0.276**	3.925	**0.26**	4.164	**0.252**	4.219	**0.254**	4.547
Max3-Min3	**0.166**	2.174	**0.146**	2.72	**0.114**	2.628	**0.104**	2.733	**0.107**	3.074	**0.108**	3.369
J=3												
Max 1	**0.215**	1.354	**0.135**	1.223	0.122	1.272	0.127	1.521	0.129	1.678	0.137	1.945
Max 1-Min1	**0.154**	1.251	**0.064**	0.749	**0.053**	0.797	**0.056**	1.029	**0.062**	1.195	0.056	1.244
Max3	**0.339**	3	**0.301**	3.564	**0.311**	4.252	**0.309**	4.548	**0.304**	4.76	**0.286**	4.832
Max3-Min3	**0.153**	1.977	**0.111**	2.039	**0.11**	2.457	**0.113**	2.794	**0.112**	2.975	**0.109**	3.21
J=4												
Max 1	**0.269**	1.677	**0.246**	2.117	0.246	2.433	0.268	3.013	0.253	3.141	0.261	3.517
Max 1-Min1	**0.137**	1.116	**0.107**	1.225	0.097	1.388	0.115	1.848	0.109	2.104	0.117	2.508
Max3	**0.343**	2.896	**0.318**	3.594	**0.317**	4.129	**0.309**	4.359	**0.305**	4.583	**0.285**	4.518
Max3-Min3	**0.096**	1.255	**0.096**	1.788	**0.108**	2.427	**0.109**	2.7	**0.108**	2.97	0.104	3.236
J=5												
Max 1	**0.292**	1.815	0.238	2.066	0.236	2.354	0.234	2.765	0.227	2.878	0.207	2.819
Max 1-Min1	**0.214**	1.701	**0.153**	1.69	0.142	1.901	**0.142**	2.52	0.146	2.952	0.137	2.936
Max3	**0.338**	2.847	**0.323**	3.591	**0.313**	4.032	**0.301**	4.308	**0.291**	4.466	**0.276**	4.445
Max3-Min3	**0.129**	1.638	**0.122**	2.139	**0.123**	2.674	**0.115**	2.834	**0.115**	3.193	0.11	3.378
J=6												
Max 1	**0.351**	2.228	**0.305**	2.683	**0.327**	3.319	**0.311**	3.662	**0.297**	3.703	**0.288**	3.86
Max 1-Min1	**0.221**	1.753	**0.183**	2.081	**0.175**	2.511	**0.166**	3.096	**0.165**	3.425	**0.156**	3.519
Max3	**0.326**	2.844	**0.31**	3.639	**0.311**	4.281	**0.293**	4.449	**0.285**	4.713	**0.273**	4.789
Max3-Min3	**0.141**	1.831	**0.122**	2.23	**0.124**	2.862	0.113	3.036	0.113	3.275	0.107	3.542
J=7												
Max 1	0.381	2.405	0.384	3.441	0.371	3.845	**0.342**	4.065	**0.326**	4.3	0.314	4.426
Max 1-Min1	**0.27**	2.079	**0.219**	2.539	0.201	2.973	0.188	3.209	**0.18**	3.528	**0.162**	3.638
Max3	**0.346**	3.104	**0.303**	3.713	**0.295**	4.27	**0.28**	4.412	**0.266**	4.589	0.259	4.888
Max3-Min3	**0.155**	2.051	**0.136**	2.571	**0.128**	3.124	**0.117**	3.13	**0.11**	3.36	0.103	3.61

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A8h: Performance of big size portfolios with strategy: Mean reversion, momentum and downside risk (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.164	1.036	0.236	2.014	0.161	1.637	0.173	1.937	0.152	1.926	0.174	2.472
Max 1-Min1	0.089	0.713	0.13	1.426	0.088	1.212	0.104	1.625	0.093	1.637	0.092	1.843
Max3	0.273	2.437	0.257	3.12	0.251	3.474	0.227	3.474	0.217	3.628	0.209	3.657
Max3-Min3	0.132	1.717	0.117	2.185	0.097	2.214	0.077	1.923	0.077	2.135	0.072	2.222
J=3												
Max 1	**0.291**	1.898	**0.303**	2.553	**0.237**	2.454	**0.232**	2.65	**0.216**	2.818	**0.219**	3.147
Max 1-Min1	0.142	1.156	**0.158**	1.772	**0.134**	1.879	**0.146**	2.277	**0.128**	2.245	**0.123**	2.417
Max3	0.285	2.47	0.239	2.799	0.236	3.252	0.224	3.378	0.215	3.561	0.207	3.613
Max3-Min3	0.14	1.791	0.109	1.913	0.097	2.138	0.086	2.077	0.08	2.12	0.073	2.137
J=4												
Max 1	0.257	1.63	**0.284**	2.399	0.225	2.284	0.199	2.238	0.179	2.31	0.205	2.906
Max 1-Min1	0.098	0.797	**0.121**	1.365	**0.098**	1.397	0.095	1.47	0.08	1.406	0.093	1.818
Max3	0.319	2.814	0.293	3.45	0.297	4.122	0.271	4.113	0.26	4.317	0.243	4.207
Max3-Min3	**0.137**	1.775	**0.123**	2.242	**0.116**	2.642	0.1	2.484	0.095	2.613	0.083	2.5
J=5												
Max 1	0.231	1.43	**0.272**	2.318	0.193	1.95	0.207	2.327	0.186	2.377	**0.215**	3.01
Max 1-Min1	0.109	0.849	0.125	1.338	0.087	1.141	0.113	1.699	0.105	1.783	0.114	2.16
Max3	0.311	2.714	0.283	3.418	0.276	3.916	0.254	3.918	0.24	4.076	0.223	3.936
Max3-Min3	**0.138**	1.737	0.121	2.127	0.113	2.488	0.095	2.294	0.086	2.299	0.076	2.21
J=6												
Max 1	**0.421**	2.607	**0.365**	3.141	0.293	2.895	0.261	2.933	0.235	2.988	0.264	3.686
Max 1-Min1	**0.244**	1.872	**0.185**	1.929	0.148	1.891	0.135	2.028	0.123	2.099	0.142	2.723
Max3	0.282	2.506	0.269	3.261	0.265	3.834	0.238	3.784	0.233	4.085	0.221	3.997
Max3-Min3	0.11	1.428	0.121	2.134	0.116	2.584	0.1	2.524	0.101	2.815	0.093	2.879
J=7												
Max 1	0.357	2.231	0.339	2.958	0.25	2.607	0.24	2.772	0.222	2.901	0.265	3.745
Max 1-Min1	0.214	1.692	0.173	1.869	0.127	1.719	0.119	1.871	0.112	1.965	0.132	2.575
Max3	0.306	2.624	0.282	3.38	0.277	3.939	0.238	3.735	0.23	3.96	0.224	4.034
Max3-Min3	0.142	1.781	**0.143**	2.502	**0.132**	2.947	0.103	2.547	0.095	2.607	0.092	2.793

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy(in short run).

Table A9a: Performance of small size portfolios with trading strategy: Pure momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.077	0.551	0.161	1.781	0.206	2.489	0.135	1.848	0.089	1.359	0.093	1.516
Max 1-Min1	0.1	1.266	0.175	3.058	0.231	4.3	0.168	3.499	0.137	2.968	0.142	3.309
Max3	0.217	1.752	0.269	3.327	0.285	3.991	0.235	3.7	0.196	3.475	0.182	3.448
Max3-Min3	0.129	2.076	0.17	4.091	0.187	4.791	0.152	4.199	0.126	3.683	0.121	3.89
J=6												
Max 1	0.324	2.231	0.361	3.712	0.316	3.686	0.252	3.289	0.226	3.361	0.19	2.944
Max 1-Min1	0.375	4.477	0.384	6.642	0.309	5.643	0.234	4.609	0.205	4.318	0.186	4.3
Max3	0.363	2.934	0.379	4.543	0.343	4.71	0.287	4.508	0.245	4.351	0.215	3.962
Max3-Min3	0.312	4.738	0.299	6.932	0.265	6.713	0.208	5.601	0.174	5.145	0.15	4.732
J=9												
Max 1	0.331	2.365	0.303	3.057	0.24	2.742	0.187	2.485	0.137	1.97	0.105	1.649
Max 1-Min1	0.372	4.556	0.326	5.201	0.264	4.577	0.219	4.175	0.167	3.343	0.148	3.185
Max3	0.326	2.611	0.314	3.659	0.266	3.731	0.219	3.513	0.173	3.14	0.147	2.937
Max3-Min3	0.282	4.372	0.251	5.392	0.207	5.102	0.161	4.305	0.12	3.452	0.097	3.01
J=12												
Max 1	0.287	2.035	0.287	2.857	0.258	3.005	0.18	2.396	0.114	1.712	0.079	1.297
Max 1-Min1	0.311	3.56	0.315	4.882	0.294	5.109	0.227	4.345	0.173	3.497	0.167	3.676
Max3	0.379	2.949	0.339	3.957	0.332	4.612	0.267	4.248	0.21	3.783	0.183	3.588
Max3-Min3	0.28	4.124	0.243	5.394	0.221	5.559	0.172	4.664	0.132	3.754	0.111	3.375
J=15												
Max 1	0.35	2.609	0.392	3.982	0.306	3.56	0.211	2.866	0.159	2.38	0.122	1.963
Max 1-Min1	0.344	4.113	0.363	5.866	0.296	5.304	0.227	4.43	0.196	4.019	0.175	3.863
Max3	0.358	2.991	0.35	4.227	0.316	4.488	0.262	4.233	0.212	3.841	0.18	3.515
Max3-Min3	0.249	3.866	0.22	5.062	0.191	4.868	0.149	3.984	0.122	3.51	0.101	3.063
J=18												
Max 1	0.409	3.028	0.377	3.803	0.295	3.446	0.218	2.906	0.145	2.134	0.093	1.497
Max 1-Min1	0.387	4.764	0.339	5.578	0.262	4.674	0.224	4.417	0.183	3.819	0.155	3.472
Max3	0.358	3.012	0.342	4.131	0.308	4.371	0.239	3.842	0.191	3.432	0.162	3.206
Max3-Min3	0.269	4.347	0.228	5.087	0.196	4.73	0.152	3.984	0.118	3.26	0.095	2.824

