Are momentum premia robust to trade frictions? Tests of large-stock portfolios

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Abstract

We test how market frictions might limit momentum profits. While most papers assume that investors can self-finance, in practice, investors must invest capital or borrow for long stock positions. No self-financing can occur. Traders can borrow to buy longs, short losers, and earn the rebate interest on the short sale proceeds. We find that the difference between the margin and rebates rates is 139 bp for 1946-2002. We test on large stocks where trade and costs are lower and price impact costs are minimal. Net of trade and borrowing costs, large-stock momentum earns, on a raw return basis, 5% per unit of borrowed capital annually. Risk-adjusted tests show larger premia.

(JEL G32, L1)

Key words: momentum, long-short strategies, market efficiency

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1 Introduction

This paper examines momentum, the strategy that buys recently ranked past winners and shorts recently ranked past losers. The paper tests if momentum trades are profitable after controlling for a variety of frictions. Jegadeesh and Titman (1993) were the first to note that momentum earns large premia in the U.S. after World War II. Papers show that momentum is not priced by the Capital Asset Pricing Model or the Fama and French (1993) 3-factor model.[1] Papers find momentum in international markets.[2] While several papers suggest specialized risk-based explanations,[3] behavioral finance papers argue that cognitive bias causes investors to underreact and generates the mispricing.[4]

To better understand momentum, papers explore trade patterns of pension funds and mutual funds. They find that institutions act as momentum traders on the buy-side but not on the sell-side.[5] They find buy-side momentum profits of 1-2% per year. Papers often characterize institutions as smart because they have better private information on firm fundamentals; institutions are thought to move prices in the correct direction,[6] but they do not appear to move prices fully to fundamental value.[7] Thus, there appears to be an unexplained sluggishness for stocks to adjust to public information.

Momentum papers assume a zero-investment strategy where losers fund winners. Fama and French (2007) rank all stocks by past performance and divide the market at the median ranking into loser and winner halves. They short 2.95 units of losers and buy 3.95 units of winners. However, in practice, such a strategy cannot be implemented because shorts cannot fund longs. In practice, buying and selling short are not similar types of trades. The lending market for short sales is quite specialized.

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[1]Jegadeesh and Titman (1993, 2001), Fama and French (1996), and Grundy and Martin (2001)

[2]Griffen, Ji, and Martin (2003) and Rouwenhorst (1998)

[3]Three papers include Berk, Green, and Naik (1999), Chordia and Shivakumar (2002), and Johnson (2002).

[4]Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmayam, (1998), and Hong and Stein (1999)

[5]Badrinath and Wahal (2002), Cohen, Gompers, and Vuolteenaho (2002), Grinblatt, Titman, and Wermers (1995), and Wermers (1999)

[6]Nofsinger and Sias (1999) and Sias (2004)

[7]Cohen, Gompers, and Vuolteenaho

Fees go to the original lender to induce lending and to the broker for setting up the transaction. Jones and Lamont (2002) describe this lending market for short sales:

> Suppose A lends shares to B and B sells short the stock. When the sale is made, the short sale proceeds do not go to B but rather to A [who keeps the cash proceeds as collateral]. The actual term of the loan is one day, though the terms can be renewed in subsequent days. Because A is effectively using collateral to borrow, A must pay interest to B. When the loan is closed, A repays cash to B and B returns the shares to A.

In foreign countries, collateral for short sales may be any high-quality common or preferred stock; in the United States, collateral is almost always cash (Faulkner, 2005).[8] Jacobs and Levy (1996) write, "institutional holders do not have access to the [short-sale] cash proceeds." They note that the cash collateral is typically 102% of the short sale and the investor often reserves additional cash for mark-to-market changes.[9]

Thus, shorts cannot fund longs. One needs capital for long positions. In a capital-investing strategy, one invests capital to buy winners, shorts losers, and earns the rebate interest on the short-sale cash collateral. In a borrowing strategy, one can borrow against other long positions to buy winners, short losers, earn the rebate rate, and pay margin costs. We find that the difference between the borrowing (margin) and lending (rebate) rates for 1946 to 2002 is 139 bp. In this paper, we explore both of the capital-investing and borrowing strategies in detail.