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A9b: Performance of small size portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.252**	1.865	**0.293**	3.298	**0.336**	4.116	**0.270**	3.755	**0.213**	3.314	**0.197**	3.207
Max 1-Min1	**0.281**	3.542	**0.339**	5.756	**0.362**	6.548	**0.314**	6.356	**0.267**	5.644	**0.255**	5.886
Max3	**0.353**	3.028	**0.367**	4.525	**0.374**	5.268	**0.343**	5.491	**0.296**	5.259	**0.271**	5.033
Max3-Min3	**0.249**	3.949	**0.271**	6.022	**0.278**	6.751	**0.256**	6.766	**0.219**	6.102	**0.205**	6.277
J=6												
Max 1	**0.338**	2.317	0.353	3.685	**0.341**	4.045	**0.287**	3.813	**0.252**	3.738	**0.204**	3.185
Max 1-Min1	0.375	4.324	0.362	5.935	**0.326**	5.863	**0.268**	5.199	**0.238**	4.847	**0.207**	4.602
Max3	**0.377**	3.148	**0.39**	4.612	**0.368**	5.039	**0.314**	4.906	**0.263**	4.56	**0.225**	4.033
Max3-Min3	0.302	4.54	0.29	6.337	**0.267**	6.58	**0.211**	5.527	**0.175**	4.845	0.145	4.31
J=9												
Max 1	**0.353**	2.563	**0.348**	3.601	**0.329**	3.932	**0.284**	3.898	**0.224**	3.381	**0.185**	3.029
Max 1-Min1	**0.382**	4.718	**0.343**	5.558	**0.304**	5.305	**0.258**	4.984	**0.204**	4.161	**0.179**	3.95
Max3	**0.337**	2.767	**0.351**	4.194	**0.328**	4.64	**0.277**	4.466	**0.227**	4.065	**0.201**	3.908
Max3-Min3	**0.287**	4.487	**0.268**	5.785	**0.219**	5.257	**0.177**	4.633	**0.14**	3.908	**0.121**	3.619
J=12												
Max 1	**0.313**	2.084	**0.31**	3.042	**0.267**	3.108	**0.186**	2.468	**0.128**	1.916	**0.08**	1.31
Max 1-Min1	0.273	2.977	0.241	3.649	0.178	3.077	0.125	2.372	0.077	1.566	0.062	1.351
Max3	0.343	2.625	0.305	3.443	0.266	3.592	0.205	3.151	0.15	2.599	0.114	2.159
Max3-Min3	0.212	3.091	0.171	3.598	0.138	3.253	0.091	2.324	0.053	1.415	0.029	0.821
J=15												
Max 1	0.302	2.144	0.306	3.011	0.254	2.92	0.181	2.394	0.12	1.798	0.067	1.086
Max 1-Min1	0.267	3.116	0.233	3.64	0.173	3.039	0.122	2.354	0.087	1.783	0.05	1.112
Max3	0.335	2.706	0.298	3.428	0.247	3.363	0.192	2.984	0.141	2.452	0.108	2.067
Max3-Min3	0.216	3.353	0.156	3.429	0.122	2.951	0.082	2.109	0.055	1.488	0.031	0.885
J=18												
Max 1	0.274	1.858	0.256	2.484	0.221	2.581	0.162	2.17	0.108	1.632	0.053	0.89
Max 1-Min1	0.215	2.448	0.178	2.796	0.138	2.443	0.108	2.077	0.063	1.279	0.034	0.749
Max3	0.281	2.214	0.251	2.787	0.202	2.7	0.143	2.193	0.088	1.517	0.056	1.081
Max3-Min3	0.155	2.374	0.114	2.33	0.079	1.809	0.049	1.209	0.01	0.27	-0.01	-0.289

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A9c: Performance of small size portfolios with strategy: Momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.176**	1.236	0.118	1.217	0.112	1.322	0.084	1.115	0.019	0.286	0.02	0.323
Max 1-Min1	**0.154**	1.973	0.116	1.994	0.112	2.152	0.099	2.045	0.044	0.994	0.038	0.915
Max3	0.204	1.704	0.197	2.487	0.193	2.822	0.189	3.117	0.147	2.748	0.143	2.795
Max3-Min3	0.094	1.677	0.099	2.44	0.101	2.758	0.108	3.119	0.08	2.502	0.078	2.6
J=6												
Max 1	0.166	1.213	0.161	1.731	0.172	2.05	0.142	1.889	0.083	1.294	0.084	1.371
Max 1-Min1	0.187	2.43	0.194	3.381	0.189	3.639	0.173	3.614	0.128	2.928	0.121	2.91
Max3	0.253	2.165	0.268	3.368	0.266	3.877	0.244	3.996	0.206	3.807	0.191	3.72
Max3-Min3	0.169	2.995	0.185	4.584	0.182	4.977	0.167	4.775	0.137	4.256	0.128	4.246
J=9												
Max 1	0.145	1.036	0.134	1.396	0.133	1.576	0.109	1.42	0.06	0.924	0.053	0.863
Max 1-Min1	0.188	2.268	0.17	2.776	0.156	2.833	0.15	3.021	0.103	2.278	0.099	2.331
Max3	0.257	2.18	0.227	2.92	0.23	3.394	**0.224**	3.722	**0.181**	3.401	**0.175**	3.447
Max3-Min3	0.151	2.635	0.141	3.539	0.142	3.886	0.143	4.13	0.111	3.497	**0.11**	3.657
J=12												
Max 1	0.282	2.024	0.224	2.488	0.214	2.576	**0.182**	2.401	**0.119**	1.841	**0.102**	1.66
Max 1-Min1	**0.326**	3.828	0.307	5.124	0.278	4.902	**0.252**	4.915	**0.191**	4.007	**0.18**	4.087
Max3	0.345	2.88	0.327	4.037	0.318	4.593	**0.283**	4.558	**0.235**	4.273	**0.217**	4.225
Max3-Min3	0.268	4.417	**0.264**	6.467	**0.246**	6.615	**0.217**	6.204	**0.172**	5.15	**0.163**	5.27
J=15												
Max 1	0.31	2.19	0.238	2.594	0.23	2.731	0.183	2.407	0.104	1.559	0.079	1.241
Max 1-Min1	0.327	3.804	0.28	4.763	0.261	4.763	**0.234**	4.741	0.178	3.844	0.153	3.514
Max3	0.319	2.687	0.293	3.694	0.278	4.036	**0.263**	4.297	**0.221**	4.119	**0.2**	3.958
Max3-Min3	0.225	3.841	0.213	5.254	**0.2**	5.407	**0.188**	5.431	**0.153**	4.76	**0.143**	4.733
J=18												
Max 1	0.27	1.888	0.217	2.298	0.217	2.553	0.173	2.268	0.093	1.401	0.074	1.186
Max 1-Min1	0.289	3.412	0.271	4.506	**0.267**	4.776	**0.246**	4.941	0.178	3.798	0.154	3.478
Max3	0.357	2.991	0.309	3.884	0.301	4.428	**0.279**	4.641	**0.232**	4.291	**0.211**	4.2
Max3-Min3	0.262	4.367	**0.244**	5.912	**0.23**	6.177	**0.214**	6.258	**0.174**	5.478	**0.156**	5.183

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A9d: Performance of small size portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.29**	2.147	0.203	2.226	0.182	2.206	0.161	2.194	0.095	1.516	0.083	1.361
Max 1-Min1	0.273	3.358	0.215	3.687	0.198	3.62	0.19	3.909	0.136	3.044	0.127	3
Max3	0.287	2.43	0.28	3.499	0.261	3.79	0.25	4.133	0.209	3.889	0.197	3.807
Max3-Min3	0.175	3.039	0.175	4.307	0.162	4.345	0.162	4.733	0.129	4.041	0.124	4.097
J=6												
Max 1	0.188	1.375	0.206	2.228	0.207	2.492	0.163	2.205	0.1	1.582	0.086	1.4
Max 1-Min1	0.219	2.727	0.229	3.98	0.211	3.916	0.187	3.897	0.135	3.061	0.125	2.949
Max3	0.337	2.84	0.335	4.119	0.32	4.63	0.286	4.654	0.236	4.343	0.219	4.205
Max3-Min3	0.22	3.822	0.228	5.555	0.218	5.899	0.192	5.564	0.153	4.669	0.14	4.567
J=9												
Max 1	0.23	1.657	0.188	2.033	0.203	2.436	0.165	2.226	0.099	1.564	0.082	1.36
Max 1-Min1	0.288	3.546	0.245	4.259	0.232	4.295	0.209	4.3	0.147	3.307	0.124	2.897
Max3	0.304	2.573	0.267	3.395	0.261	3.861	0.245	4.094	0.2	3.754	0.191	3.722
Max3-Min3	0.195	3.334	0.18	4.579	0.169	4.623	0.164	4.754	0.126	3.931	0.118	3.87
J=12												
Max 1	**0.324**	2.271	0.249	2.645	0.229	2.744	0.175	2.326	0.104	1.635	0.08	1.314
Max 1-Min1	**0.319**	3.812	**0.279**	4.642	**0.233**	4.197	**0.194**	3.865	**0.133**	2.829	**0.113**	2.564
Max3	0.298	2.385	0.282	3.367	0.266	3.716	**0.223**	3.468	**0.173**	3.062	**0.153**	2.903
Max3-Min3	**0.221**	3.496	**0.21**	4.854	**0.176**	4.612	**0.144**	4.02	**0.098**	2.884	**0.086**	2.713
J=15												
Max 1	0.284	1.976	0.221	2.359	0.209	2.464	0.153	2.015	0.088	1.331	0.062	0.988
Max 1-Min1	**0.276**	3.237	**0.248**	4.229	**0.214**	3.885	**0.183**	3.711	**0.133**	2.855	**0.105**	2.356
Max3	0.308	2.56	0.276	3.415	**0.253**	3.648	**0.227**	3.645	**0.179**	3.248	**0.158**	3.038
Max3-Min3	0.207	3.374	**0.191**	4.581	**0.165**	4.366	**0.145**	4.121	**0.105**	3.116	**0.09**	2.881
J=18												
Max 1	0.254	1.727	0.195	2.003	0.182	2.12	0.138	1.814	0.075	1.122	0.05	0.807
Max 1-Min1	**0.252**	2.893	**0.228**	3.754	**0.195**	3.507	**0.167**	3.329	**0.11**	2.34	**0.077**	1.702
Max3	**0.297**	2.448	**0.265**	3.279	**0.245**	3.508	**0.217**	3.485	**0.174**	3.118	**0.15**	2.901
Max3-Min3	**0.189**	3.118	**0.17**	4.074	**0.156**	4.078	**0.136**	3.835	**0.096**	2.856	**0.077**	2.441

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table A9e: Performance of small size portfolios with strategy: Pure Momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.216	0.956	0.147	0.857	0.082	0.614	0.083	0.74	0.118	1.173	0.144	1.541
Max 1-Min1	0.195	1.442	0.128	1.335	0.096	1.283	0.11	1.695	0.137	2.252	0.158	2.793
Max3	0.293	1.426	0.224	1.511	0.194	1.593	0.197	1.848	0.224	2.428	0.231	2.818
Max3-Min3	0.124	1.216	0.105	1.423	0.088	1.441	0.088	1.674	0.105	2.147	0.115	2.584
J=3												
Max 1	0.185	0.791	0.082	0.458	0.077	0.551	0.108	0.905	0.155	1.503	0.161	1.781
Max 1-Min1	0.164	1.192	0.091	0.911	0.1	1.266	0.139	1.954	0.174	2.73	0.175	3.058
Max3	0.284	1.386	0.214	1.414	0.217	1.752	0.247	2.362	0.262	2.93	0.269	3.327
Max3-Min3	0.156	1.471	0.125	1.662	0.129	2.076	0.148	2.888	0.164	3.599	0.17	4.091
J=4												
Max 1	0.233	0.997	0.127	0.725	0.173	1.292	0.206	1.794	0.217	2.164	0.241	2.663
Max 1-Min1	0.231	1.756	0.166	1.687	0.182	2.299	0.211	2.971	0.222	3.494	0.236	4.025
Max3	0.271	1.332	0.249	1.68	0.264	2.141	0.281	2.704	0.295	3.302	0.303	3.709
Max3-Min3	0.168	1.638	0.157	2.116	0.18	2.898	0.203	3.824	0.209	4.556	0.213	5.099
J=5												
Max 1	0.296	1.243	0.231	1.325	0.259	1.828	0.258	2.217	0.277	2.773	0.312	3.285
Max 1-Min1	0.323	2.408	0.268	2.722	0.289	3.569	0.297	4.213	0.313	5.15	0.333	5.641
Max3	0.334	1.626	0.32	2.143	0.34	2.765	0.346	3.358	0.342	3.787	0.349	4.231
Max3-Min3	0.234	2.263	0.234	3.03	0.257	4.046	0.27	4.984	0.262	5.592	0.266	6.113
J=6												
Max 1	0.295	1.211	0.276	1.544	0.324	2.231	0.322	2.673	0.344	3.29	0.361	3.712
Max 1-Min1	0.355	2.716	0.349	3.422	0.375	4.477	0.371	5.34	0.386	6.273	0.384	6.642
Max3	0.361	1.747	0.365	2.411	0.363	2.934	0.367	3.464	0.37	4.069	0.379	4.543
Max3-Min3	0.318	3.013	0.319	3.941	0.312	4.738	0.307	5.602	0.299	6.435	0.299	6.932
J=7												
Max 1	0.281	1.129	0.313	1.721	0.337	2.284	0.328	2.761	0.343	3.178	0.343	3.393
Max 1-Min1	0.392	2.909	0.402	3.944	0.401	4.965	0.392	5.873	0.392	6.37	0.385	6.544
Max3	0.461	2.208	0.393	2.603	0.382	3.079	0.362	3.575	0.36	3.987	0.355	4.294
Max3-Min3	0.384	3.593	0.342	4.269	0.33	5.139	0.307	5.967	0.293	6.264	0.287	6.582

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A9f: Performance of small size portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.251**	1.094	0.098	0.55	**0.103**	0.734	0.056	0.478	0.067	0.621	0.08	0.829
Max 1-Min1	**0.252**	1.815	**0.14**	1.385	**0.119**	1.519	0.077	1.149	0.082	1.285	0.099	1.697
Max3	**0.31**	1.578	0.219	1.513	**0.205**	1.726	**0.198**	1.976	0.21	2.398	0.213	2.672
Max3-Min3	**0.186**	1.818	**0.108**	1.499	**0.099**	1.727	**0.100**	1.984	**0.107**	2.377	**0.117**	2.778
J=3												
Max 1	**0.301**	1.311	**0.203**	1.142	**0.176**	1.236	**0.130**	1.093	0.118	1.092	0.118	1.217
Max 1-Min1	**0.258**	1.892	**0.179**	1.795	**0.154**	1.973	0.114	1.694	0.113	1.786	0.116	1.994
Max3	**0.29**	1.458	**0.217**	1.495	0.204	1.704	0.195	1.905	0.19	2.127	0.197	2.487
Max3-Min3	**0.178**	1.812	0.099	1.435	0.094	1.677	0.09	1.808	0.088	2.018	0.099	2.44
J=4												
Max 1	**0.261**	1.141	0.124	0.697	0.146	1.034	0.098	0.835	0.1	0.927	0.106	1.087
Max 1-Min1	**0.233**	1.698	0.142	1.424	0.142	1.829	0.109	1.679	0.118	1.887	0.123	2.18
Max3	**0.307**	1.55	0.21	1.438	0.196	1.641	0.185	1.83	0.186	2.13	0.193	2.442
Max3-Min3	**0.174**	1.721	0.096	1.369	0.095	1.683	0.091	1.852	0.092	2.1	0.102	2.483
J=5												
Max 1	0.258	1.096	0.129	0.726	0.145	1.021	0.094	0.795	0.089	0.821	0.098	1.008
Max 1-Min1	0.252	1.814	0.156	1.559	0.155	1.987	0.116	1.744	0.115	1.822	0.122	2.154
Max3	0.315	1.591	0.222	1.527	0.209	1.757	0.192	1.909	0.193	2.211	0.196	2.481
Max3-Min3	0.192	1.911	0.111	1.583	0.11	1.934	0.101	2.048	0.104	2.387	0.113	2.767
J=6												
Max 1	0.252	1.098	0.09	0.507	0.166	1.213	0.118	1.038	0.136	1.345	0.161	1.731
Max 1-Min1	0.278	2.017	0.164	1.615	0.187	2.43	0.162	2.451	0.179	2.914	0.194	3.381
Max3	0.338	1.753	0.245	1.723	0.253	2.165	0.242	2.407	0.26	2.95	0.268	3.368
Max3-Min3	0.237	2.348	0.162	2.28	0.169	2.995	0.168	3.356	0.174	3.958	0.185	4.584
J=7												
Max 1	0.259	1.129	0.109	0.62	0.171	1.255	0.121	1.073	0.128	1.272	0.147	1.609
Max 1-Min1	0.271	1.974	0.167	1.687	0.2	2.634	0.177	2.765	0.179	3.002	0.188	3.41
Max3	0.352	1.808	0.258	1.804	0.26	2.187	0.254	2.516	0.258	2.911	0.262	3.284
Max3-Min3	0.238	2.326	0.175	2.42	0.178	3.066	0.18	3.596	0.175	4.005	0.182	4.56

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A9g: Performance of small size portfolios with strategy: Mean reversion and momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.327**	1.48	**0.294**	1.731	**0.212**	1.582	**0.196**	1.781	**0.214**	2.229	**0.230**	2.497
Max 1-Min1	**0.313**	2.314	**0.283**	2.859	**0.21**	2.791	**0.218**	3.393	**0.242**	4.109	**0.253**	4.518
Max3	**0.354**	1.739	**0.305**	2.061	**0.286**	2.384	**0.285**	2.758	**0.293**	3.29	**0.296**	3.7
Max3-Min3	**0.266**	2.489	**0.232**	3.024	**0.213**	3.437	**0.201**	3.946	**0.205**	4.453	**0.212**	5.018
J=3												
Max 1	**0.39**	1.728	**0.284**	1.626	**0.252**	1.865	**0.277**	2.419	**0.279**	2.881	**0.293**	3.298
Max 1-Min1	**0.402**	2.84	**0.297**	2.91	**0.281**	3.542	**0.299**	4.366	**0.321**	5.113	**0.339**	5.756
Max3	**0.411**	2.072	**0.348**	2.408	**0.353**	3.028	**0.376**	3.762	**0.377**	4.234	**0.367**	4.525
Max3-Min3	**0.293**	2.682	**0.249**	3.187	**0.249**	3.949	**0.272**	5.032	**0.275**	5.704	**0.271**	6.022
J=4												
Max 1	**0.362**	1.552	**0.278**	1.654	**0.289**	2.056	**0.304**	2.581	**0.296**	2.946	**0.308**	3.308
Max 1-Min1	**0.39**	2.811	**0.323**	3.232	**0.333**	4	**0.342**	4.618	**0.345**	5.286	**0.348**	5.606
Max3	**0.323**	1.608	**0.313**	2.138	**0.335**	2.84	**0.347**	3.441	**0.353**	3.932	**0.361**	4.395
Max3-Min3	**0.223**	2.117	**0.229**	2.964	**0.253**	3.964	**0.266**	4.847	**0.266**	5.455	**0.268**	5.759
J=5												
Max 1	**0.391**	1.689	**0.353**	2.02	**0.333**	2.358	**0.316**	2.699	**0.323**	3.224	**0.350**	3.694
Max 1-Min1	**0.388**	2.858	**0.375**	3.639	**0.375**	4.377	**0.365**	4.863	**0.360**	5.461	**0.377**	5.871
Max3	**0.397**	1.937	**0.369**	2.488	**0.354**	2.939	0.346	3.386	**0.358**	3.957	**0.372**	4.435
Max3-Min3	**0.315**	2.946	**0.300**	3.681	**0.296**	4.447	**0.286**	5.085	**0.285**	5.569	**0.290**	5.966
J=6												
Max 1	**0.391**	1.619	**0.287**	1.611	**0.338**	2.317	0.321	2.757	0.343	3.306	0.353	3.685
Max 1-Min1	**0.417**	3.145	**0.360**	3.461	0.375	4.324	0.352	5.015	0.361	5.65	0.362	5.935
Max3	**0.405**	1.967	**0.382**	2.549	**0.377**	3.148	**0.371**	3.596	**0.373**	4.044	**0.390**	4.612
Max3-Min3	**0.335**	3.108	0.308	3.721	0.302	4.54	0.294	5.323	0.286	5.827	0.29	6.337
J=7												
Max 1	**0.379**	1.554	**0.337**	1.872	**0.338**	2.317	0.323	2.768	0.336	3.251	0.342	3.545
Max 1-Min1	**0.415**	2.992	0.388	3.752	0.374	4.534	0.361	5.152	0.358	5.676	0.363	6.165
Max3	0.421	2.025	0.37	2.457	0.367	3.018	0.356	3.488	**0.366**	3.99	**0.376**	4.49
Max3-Min3	0.338	3.128	0.298	3.653	0.284	4.373	0.269	5.068	0.265	5.383	0.272	6.035

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A9h: Performance of small size portfolios with strategy: Mean reversion, momentum and downside risk (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.446**	2.01	0.288	1.644	**0.288**	2.114	**0.218**	1.914	0.214	2.125	0.208	2.284
Max 1-Min1	**0.402**	2.872	0.27	2.635	**0.255**	3.232	0.215	3.166	0.216	3.432	0.218	3.749
Max3	**0.387**	1.991	0.295	2.082	**0.291**	2.482	0.267	2.758	0.285	3.277	0.288	3.649
Max3-Min3	0.252	2.449	0.186	2.572	0.186	3.173	0.176	3.456	0.18	4.04	0.187	4.558
J=3												
Max 1	**0.485**	2.228	**0.318**	1.864	**0.290**	2.147	0.233	2.047	0.208	2.097	0.203	2.226
Max 1-Min1	**0.408**	2.942	**0.301**	2.949	0.273	3.358	0.232	3.287	0.216	3.378	0.215	3.687
Max3	0.386	1.992	0.293	2.069	0.287	2.43	0.262	2.633	0.277	3.114	0.28	3.499
Max3-Min3	0.258	2.56	0.17	2.419	0.175	3.039	0.164	3.228	0.17	3.823	0.175	4.307
J=4												
Max 1	**0.419**	1.859	0.258	1.496	0.286	2.14	0.234	2.09	0.225	2.279	0.24	2.654
Max 1-Min1	0.379	2.693	0.251	2.441	0.258	3.217	0.227	3.295	0.218	3.491	0.229	4.004
Max3	**0.351**	1.799	0.257	1.809	0.255	2.178	0.243	2.493	0.258	2.961	0.265	3.32
Max3-Min3	0.208	2.048	0.143	1.962	0.15	2.529	0.151	2.945	0.154	3.409	0.162	3.885
J=5												
Max 1	**0.415**	1.841	0.248	1.425	0.273	2.026	0.224	1.993	0.221	2.212	0.234	2.585
Max 1-Min1	**0.392**	2.786	0.262	2.545	0.266	3.311	0.229	3.333	0.22	3.504	0.226	3.91
Max3	0.377	1.93	0.27	1.907	0.269	2.295	0.25	2.557	0.262	3.009	0.272	3.402
Max3-Min3	0.236	2.315	0.159	2.219	0.164	2.813	0.159	3.139	0.159	3.588	0.169	4.088
J=6												
Max 1	0.31	1.375	0.14	0.796	0.188	1.375	0.16	1.399	0.178	1.739	0.206	2.228
Max 1-Min1	0.332	2.368	0.219	2.102	0.219	2.727	0.206	2.992	0.211	3.338	0.229	3.98
Max3	**0.412**	2.128	0.321	2.255	0.337	2.84	0.32	3.124	0.33	3.662	0.335	4.119
Max3-Min3	0.284	2.782	0.211	2.921	0.22	3.822	0.218	4.251	0.218	4.884	0.228	5.555
J=7												
Max 1	**0.428**	1.917	0.227	1.296	0.248	1.819	0.211	1.869	0.214	2.128	0.224	2.475
Max 1-Min1	0.394	2.829	0.261	2.558	0.262	3.36	0.247	3.723	0.256	4.188	0.259	4.679
Max3	0.376	1.924	0.306	2.157	0.319	2.715	0.292	2.975	0.307	3.461	0.315	3.948
Max3-Min3	0.263	2.571	0.205	2.814	0.208	3.532	0.207	4.11	0.209	4.698	0.217	5.37

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy(in short run).

Table A10a: Performance of low book-to-market portfolios with trading strategy: Pure momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.085	0.691	0.152	1.881	0.148	2.057	0.088	1.463	0.07	1.349	0.067	1.293
Max 1-Min1	0.214	2.422	0.262	4.338	0.249	4.645	0.171	3.761	0.154	3.604	0.162	4.118
Max3	0.028	0.27	0.084	1.226	0.071	1.251	0.026	0.54	0.006	0.159	0.002	0.054
Max3-Min3	0.077	1.203	0.138	3.287	0.134	3.617	0.096	3.054	0.08	2.675	0.084	3.171
J=6												
Max 1	0.222	1.713	0.224	2.689	0.158	2.147	0.089	1.482	0.107	2.014	0.086	1.722
Max 1-Min1	0.369	3.948	0.358	5.938	0.258	4.837	0.177	3.618	0.166	3.707	0.177	4.364
Max3	0.234	2.172	0.2	3.042	0.143	2.591	0.1	2.169	0.074	1.839	0.055	1.445
Max3-Min3	0.292	4.133	0.255	6.094	0.201	5.75	0.146	4.554	0.127	4.373	0.117	4.309
J=9												
Max 1	0.203	1.648	0.156	1.83	0.079	1.02	0.072	1.124	0.075	1.36	0.089	1.781
Max 1-Min1	0.386	4.306	0.304	4.96	0.215	3.941	0.172	3.617	0.161	3.674	0.189	4.715
Max3	0.202	1.962	0.168	2.441	0.124	2.319	0.08	1.764	0.055	1.399	0.052	1.439
Max3-Min3	0.278	4.186	0.24	5.393	0.177	4.71	0.139	4.316	0.124	4.21	0.129	4.784
J=12												
Max 1	0.12	0.964	0.133	1.552	0.097	1.323	0.11	1.895	0.131	2.616	0.131	2.808
Max 1-Min1	0.288	3.194	0.241	3.909	0.206	3.74	0.187	3.891	0.212	4.832	0.241	6.057
Max3	0.137	1.308	0.103	1.582	0.083	1.601	0.055	1.255	0.054	1.414	0.048	1.399
Max3-Min3	0.209	3.111	0.154	3.556	0.135	3.653	0.111	3.401	0.117	3.829	0.121	4.344
J=15												
Max 1	0.189	1.606	0.2	2.638	0.151	2.297	0.166	3.177	0.168	3.628	0.132	2.962
Max 1-Min1	0.256	2.795	0.239	3.66	0.203	3.62	0.211	4.322	0.243	5.595	0.249	6.371
Max3	0.107	1.137	0.11	1.827	0.106	2.142	0.093	2.201	0.081	2.177	0.064	1.861
Max3-Min3	0.148	2.228	0.134	3.079	0.139	3.83	0.135	4.193	0.14	4.801	0.137	5.295
J=18												
Max 1	0.251	2.413	0.21	2.816	0.195	3.14	0.193	3.619	0.149	3.079	0.119	2.635
Max 1-Min1	0.273	2.993	0.246	3.799	0.228	4.078	0.239	4.888	0.241	5.628	0.257	6.596
Max3	0.116	1.289	0.133	2.251	0.132	2.638	0.112	2.663	0.089	2.39	0.067	1.994
Max3-Min3	0.145	2.229	0.153	3.562	0.155	4.043	0.147	4.402	0.142	4.742	0.135	4.925

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A10b: Performance of low book-to-market portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.082	0.686	0.115	1.391	0.094	1.282	0.039	0.626	0.03	0.558	0.029	0.545
Max 1-Min1	0.189	2.223	0.221	3.687	0.191	3.428	0.117	2.492	0.102	2.331	0.098	2.422
Max3	-0.005	-0.054	0.013	0.196	0.007	0.135	-0.035	-0.747	-0.039	-0.977	-0.032	-0.822
Max3-Min3	0.033	0.523	0.075	1.827	0.066	1.784	0.035	1.115	0.029	0.962	0.039	1.434
J=6												
Max 1	0.174	1.317	0.128	1.476	0.033	0.433	-0.017	-0.266	0.015	0.279	0.015	0.292
Max 1-Min1	0.31	3.314	0.266	4.2	0.137	2.364	0.071	1.393	0.068	1.465	0.077	1.797
Max3	0.103	1.036	0.099	1.599	0.041	0.772	0.003	0.056	0.003	0.077	0.005	0.139
Max3-Min3	0.145	2.166	0.131	3.178	0.086	2.408	0.045	1.414	0.046	1.538	0.055	1.969
J=9												
Max 1	0.05	0.394	0.019	0.215	-0.066	-0.855	-0.06	-0.929	-0.032	-0.579	-0.001	-0.02
Max 1-Min1	0.197	2.184	0.15	2.387	0.05	0.894	0.021	0.428	0.027	0.61	0.05	1.214
Max3	0.094	0.957	0.058	0.857	0.001	0.027	-0.028	-0.612	-0.032	-0.8	-0.023	-0.642
Max3-Min3	0.128	1.968	0.099	2.197	0.044	1.164	0.018	0.546	0.022	0.724	0.032	1.161
J=12												
Max 1	-0.034	-0.251	0.004	0.043	-0.036	-0.476	-0.035	-0.553	0.009	0.168	0.03	0.593
Max 1-Min1	0.08	0.851	0.053	0.821	0.022	0.383	-0.001	-0.015	0.03	0.65	0.055	1.311
Max3	0.032	0.309	0.015	0.239	-0.005	-0.099	-0.02	-0.48	-0.015	-0.413	-0.007	-0.22
Max3-Min3	0.047	0.723	0.023	0.543	0.007	0.176	-0.003	-0.103	0.01	0.323	0.024	0.854
J=15												
Max 1	-0.07	-0.553	-0.009	-0.107	-0.018	-0.256	0.023	0.396	0.049	0.979	0.031	0.654
Max 1-Min1	-0.002	-0.016	0.025	0.37	-0.002	-0.04	0.008	0.149	0.035	0.76	0.034	0.827
Max3	0.005	0.061	-0.015	-0.237	0.001	0.025	0.007	0.169	0.013	0.365	0.014	0.423
Max3-Min3	0.01	0.159	-0.012	-0.281	-0.003	-0.073	0.001	0.023	0.014	0.467	0.017	0.606
J=18												
Max 1	-0.015	-0.124	0.028	0.346	0.082	1.183	0.095	1.691	0.089	1.862	0.086	1.859
Max 1-Min1	0.02	0.216	0.036	0.553	0.059	1.039	0.065	1.353	0.06	1.394	0.067	1.673
Max3	-0.071	-0.8	-0.005	-0.079	0.022	0.445	0.026	0.632	0.021	0.585	0.021	0.63
Max3-Min3	-0.027	-0.453	0.008	0.187	0.021	0.543	0.025	0.757	0.021	0.671	0.019	0.683

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A10c: Performance of low book-to-market portfolios with strategy: Momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	-0.024	-0.188	0.039	0.446	0.031	0.406	0.018	0.261	-0.018	-0.323	-0.015	-0.29
Max 1-Min1	0.148	1.755	0.185	2.982	0.175	3.392	0.163	3.509	0.126	3.043	0.124	3.213
Max3	0.001	0.014	0.042	0.605	0.031	0.544	0.021	0.424	0.001	0.03	-0.007	-0.191
Max3-Min3	**0.085**	1.468	0.123	3.04	0.113	3.351	0.095	3.241	0.074	2.745	0.069	2.858
J=6												
Max 1	-0.031	-0.251	0.043	0.49	0.04	0.54	0.028	0.417	-0.002	-0.043	-0.005	-0.099
Max 1-Min1	0.156	1.858	0.209	3.345	0.201	3.876	0.173	3.724	0.134	3.236	0.132	3.511
Max3	0	-0.002	0.068	0.934	0.056	0.955	0.036	0.715	0.012	0.283	0.005	0.116
Max3-Min3	0.088	1.339	0.153	3.517	0.134	3.618	0.107	3.387	0.085	2.952	0.085	3.292
J=9												
Max 1	-0.019	-0.16	0.055	0.641	0.034	0.473	0.019	0.3	0.009	0.172	0.004	0.078
Max 1-Min1	0.134	1.603	0.189	3.025	0.173	3.304	0.156	3.374	0.126	3.027	0.13	3.417
Max3	0.024	0.225	0.074	1.031	0.061	1.033	0.04	0.802	0.017	0.42	0.01	0.272
Max3-Min3	0.101	1.591	0.158	3.67	0.134	3.667	0.108	3.411	0.088	3.092	0.09	3.512
J=12												
Max 1	0.001	0.007	0.057	0.684	0.048	0.664	0.031	0.511	0.029	0.568	0.033	0.663
Max 1-Min1	0.193	2.393	0.238	3.884	**0.216**	4.144	0.185	4.031	0.168	3.965	0.177	4.659
Max3	0.055	0.524	**0.103**	1.482	**0.093**	1.642	**0.069**	1.419	0.045	1.127	0.038	0.997
Max3-Min3	0.134	2.039	0.179	3.991	**0.155**	4.214	**0.133**	4.202	0.113	3.941	0.118	4.553
J=15												
Max 1	-0.004	-0.032	0.037	0.438	0.036	0.495	0.03	0.483	0.018	0.336	0.007	0.143
Max 1-Min1	0.179	2.21	0.2	3.414	**0.204**	3.929	0.179	3.993	0.148	3.585	0.149	3.994
Max3	0.026	0.254	0.092	1.331	0.084	1.479	0.067	1.362	0.043	1.058	0.033	0.844
Max3-Min3	0.101	1.568	**0.163**	3.668	**0.14**	3.756	0.121	3.778	0.102	3.503	0.103	3.935
J=18												
Max 1	0.06	0.508	0.104	1.241	0.101	1.414	0.081	1.339	0.055	1.07	0.047	0.956
Max 1-Min1	0.229	2.756	**0.255**	4.365	**0.259**	5.012	0.221	4.827	0.188	4.507	0.187	4.876
Max3	0.068	0.672	0.121	1.78	0.104	1.866	0.088	1.832	0.054	1.319	0.041	1.078
Max3-Min3	0.123	1.922	**0.183**	4.18	**0.161**	4.256	0.14	4.395	0.111	3.795	0.108	4.08

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A10d: Performance of low book-to-market portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	-0.052	-0.411	-0.02	-0.24	-0.028	-0.392	-0.026	-0.392	-0.053	-0.957	-0.045	-0.859
Max 1-Min1	0.055	0.624	0.127	2.068	0.116	2.245	0.106	2.29	0.077	1.875	0.076	2.018
Max3	-0.027	-0.275	0.009	0.136	-0.002	-0.032	**−0.001**	-0.026	**−0.02**	-0.503	**−0.024**	-0.629
Max3-Min3	**0.041**	0.72	**0.085**	2.159	**0.075**	2.185	**0.067**	2.22	**0.046**	1.67	**0.044**	1.749
J=6												
Max 1	-0.089	-0.726	-0.029	-0.343	-0.037	-0.506	-0.037	-0.561	-0.05	-0.933	-0.048	-0.929
Max 1-Min1	0.066	0.753	0.153	2.48	0.114	2.196	**0.098**	2.106	**0.072**	1.762	0.072	1.891
Max3	-0.043	-0.428	0.03	0.425	0.012	0.213	-0.009	-0.184	-0.027	-0.644	-0.027	-0.829
Max3-Min3	0.011	0.178	0.089	2.091	0.074	2.004	**0.051**	1.588	0.032	1.079	0.037	1.381
J=9												
Max 1	-0.024	-0.194	0.002	0.026	**−0.022**	-0.301	**−0.046**	-0.737	-0.057	-1.083	-0.048	-0.974
Max 1-Min1	0.098	1.197	0.149	2.405	**0.118**	2.296	**0.085**	1.84	**0.065**	1.558	**0.068**	1.821
Max3	0	0.003	0.027	0.391	**0.007**	0.129	**−0.015**	-0.3	-0.034	-0.843	-0.035	-0.902
Max3-Min3	0.047	0.772	0.098	2.334	**0.075**	2.076	**0.054**	1.714	**0.034**	1.186	**0.038**	1.475
J=12												
Max 1	**0.003**	0.027	**0.014**	0.166	**0.004**	0.056	**−0.027**	-0.433	-0.02	-0.379	-0.003	-0.054
Max 1-Min1	**0.121**	1.497	**0.158**	2.566	**0.118**	2.271	**0.078**	1.682	**0.069**	1.6	**0.081**	2.123
Max3	0.014	0.135	**0.047**	0.675	**0.034**	0.611	**0.001**	0.019	-0.017	-0.437	-0.019	-0.51
Max3-Min3	**0.052**	0.823	**0.101**	2.29	**0.09**	2.482	**0.062**	1.956	**0.046**	1.568	**0.048**	1.85
J=15												
Max 1	**−0.046**	-0.382	-0.02	-0.24	**−0.016**	-0.22	-0.04	-0.66	-0.034	-0.629	-0.024	-0.478
Max 1-Min1	**0.08**	0.994	**0.12**	2.052	**0.102**	1.949	**0.066**	1.419	**0.055**	1.292	**0.067**	1.747
Max3	-0.002	-0.017	**0.039**	0.573	**0.027**	0.477	0.007	0.141	-0.015	-0.359	-0.022	-0.564
Max3-Min3	**0.044**	0.699	**0.097**	2.217	**0.079**	2.159	**0.06**	1.887	**0.04**	1.386	**0.041**	1.555
J=18												
Max 1	**0.044**	0.361	**0.048**	0.58	0.045	0.639	0.012	0.193	0.004	0.081	0.011	0.23
Max 1-Min1	**0.158**	1.953	**0.185**	2.942	**0.16**	3.037	**0.117**	2.491	**0.09**	2.134	**0.094**	2.487
Max3	**0**	-0.003	**0.046**	0.675	**0.052**	0.936	0.024	0.499	0	-0.005	-0.005	-0.12
Max3-Min3	**0.044**	0.708	**0.099**	2.276	**0.096**	2.533	**0.072**	2.242	**0.051**	1.718	**0.053**	1.986

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table A10e: Performance of low book-to-market portfolios with strategy: Pure Momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.136	0.646	0.036	0.231	0.045	0.358	0.081	0.79	0.096	1.055	0.103	1.23
Max 1-Min1	0.274	1.747	0.158	1.455	0.189	2.158	0.22	2.991	0.229	3.483	0.217	3.632
Max3	0.068	0.364	0.024	0.177	0.047	0.45	0.058	0.653	0.049	0.627	0.058	0.827
Max3-Min3	0.094	0.801	0.067	0.828	0.092	1.419	0.112	2.011	0.111	2.275	0.12	2.82
J=3												
Max 1	0.144	0.645	0.08	0.505	0.085	0.691	0.181	1.692	0.196	2.116	0.152	1.881
Max 1-Min1	0.219	1.381	0.184	1.688	0.214	2.422	0.279	3.562	0.287	4.194	0.262	4.338
Max3	0.061	0.326	0.029	0.212	0.028	0.27	0.075	0.854	0.078	1.03	0.084	1.226
Max3-Min3	0.096	0.812	0.059	0.711	0.077	1.203	0.116	2.163	0.128	2.731	0.138	3.287
J=4												
Max 1	-0.102	-0.473	-0.062	-0.403	0.059	0.482	0.12	1.124	0.111	1.2	0.098	1.173
Max 1-Min1	0.158	1.026	0.172	1.557	0.243	2.687	0.281	3.416	0.281	4.033	0.275	4.347
Max3	0.063	0.364	0.036	0.289	0.059	0.625	0.099	1.202	0.107	1.462	0.105	1.589
Max3-Min3	0.068	0.617	0.067	0.849	0.105	1.703	0.148	2.728	0.157	3.387	0.157	3.769
J=5												
Max 1	0.032	0.146	0.086	0.518	0.185	1.455	0.173	1.614	0.171	1.835	0.167	2.002
Max 1-Min1	0.255	1.639	0.264	2.338	0.321	3.472	0.311	3.873	0.311	4.592	0.315	5.113
Max3	0.083	0.467	0.103	0.819	0.126	1.273	0.158	1.868	0.15	2.013	0.142	2.193
Max3-Min3	0.169	1.473	0.173	2.113	0.2	3.073	0.226	4.06	0.221	4.653	0.216	5.115
J=6												
Max 1	0.137	0.59	0.225	1.337	0.222	1.713	0.231	2.111	0.223	2.39	0.224	2.689
Max 1-Min1	0.348	2.169	0.38	3.212	0.369	3.948	0.372	4.744	0.366	5.388	0.358	5.938
Max3	0.189	1.047	0.219	1.667	0.234	2.172	0.205	2.332	0.199	2.562	0.2	3.042
Max3-Min3	0.264	2.261	0.272	3.152	0.292	4.133	0.273	4.736	0.261	5.404	0.255	6.094
J=7												
Max 1	0.208	0.931	0.185	1.103	0.226	1.772	0.22	2.087	0.249	2.568	0.248	2.735
Max 1-Min1	0.444	2.822	0.408	3.487	0.407	4.508	0.395	5.143	0.39	5.631	0.37	5.95
Max3	0.239	1.304	0.203	1.555	0.206	1.974	0.189	2.253	0.187	2.486	0.18	2.569
Max3-Min3	0.299	2.57	0.274	3.237	0.282	4.197	0.263	4.94	0.249	5.486	0.235	5.795

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A10f: Performance of low book-to-market portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.159**	0.735	0.016	0.097	-0.035	-0.274	0.012	0.118	-0.023	-0.251	0.019	0.228
Max 1-Min1	**0.326**	2.043	**0.175**	1.509	0.12	1.427	0.157	2.164	0.146	2.233	0.169	2.749
Max3	**0.135**	0.727	0.002	0.015	0.008	0.078	**0.061**	0.671	0.045	0.563	0.046	0.623
Max3-Min3	**0.18**	1.562	0.067	0.815	0.073	1.128	**0.129**	2.269	**0.12**	2.519	0.119	2.766
J=3												
Max 1	**0.174**	0.794	0.019	0.112	-0.024	-0.188	0.031	0.294	-0.003	-0.03	0.039	0.446
Max 1-Min1	**0.323**	2.021	**0.192**	1.664	0.148	1.755	0.185	2.543	0.161	2.436	0.185	2.982
Max3	**0.1**	0.555	-0.005	-0.037	0.001	0.014	0.044	0.519	0.03	0.394	0.042	0.605
Max3-Min3	**0.17**	1.568	**0.076**	1.012	**0.085**	1.468	**0.131**	2.497	0.122	2.735	0.123	3.04
J=4												
Max 1	**0.197**	0.907	**0.052**	0.31	-0.015	-0.114	0.038	0.368	0.004	0.04	0.037	0.423
Max 1-Min1	**0.324**	2.023	**0.202**	1.734	0.143	1.683	0.188	2.565	0.17	2.55	0.189	3.019
Max3	**0.131**	0.714	0.012	0.09	0.007	0.068	0.062	0.699	0.048	0.619	0.054	0.762
Max3-Min3	**0.188**	1.62	**0.08**	0.973	0.074	1.154	0.128	2.275	0.124	2.584	0.125	2.907
J=5												
Max 1	**0.221**	1.02	0.072	0.43	-0.001	-0.004	0.054	0.52	0.017	0.187	0.057	0.655
Max 1-Min1	**0.314**	1.963	0.197	1.7	0.133	1.572	0.18	2.463	0.159	2.403	0.181	2.911
Max3	**0.12**	0.653	-0.001	-0.004	-0.003	-0.028	0.051	0.582	0.041	0.536	0.045	0.636
Max3-Min3	**0.184**	1.582	0.076	0.921	0.072	1.144	0.128	2.32	0.124	2.609	0.125	2.949
J=6												
Max 1	0.124	0.576	0.004	0.026	-0.031	-0.251	0.035	0.342	-0.007	-0.071	0.043	0.49
Max 1-Min1	0.329	2.08	0.197	1.713	0.156	1.858	0.198	2.674	0.184	2.755	0.209	3.345
Max3	0.107	0.579	-0.013	-0.094	0	-0.002	0.062	0.675	0.057	0.704	0.068	0.934
Max3-Min3	0.176	1.51	0.079	0.951	0.088	1.339	0.149	2.581	0.151	3.108	0.153	3.517
J=7												
Max 1	0.128	0.602	0.002	0.014	-0.02	-0.166	0.039	0.385	0.001	0.015	0.046	0.531
Max 1-Min1	0.32	2.043	0.201	1.751	0.168	1.968	0.209	2.851	0.188	2.847	0.209	3.347
Max3	0.136	0.75	0.012	0.09	0.018	0.172	0.078	0.903	0.07	0.898	0.083	1.158
Max3-Min3	0.194	1.674	0.097	1.191	0.102	1.603	0.164	2.945	0.161	3.357	0.166	3.809

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A10g: Performance of low book-to-market portfolios with strategy: Mean reversion and momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.087	0.418	-0.03	-0.203	-0.006	-0.051	0.047	0.477	0.068	0.76	0.06	0.729
Max 1-Min1	0.167	1.043	0.103	0.978	0.127	1.485	0.181	2.543	0.202	3.115	0.186	3.176
Max3	0.009	0.049	-0.004	-0.032	0.014	0.145	0.017	0.208	0.021	0.278	0.033	0.479
Max3-Min3	0.039	0.347	0.023	0.302	0.043	0.685	0.062	1.215	0.078	1.66	0.086	2.033
J=3												
Max 1	**0.166**	0.774	**0.102**	0.671	0.082	0.686	0.149	1.435	0.145	1.598	0.115	1.391
Max 1-Min1	0.152	0.967	0.162	1.543	0.189	2.223	0.246	3.188	0.254	3.659	0.221	3.687
Max3	**0.08**	0.435	0.027	0.207	-0.005	-0.054	0.011	0.125	0.005	0.064	0.013	0.196
Max3-Min3	0.072	0.623	0.041	0.5	0.033	0.523	0.059	1.124	0.068	1.506	0.075	1.827
J=4												
Max 1	**−0.031**	-0.145	**0.08**	0.533	**0.105**	0.871	**0.156**	1.488	**0.142**	1.565	**0.131**	1.592
Max 1-Min1	0.116	0.767	**0.221**	2.114	**0.246**	2.815	**0.282**	3.486	0.266	3.809	0.247	3.893
Max3	0.046	0.273	0.002	0.015	0.012	0.132	0.038	0.472	0.029	0.419	0.03	0.488
Max3-Min3	0.056	0.52	0.036	0.475	0.059	0.981	0.088	1.645	0.09	2.028	0.086	2.093
J=5												
Max 1	**0.075**	0.357	0.081	0.529	0.102	0.813	0.126	1.167	0.118	1.251	0.094	1.136
Max 1-Min1	0.253	1.679	0.243	2.229	0.272	2.926	0.285	3.486	0.276	3.914	0.255	3.891
Max3	0.021	0.128	0.031	0.261	0.058	0.623	0.071	0.91	0.078	1.134	0.068	1.126
Max3-Min3	0.102	0.937	0.101	1.27	0.119	1.888	0.134	2.463	0.136	2.873	0.13	3.023
J=6												
Max 1	**0.205**	0.902	0.214	1.265	0.174	1.317	0.165	1.466	0.125	1.263	0.128	1.476
Max 1-Min1	0.281	1.775	0.317	2.699	0.31	3.314	0.301	3.754	0.276	3.866	0.266	4.2
Max3	0.06	0.344	0.063	0.494	0.103	1.036	0.09	1.087	0.089	1.245	0.099	1.599
Max3-Min3	0.114	1.011	0.114	1.376	0.145	2.166	0.138	2.463	0.129	2.781	0.131	3.178
J=7												
Max 1	0.207	0.955	0.129	0.791	0.119	0.955	0.111	1.073	0.104	1.085	0.11	1.301
Max 1-Min1	0.361	2.357	0.321	2.876	0.311	3.583	0.289	3.771	0.264	3.843	0.248	3.955
Max3	0.092	0.521	0.078	0.617	0.09	0.932	0.07	0.905	0.075	1.043	0.067	1.039
Max3-Min3	0.154	1.369	0.146	1.804	0.159	2.47	0.14	2.723	0.127	2.825	0.12	2.953

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A10h: Performance of low book-to-market portfolios with strategy: Mean reversion, momentum and downside risk (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.124**	0.572	**0.052**	0.316	-0.052	-0.42	-0.01	-0.097	-0.057	-0.635	-0.034	-0.397
Max 1-Min1	**0.221**	1.379	**0.122**	1.067	0.061	0.692	0.105	1.449	0.102	1.565	0.114	1.864
Max3	**0.055**	0.307	-0.049	-0.38	-0.038	-0.377	**0.019**	0.226	-0.001	-0.009	0.008	0.116
Max3-Min3	**0.106**	0.944	**0.027**	0.342	0.028	0.463	**0.091**	1.703	**0.089**	1.955	**0.089**	2.126
J=3												
Max 1	**0.17**	0.78	0.026	0.157	-0.052	-0.411	0.004	0.044	-0.049	-0.551	-0.02	-0.24
Max 1-Min1	**0.232**	1.433	0.108	0.949	0.055	0.624	0.114	1.553	0.111	1.692	0.127	2.068
Max3	0.078	0.447	-0.035	-0.277	-0.027	-0.275	**0.016**	0.19	0.001	0.013	0.009	0.136
Max3-Min3	**0.148**	1.399	**0.048**	0.643	**0.041**	0.72	**0.088**	1.699	**0.088**	2.031	**0.085**	2.159
J=4												
Max 1	**0.116**	0.538	0.008	0.05	-0.071	-0.563	-0.012	-0.116	-0.057	-0.632	-0.027	-0.314
Max 1-Min1	**0.176**	1.089	0.113	0.987	0.052	0.578	0.112	1.51	0.114	1.726	0.135	2.182
Max3	**0.052**	0.296	-0.054	-0.424	-0.055	-0.555	-0.002	-0.023	-0.011	-0.149	0	0.005
Max3-Min3	**0.107**	0.959	0.011	0.139	0.009	0.156	0.067	1.266	0.072	1.574	0.074	1.797
J=5												
Max 1	**0.085**	0.394	-0.013	-0.081	-0.081	-0.649	-0.026	-0.259	-0.062	-0.687	-0.028	-0.323
Max 1-Min1	0.164	1.017	0.09	0.79	0.041	0.458	0.096	1.29	0.104	1.569	0.129	2.07
Max3	**0.061**	0.345	-0.064	-0.501	-0.063	-0.635	-0.009	-0.111	-0.02	-0.27	-0.007	-0.108
Max3-Min3	**0.12**	1.074	0.016	0.199	0.011	0.182	0.069	1.33	0.073	1.617	0.076	1.864
J=6												
Max 1	0.051	0.238	-0.044	-0.266	-0.089	-0.726	-0.024	-0.236	-0.075	-0.839	-0.029	-0.343
Max 1-Min1	0.172	1.069	0.104	0.91	0.066	0.753	0.123	1.665	0.116	1.784	0.153	2.48
Max3	0.053	0.3	-0.047	-0.369	-0.043	-0.428	0.019	0.222	0.007	0.094	0.03	0.425
Max3-Min3	0.094	0.838	0.006	0.074	0.011	0.178	0.076	1.404	0.08	1.725	0.089	2.091
J=7												
Max 1	0.125	0.577	0.011	0.065	-0.036	-0.289	0.009	0.092	-0.028	-0.31	-0.001	-0.008
Max 1-Min1	0.187	1.162	0.118	1.027	0.08	0.887	0.139	1.878	0.138	2.118	0.161	2.611
Max3	**0.096**	0.544	-0.018	-0.14	-0.016	-0.161	0.034	0.401	0.018	0.237	0.033	0.46
Max3-Min3	0.124	1.11	0.028	0.353	0.039	0.623	0.093	1.725	0.095	2.052	0.103	2.433

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy(in short run).

Table A11a: Performance of high book-to-market portfolios with trading strategy: Pure momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	0.222	2.131	0.277	3.452	0.295	4.172	0.331	5.352	0.296	5.077	0.291	5.243
Max 1-Min1	-0.057	-0.896	-0.010	-0.203	0.012	0.306	0.048	1.558	0.019	0.645	0.008	0.307
Max3	0.294	3.482	0.318	4.753	0.336	5.59	0.355	6.494	0.321	6.013	0.309	6.046
Max3-Min3	-0.052	-1.131	-0.013	-0.419	0.006	0.213	0.031	1.403	0.005	0.226	-0.004	-0.233
J=6												
Max 1	0.345	3.183	0.425	5.064	0.416	5.683	0.389	5.885	0.379	5.987	0.38	6.391
Max 1-Min1	0.091	1.385	0.149	3.368	0.155	4.426	0.138	4.443	0.117	4.011	0.116	4.333
Max3	0.395	4.501	0.423	6.04	0.431	7.027	0.405	7.105	0.37	6.794	0.357	6.812
Max3-Min3	0.074	1.641	0.102	3.446	0.11	4.606	0.09	4.33	0.062	3.335	0.057	3.181
J=9												
Max 1	0.418	4.108	0.468	6.021	0.417	5.804	0.382	5.815	0.363	5.818	0.348	6.041
Max 1-Min1	0.057	0.865	0.088	1.981	0.087	2.389	0.084	2.679	0.064	2.153	0.057	2.114
Max3	0.375	4.418	0.395	5.951	0.372	6.025	0.345	5.935	0.324	5.811	0.32	6.069
Max3-Min3	0.041	0.98	0.075	2.568	0.059	2.296	0.044	2.08	0.026	1.35	0.03	1.593
J=12												
Max 1	0.541	5.306	0.517	6.457	0.499	6.708	0.462	6.778	0.445	6.999	0.446	7.524
Max 1-Min1	0.210	3.130	0.204	4.624	0.224	5.89	0.209	6.494	0.19	6.369	0.193	6.953
Max3	0.495	5.494	0.464	6.385	0.425	6.496	0.398	6.652	0.388	6.9	0.388	7.388
Max3-Min3	0.166	3.834	0.145	5.061	0.124	5.022	0.106	5.061	0.101	5.218	0.104	5.945
J=15												
Max 1	0.405	3.98	0.382	4.757	0.394	5.366	0.365	5.415	0.37	5.891	0.383	6.458
Max 1-Min1	0.159	2.38	0.148	3.267	0.171	4.543	0.161	4.849	0.16	5.305	0.156	5.354
Max3	0.419	4.579	0.412	5.515	0.395	6.016	0.383	6.418	0.371	6.652	0.375	7.203
Max3-Min3	0.114	2.664	0.113	4.014	0.106	4.451	0.104	4.927	0.092	4.882	0.094	5.362
J=18												
Max 1	0.365	3.507	0.37	4.333	0.383	5.077	0.379	5.435	0.395	6.147	0.396	6.683
Max 1-Min1	0.184	2.885	0.179	3.949	0.203	5.372	0.206	5.905	0.198	6.115	0.193	6.438
Max3	0.419	4.59	0.414	5.574	0.406	6.179	0.391	6.517	0.381	6.781	0.381	7.289
Max3-Min3	0.135	3.144	0.134	4.69	0.136	5.442	0.128	5.998	0.115	5.932	0.113	6.322

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A11b: Performance of high book-to-market portfolios with trading strategy: Mean reversion and momentum

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.253**	2.507	**0.316**	4.265	**0.298**	4.514	0.302	5.095	0.282	5.124	0.291	5.815
Max 1-Min1	-0.077	-1.09	-0.016	-0.333	-0.014	-0.351	-0.006	-0.172	-0.009	-0.268	-0.01	-0.333
Max3	0.225	2.696	0.268	4.32	0.276	4.932	0.289	5.794	0.282	5.916	0.274	6.264
Max3-Min3	-0.086	-1.827	-0.041	-1.243	-0.029	-1.084	-0.014	-0.618	-0.021	-0.949	-0.026	-1.279
J=6												
Max 1	0.336	3.402	0.316	3.997	0.33	4.861	0.306	4.974	0.309	5.455	0.306	5.755
Max 1-Min1	-0.003	-0.051	-0.007	-0.16	0.018	0.519	0.008	0.246	0.001	0.042	-0.005	-0.173
Max3	0.346	4.15	0.374	5.553	0.389	6.76	0.369	6.99	0.351	7.118	0.337	7.252
Max3-Min3	0.014	0.344	0.042	1.472	0.057	2.488	0.044	2.165	0.029	1.564	0.017	0.97
J=9												
Max 1	0.232	2.135	0.264	3.215	0.277	4.086	0.296	4.938	0.314	5.676	0.315	6.113
Max 1-Min1	-0.091	-1.296	-0.06	-1.262	-0.042	-1.028	-0.024	-0.645	-0.008	-0.242	-0.005	-0.169
Max3	0.29	3.495	0.325	5.079	0.323	5.746	0.319	6.258	0.307	6.35	0.298	6.702
Max3-Min3	-0.033	-0.733	-0.007	-0.218	0	0.009	0.005	0.224	0.003	0.127	-0.004	-0.193
J=12												
Max 1	0.491	4.764	0.431	5.311	0.425	5.963	0.394	6.082	0.397	6.531	0.387	6.838
Max 1-Min1	0.109	1.676	0.098	2.307	0.132	3.691	0.122	3.941	0.126	4.332	0.121	4.662
Max3	0.452	5.277	0.418	5.986	0.408	6.806	0.383	7.045	0.376	7.312	0.367	7.513
Max3-Min3	0.092	2.259	0.084	2.96	0.088	3.847	0.079	4.123	0.075	4.054	0.072	4.313
J=15												
Max 1	0.296	2.944	0.355	4.56	0.36	5.311	0.353	5.782	0.341	6.04	0.345	6.565
Max 1-Min1	0.054	0.833	0.101	2.367	0.114	3.227	0.119	3.778	0.108	3.787	0.104	3.882
Max3	0.378	4.29	0.398	5.691	0.386	6.298	0.38	6.903	0.362	7.002	0.359	7.439
Max3-Min3	0.053	1.278	0.075	2.777	0.076	3.369	0.08	4.152	0.071	3.95	0.068	4.156
J=18												
Max 1	0.281	2.884	0.316	4.077	0.324	4.825	0.311	5.13	0.317	5.701	0.315	6.037
Max 1-Min1	0.078	1.251	0.08	1.958	0.094	2.758	0.092	3.077	0.085	3.041	0.078	3.068
Max3	0.382	4.304	0.374	5.322	0.378	6.205	0.368	6.695	0.364	7.115	0.361	7.706
Max3-Min3	0.08	1.993	0.064	2.397	0.071	3.197	0.075	4.095	0.074	4.455	0.071	4.792

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A11c: Performance of high book-to-market portfolios with strategy: Momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.324**	2.891	**0.342**	4.300	0.282	4.283	0.325	5.394	**0.309**	5.483	**0.307**	5.835
Max 1-Min1	**0.083**	1.299	**0.08**	1.735	**0.033**	0.917	0.047	1.575	**0.027**	1.004	**0.019**	0.771
Max3	**0.354**	3.721	**0.363**	5.312	**0.351**	5.983	**0.361**	6.719	**0.341**	6.747	**0.331**	6.988
Max3-Min3	**0.041**	0.912	**0.032**	1.068	**0.017**	0.725	0.029	1.434	**0.014**	0.739	**0.007**	0.392
J=6												
Max 1	**0.351**	3.278	0.395	4.884	0.411	6.005	**0.394**	6.263	0.371	6.198	0.363	6.377
Max 1-Min1	0.066	1.002	0.092	2.089	0.115	3.273	0.116	3.818	0.085	2.964	0.076	2.97
Max3	0.371	4.085	0.409	5.888	0.409	6.869	**0.406**	7.496	0.367	7.066	**0.362**	7.265
Max3-Min3	0.029	0.642	0.081	2.641	0.088	3.545	0.085	4.014	0.053	2.723	0.049	2.787
J=9												
Max 1	0.342	3.095	0.377	4.57	0.368	5.275	**0.387**	6.118	0.363	6.125	**0.362**	6.481
Max 1-Min1	**0.06**	0.927	0.052	1.161	0.065	1.797	0.082	2.76	0.054	1.96	0.052	2.074
Max3	0.326	3.547	0.35	5.184	0.355	5.983	**0.378**	7.039	**0.35**	6.865	**0.337**	6.958
Max3-Min3	0.007	0.147	0.023	0.759	0.028	1.106	**0.049**	2.375	0.024	1.212	0.016	0.882
J=12												
Max 1	0.456	4.47	0.492	6.152	0.455	6.214	0.423	6.28	0.403	6.493	0.407	7.087
Max 1-Min1	0.144	2.203	0.169	3.831	0.169	4.418	0.158	4.771	0.127	4.146	0.127	4.506
Max3	0.446	4.955	0.457	6.292	**0.429**	6.562	**0.409**	6.899	0.376	6.674	0.378	7.116
Max3-Min3	0.117	2.653	0.125	4.101	0.115	4.547	**0.109**	5.322	0.086	4.432	0.089	5.082
J=15												
Max 1	0.392	3.73	**0.407**	5.02	**0.407**	5.65	**0.405**	6.088	0.37	6.027	0.373	6.484
Max 1-Min1	0.107	1.612	0.123	2.803	0.136	3.916	0.139	4.617	0.108	3.804	0.095	3.648
Max3	0.38	4.154	0.411	5.757	**0.398**	6.2	**0.401**	6.97	0.37	6.821	0.368	7.308
Max3-Min3	0.07	1.585	0.095	3.217	0.094	3.749	0.1	4.729	0.075	3.824	0.072	4.094
J=18												
Max 1	**0.401**	3.753	**0.422**	5.117	**0.405**	5.695	**0.401**	6.194	0.379	6.461	0.374	6.782
Max 1-Min1	0.163	2.44	0.165	3.67	0.158	4.351	0.149	4.77	0.123	4.302	0.116	4.412
Max3	0.375	4.058	0.41	5.788	**0.409**	6.461	**0.413**	7.307	0.38	7.125	0.375	7.449
Max3-Min3	0.077	1.722	0.103	3.484	0.107	4.255	0.111	5.195	0.086	4.465	0.079	4.581

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy.

Table A11d: Performance of high book-to-market portfolios with strategy: Mean reversion, momentum and downside risk

	K=3		K=6		K=9		K=12		K=15		K=18	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=3												
Max 1	**0.26**	2.506	0.298	3.875	0.253	4.009	0.287	4.97	0.266	4.987	0.256	5.072
Max 1-Min1	**0.021**	0.327	**0.02**	0.417	**−0.007**	-0.187	**0.012**	0.39	**−0.008**	-0.265	-0.017	-0.632
Max3	**0.347**	3.87	**0.322**	4.927	**0.304**	5.408	**0.324**	6.528	**0.306**	6.461	**0.294**	6.622
Max3-Min3	**0.029**	0.658	**0.002**	0.071	**−0.01**	-0.4	**0.008**	0.367	**−0.008**	-0.396	**−0.017**	-0.94
J=6												
Max 1	0.31	3.001	**0.337**	4.207	0.302	4.335	**0.326**	5.248	0.299	5.228	0.29	5.449
Max 1-Min1	**0.002**	0.036	**0.025**	0.536	0.017	0.46	**0.037**	1.193	**0.014**	0.465	**0.007**	0.261
Max3	0.313	3.529	0.362	5.422	0.366	6.448	0.361	7.019	0.333	6.924	0.324	7.125
Max3-Min3	-0.017	-0.357	0.03	0.964	0.04	1.575	0.04	1.892	0.021	1.028	0.014	0.755
J=9												
Max 1	**0.27**	2.671	**0.297**	3.713	**0.301**	4.538	**0.328**	5.582	0.294	5.476	0.284	5.583
Max 1-Min1	**0.013**	0.199	**0.001**	0.028	**0.011**	0.301	**0.03**	0.943	**0.009**	0.305	**0.002**	0.082
Max3	**0.309**	3.491	0.324	4.887	0.32	5.563	**0.344**	6.784	**0.319**	6.567	**0.308**	6.761
Max3-Min3	**−0.009**	-0.195	-0.008	-0.248	-0.005	-0.19	**0.019**	0.885	0	-0.014	-0.008	-0.416
J=12												
Max 1	0.41	4.032	0.422	5.219	0.395	5.563	0.393	6.186	0.377	6.43	0.366	6.684
Max 1-Min1	0.079	1.162	**0.099**	2.15	0.107	2.89	0.119	3.729	0.11	3.655	0.099	3.68
Max3	0.401	4.564	0.414	5.936	0.4	6.568	**0.387**	7.089	0.369	7.145	0.359	7.35
Max3-Min3	0.079	1.77	**0.085**	2.891	0.084	3.472	0.077	3.84	0.062	3.202	0.056	3.177
J=15												
Max 1	**0.375**	3.697	**0.42**	5.25	**0.39**	5.643	**0.385**	6.25	**0.345**	6.079	0.336	6.289
Max 1-Min1	**0.066**	1.009	**0.102**	2.264	0.086	2.348	0.094	3.088	0.066	2.267	0.055	2.088
Max3	0.353	4.041	0.383	5.625	**0.389**	6.474	**0.39**	7.353	**0.367**	7.387	0.354	7.551
Max3-Min3	0.019	0.409	0.054	1.848	0.06	2.364	0.065	3.186	0.048	2.438	0.042	2.382
J=18												
Max 1	**0.378**	3.66	**0.401**	4.92	**0.36**	5.215	**0.357**	5.803	**0.333**	5.903	**0.321**	6.162
Max 1-Min1	**0.107**	1.677	**0.101**	2.255	0.092	2.572	0.086	2.945	0.068	2.485	0.056	2.346
Max3	0.35	3.954	0.361	5.35	0.36	6.172	0.358	6.88	0.34	7.037	0.327	7.232
Max3-Min3	0.031	0.708	0.045	1.568	0.045	1.82	0.05	2.472	0.033	1.731	0.026	1.545

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy.

Table A11e: Performance of high book-to-market portfolios with strategy: Pure Momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.348	2.021	0.272	2.164	0.288	2.675	0.299	3.199	0.335	3.928	0.317	4.037
Max 1-Min1	0.12	1.081	0.067	0.837	0.014	0.218	0.035	0.639	0.068	1.407	0.058	1.3
Max3	0.377	2.539	0.33	3.141	0.337	3.746	0.348	4.47	0.369	5.059	0.377	5.428
Max3-Min3	0.054	0.645	0.016	0.284	0.008	0.178	0.024	0.652	0.046	1.405	0.055	1.793
J=3												
Max 1	0.175	0.995	0.201	1.638	0.222	2.131	0.28	3.024	0.292	3.416	0.277	3.452
Max 1-Min1	-0.022	-0.192	-0.063	-0.827	-0.057	-0.896	-0.009	-0.175	0.007	0.135	-0.01	-0.203
Max3	0.305	2.137	0.285	2.765	0.294	3.482	0.301	3.932	0.317	4.461	0.318	4.753
Max3-Min3	-0.043	-0.572	-0.048	-0.819	-0.052	-1.131	-0.028	-0.737	-0.008	-0.238	-0.013	-0.419
J=4												
Max 1	0.277	1.651	0.306	2.56	0.33	3.098	0.392	4.084	0.384	4.337	0.392	4.646
Max 1-Min1	0.024	0.214	0.031	0.407	0.032	0.502	0.071	1.271	0.076	1.493	0.087	1.913
Max3	0.385	2.761	0.355	3.606	0.382	4.367	0.404	4.946	0.411	5.428	0.411	5.762
Max3-Min3	0.042	0.587	0.022	0.419	0.035	0.806	0.056	1.419	0.065	1.865	0.064	1.991
J=5												
Max 1	0.37	2.164	0.314	2.484	0.335	3.095	0.318	3.401	0.335	3.8	0.362	4.207
Max 1-Min1	0.092	0.774	0.078	0.916	0.057	0.817	0.044	0.801	0.068	1.361	0.091	2.01
Max3	0.396	2.883	0.361	3.578	0.373	4.169	0.382	4.687	0.392	5.197	0.392	5.456
Max3-Min3	0.073	0.966	0.048	0.888	0.053	1.208	0.06	1.569	0.07	2.063	0.071	2.329
J=6												
Max 1	0.388	2.315	0.35	2.736	0.345	3.183	0.356	3.734	0.364	4.128	0.425	5.064
Max 1-Min1	0.167	1.45	0.107	1.265	0.091	1.385	0.101	1.773	0.115	2.337	0.149	3.368
Max3	0.396	2.916	0.369	3.58	0.395	4.501	0.399	5.025	0.409	5.502	0.423	6.04
Max3-Min3	0.08	1.087	0.059	1.069	0.074	1.641	0.084	2.127	0.09	2.632	0.102	3.446
J=7												
Max 1	0.473	2.747	0.385	3.031	0.374	3.453	0.347	3.711	0.393	4.601	0.456	5.672
Max 1-Min1	0.139	1.216	0.097	1.139	0.096	1.407	0.075	1.371	0.097	2.069	0.127	2.964
Max3	0.366	2.576	0.373	3.661	0.39	4.479	0.41	5.109	0.441	5.947	0.455	6.514
Max3-Min3	0.059	0.814	0.059	1.04	0.072	1.64	0.088	2.274	0.11	3.305	0.121	4.099

* Notes: All entries are return rate based on sorting period J and holding period K.

Table A11f: Performance of high book-to-market portfolios with strategy: Momentum and downside risk(short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.537**	3.194	**0.354**	2.729	**0.349**	3.072	**0.368**	3.817	**0.382**	4.315	**0.383**	4.765
Max 1-Min1	**0.254**	2.249	**0.14**	1.597	**0.093**	1.365	**0.093**	1.631	**0.092**	1.821	**0.086**	1.886
Max3	**0.547**	3.717	**0.406**	3.849	**0.369**	3.942	**0.366**	4.546	**0.39**	5.285	**0.382**	5.52
Max3-Min3	**0.175**	2.256	**0.085**	1.594	**0.047**	1.061	**0.042**	1.157	**0.059**	1.821	**0.056**	1.892
J=3												
Max 1	**0.558**	3.102	**0.39**	2.959	**0.324**	2.891	**0.332**	3.455	**0.359**	4.174	**0.342**	4.3
Max 1-Min1	**0.24**	2.05	**0.13**	1.594	**0.083**	1.299	**0.085**	1.515	**0.094**	1.888	**0.08**	1.735
Max3	**0.544**	3.697	**0.422**	3.874	**0.354**	3.721	**0.344**	4.209	**0.366**	4.963	**0.363**	5.312
Max3-Min3	**0.2**	2.537	**0.094**	1.673	**0.041**	0.912	**0.032**	0.88	**0.037**	1.116	**0.032**	1.068
J=4												
Max 1	**0.534**	3.059	**0.385**	2.94	**0.332**	2.867	0.354	3.595	**0.394**	4.393	**0.396**	4.755
Max 1-Min1	**0.175**	1.547	**0.101**	1.194	**0.049**	0.739	0.069	1.213	**0.099**	1.972	**0.097**	2.066
Max3	**0.529**	3.574	**0.414**	3.849	0.372	3.94	0.372	4.586	0.391	5.373	0.384	5.595
Max3-Min3	**0.17**	2.162	**0.08**	1.419	**0.046**	1.007	0.047	1.242	0.059	1.758	0.052	1.722
J=5												
Max 1	**0.478**	2.734	**0.355**	2.733	**0.348**	3.048	**0.381**	3.938	**0.424**	4.764	**0.407**	4.889
Max 1-Min1	**0.153**	1.347	0.053	0.62	0.051	0.74	**0.073**	1.263	**0.109**	2.125	**0.098**	2.094
Max3	**0.512**	3.466	**0.395**	3.742	0.366	3.945	0.371	4.618	0.386	5.315	0.382	5.577
Max3-Min3	**0.152**	1.964	**0.069**	1.25	0.04	0.887	0.044	1.132	0.056	1.635	0.051	1.651
J=6												
Max 1	**0.526**	3.153	**0.376**	2.991	**0.351**	3.278	**0.375**	4.031	**0.371**	4.276	0.395	4.884
Max 1-Min1	**0.22**	1.959	0.098	1.135	0.066	1.002	0.076	1.376	0.084	1.706	0.092	2.089
Max3	**0.468**	3.248	**0.387**	3.684	0.371	4.085	0.379	4.718	0.392	5.366	0.409	5.888
Max3-Min3	**0.113**	1.5	0.04	0.712	0.029	0.642	0.048	1.236	0.069	2.023	0.081	2.641
J=7												
Max 1	**0.591**	3.538	**0.394**	3.2	**0.379**	3.501	**0.396**	4.193	**0.405**	4.606	0.409	5.006
Max 1-Min1	**0.206**	1.829	0.071	0.841	0.058	0.884	0.062	1.14	0.084	1.706	0.085	1.961
Max3	**0.498**	3.382	**0.402**	3.753	0.383	4.176	0.386	4.759	0.412	5.556	0.428	6.063
Max3-Min3	**0.15**	1.924	**0.065**	1.136	0.048	1.094	0.058	1.523	0.078	2.291	0.09	2.904

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A11g: Performance of high book-to-market portfolios with strategy: Mean reversion and momentum (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	0.332	1.939	0.265	2.19	**0.309**	3.012	**0.314**	3.56	0.333	4.061	0.302	3.985
Max 1-Min1	0.023	0.193	0.013	0.162	0.008	0.117	0.013	0.221	0.034	0.675	0.021	0.457
Max3	0.341	2.382	0.27	2.694	0.285	3.254	0.289	3.77	0.314	4.506	0.324	4.985
Max3-Min3	0.013	0.161	-0.034	-0.622	-0.041	-0.876	-0.036	-0.89	-0.015	-0.429	-0.002	-0.048
J=3												
Max 1	**0.324**	1.822	**0.29**	2.427	**0.253**	2.507	**0.31**	3.501	**0.327**	4.139	**0.316**	4.265
Max 1-Min1	-0.032	-0.279	**−0.055**	-0.637	-0.077	-1.09	-0.033	-0.584	-0.011	-0.208	-0.016	-0.333
Max3	0.234	1.661	0.227	2.312	0.225	2.696	0.243	3.319	0.269	3.994	0.268	4.32
Max3-Min3	-0.098	-1.234	-0.089	-1.578	-0.086	-1.827	-0.065	-1.673	-0.043	-1.233	-0.041	-1.243
J=4												
Max 1	0.243	1.405	0.224	1.915	0.246	2.465	0.28	3.102	0.272	3.339	0.266	3.537
Max 1-Min1	-0.049	-0.441	-0.041	-0.515	-0.019	-0.302	0.005	0.081	0	0.007	-0.008	-0.193
Max3	0.324	2.283	0.302	3.028	0.309	3.541	0.32	4.193	0.333	4.815	0.335	5.188
Max3-Min3	-0.012	-0.163	-0.03	-0.554	-0.019	-0.415	-0.004	-0.097	0.003	0.104	0.004	0.148
J=5												
Max 1	0.308	1.845	0.267	2.259	0.278	2.849	0.284	3.218	0.289	3.534	0.278	3.553
Max 1-Min1	-0.02	-0.185	-0.025	-0.323	-0.022	-0.359	-0.013	-0.245	-0.011	-0.236	-0.02	-0.487
Max3	0.328	2.491	0.317	3.324	0.326	4.04	0.34	4.718	0.347	5.187	0.346	5.47
Max3-Min3	-0.04	-0.547	-0.027	-0.507	-0.009	-0.218	0.002	0.041	0.006	0.187	0.005	0.174
J=6												
Max 1	0.373	2.329	0.319	2.678	0.336	3.402	0.336	3.786	0.298	3.663	0.316	3.997
Max 1-Min1	-0.029	-0.271	-0.013	-0.157	-0.003	-0.051	0.007	0.129	-0.009	-0.196	-0.007	-0.16
Max3	0.335	2.664	0.317	3.34	0.346	4.15	0.351	4.556	0.356	5.011	0.374	5.553
Max3-Min3	0.001	0.018	-0.002	-0.042	0.014	0.344	0.026	0.683	0.028	0.867	0.042	1.472
J=7												
Max 1	0.34	2.058	0.333	2.73	0.348	3.351	0.318	3.417	0.319	3.654	0.338	4.06
Max 1-Min1	0.009	0.085	0.024	0.301	0.027	0.43	0.011	0.197	0.012	0.238	0.017	0.394
Max3	0.346	2.667	0.333	3.424	0.363	4.373	0.375	4.987	0.395	5.611	0.41	6.234
Max3-Min3	0.006	0.086	0.007	0.144	0.02	0.484	0.03	0.844	0.05	1.572	0.068	2.399

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat pure momentum strategy (short run performance).

Table A11h: Performance of high book-to-market portfolios with strategy: Mean reversion, momentum and downside risk (short run performance)

	K=1		K=2		K=3		K=4		K=5		K=6	
	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio	mean return	t-ratio
J=2												
Max 1	**0.722**	4.233	**0.413**	3.321	**0.364**	3.395	**0.352**	3.873	**0.377**	4.573	**0.361**	4.66
Max 1-Min1	**0.24**	2.06	**0.117**	1.408	**0.071**	1.089	**0.04**	0.731	**0.06**	1.25	**0.059**	1.312
Max3	**0.492**	3.512	**0.357**	3.625	**0.322**	3.639	**0.324**	4.214	**0.331**	4.689	**0.335**	5.072
Max3-Min3	**0.109**	1.36	**0.036**	0.679	**0.004**	0.086	**0.002**	0.051	**0.01**	0.311	**0.01**	0.331
J=3												
Max 1	**0.508**	2.995	**0.3**	2.363	**0.26**	2.506	0.272	3.039	0.277	3.464	0.298	3.875
Max 1-Min1	**0.156**	1.339	**0.06**	0.724	**0.021**	0.327	**−0.007**	-0.135	**0.004**	0.083	**0.02**	0.417
Max3	**0.533**	3.85	**0.39**	3.856	**0.347**	3.87	**0.329**	4.302	**0.333**	4.691	**0.322**	4.927
Max3-Min3	**0.18**	2.327	**0.076**	1.458	**0.029**	0.658	**0.009**	0.259	**0.008**	0.24	**0.002**	0.071
J=4												
Max 1	**0.55**	3.184	**0.301**	2.407	0.239	2.299	0.272	3.056	**0.297**	3.636	**0.3**	3.772
Max 1-Min1	**0.131**	1.146	**0.025**	0.301	**−0.018**	-0.267	−0.016	-0.288	**0.002**	0.031	**0.01**	0.207
Max3	**0.468**	3.39	**0.357**	3.617	**0.333**	3.813	**0.333**	4.431	**0.341**	4.861	**0.343**	5.265
Max3-Min3	**0.104**	1.374	**0.037**	0.691	**0.02**	0.451	**0.013**	0.364	**0.017**	0.518	**0.014**	0.464
J=5												
Max 1	**0.566**	3.302	**0.304**	2.45	**0.28**	2.762	**0.317**	3.667	**0.33**	4.086	**0.323**	4.101
Max 1-Min1	**0.119**	1.088	**0.025**	0.302	**0.007**	0.106	**0.001**	0.022	**0.012**	0.237	**0.009**	0.195
Max3	**0.473**	3.346	**0.341**	3.369	**0.327**	3.685	0.329	4.326	0.339	4.814	0.337	5.13
Max3-Min3	**0.095**	1.219	**0.024**	0.458	**0.008**	0.189	**0.006**	0.169	**0.013**	0.368	**0.008**	0.276
J=6												
Max 1	**0.52**	3.058	0.278	2.199	0.31	3.001	0.326	3.651	**0.304**	3.558	**0.337**	4.207
Max 1-Min1	**0.134**	1.173	**0.009**	0.108	**0.002**	0.036	0.003	0.058	**0.011**	0.213	**0.025**	0.536
Max3	**0.412**	2.975	0.315	3.096	0.313	3.529	0.334	4.335	0.339	4.747	0.362	5.422
Max3-Min3	**0.068**	0.864	**−0.001**	-0.009	−0.017	-0.357	−0.002	-0.06	0.013	0.364	0.03	0.964
J=7												
Max 1	**0.584**	3.395	**0.35**	2.766	0.34	3.232	**0.354**	3.893	**0.348**	4.081	**0.371**	4.6
Max 1-Min1	**0.149**	1.318	**0.052**	0.616	**0.034**	0.509	**0.033**	0.586	**0.038**	0.743	**0.042**	0.915
Max3	**0.473**	3.368	**0.345**	3.382	0.334	3.739	0.34	4.414	0.353	4.907	0.37	5.547
Max3-Min3	**0.097**	1.234	**0.018**	0.318	0.004	0.096	0.006	0.159	0.022	0.61	0.031	0.99

* Notes: All entries are return rate based on sorting period J and holding period K. Bold entries are those that beat mean reversion and momentum strategy(in short run).

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