Trade costs may be expensive and restrain investor trades.[10] Momentum is trade intensive. Lesmond, Schill, and Zhou (2004) find that momentum portfolios are often composed of small, illiquid stocks that are costly to trade. They estimate costs, recalibrate the asset pricing premia of Jegadeesh and Titman (1993, 2001) and Hong, Lim, and Stein (2000), and show that trade costs absorb the premia. However, Jegadeesh and Titman (2001) show momentum in large stocks, where trade costs

[8] For the U.S. market, D'Avolio (2002) reports that 98% of the collateral positions are cash and 2% are Treasury securities.

[9] Jacobs and Levy, Jacobs, Levy, and Starer (1998), and Alexander (2000) model short-sale strategies where the investor typically adds a 10% buffer to cover the potential for additional collateral if short-sale prices rise.

[10] Constantinides (1979, 1986) are important early theory papers on trade costs.

are smaller,[11] and Lesmond, Schill, and Zhou do not consider large stocks. Chen, Stanzl, and Watanabe (2002) estimate costs for momentum and find little gain. They also note that investors cannot short-sell to finance winner positions. They study the strategy where one shorts losers, earns returns for rebate cash, and goes long in winners with invested capital. These tests include a large number of stocks that are small and illiquid, similar to the Lesmond, Schill, and Zhou tests. Korajczyk and Sadka (2004) study buy-side momentum. They do not consider shorts of losers because they suggest that short trade costs are too difficult to estimate. They control for winner trade costs and find trading gains for winner portfolios that are highly liquid.

We concentrate tests on large stocks where price-impact costs are small and trade costs are straightforward to estimate. Geczy, Musto, and Reed (2002) show that one can typically short large market-size stocks. Fama (1998) also notes that market efficiency tests should concentrate on large stocks that better capture investor wealth effects; he argues that anomalies tend to shrink when large stocks are used. We test back to 1946, a longer time period than previous trade-cost studies.

To give generality and greater precision to our tests, we measure three different types of momentum returns. First, we first measure the frictionless momentum return and then incorporate trade costs. We call this return *winner-loser*.

Second, we study two capital-investing strategies. First, we buy winners, short losers, and earn the rebate return on short-sale cash. We refer to this strategy as *winner-loser+rebate*. We assume that investors are institutions. We do not consider the retail investor, who typically would not earn the rebate rate. Second, we buy winners (and ignore losers), similar to Korajczyk and Sadka. We refer to this strategy as *winner buys*.

Third, we study two near-self-financing strategies. First, we buy winners, short losers, earn the rebate interest on the short-sale cash, and finance winners from margin. We call this strategy *winner-loser-netmargin*. Second, we short losers and earn the rebate rate on the short-sale cash proceeds. Because the investor is required to post 102% of the short sales as cash, this strategy is nearly self-financing. We call this strategy *rebate-loser*.

[11] See Jegadeesh and Titman (2001) Table I.

In a variety of tests, large-stock momentum, net of trade costs, remains profitable. In the most pivotal test, we borrow to invest a unit of capital in past winners and short a unit of past losers. The incremental raw return for this borrowing strategy is 5% per year. CAPM and Fama and French 3-factor tests show higher performance. In an additional test, we combined at a small position of the momentum borrowing portfolio with a unit of the market portfolio. We found that the variance of the combined portfolios is the same and the return increases. Thus, a linear combination of the momentum portfolio dominates (in a mean-variance sense) the standard CRSP VW portfolio.

The remainder of the paper is organized as follows. Section 2 reports the data and the portfolio construction methods. Section 3 shows the raw returns for full sample and large-stock portfolios. Section 4 reports the trade-execution costs. Section 5 computes risk-adjusted returns for different strategies. Section 6 examines residuals and provides a brief discussion. Section 7 concludes.

2 Setup for empirical tests

2.1 Data

The return data are for U.S. stocks for 1946-2002 from the Center for Research in Security Prices (CRSP). To be consistent with past papers, we use NYSE and AMEX stocks. We also made tests with NASDAQ stocks. In these tests, we trimmed all NYSE, AMEX, and NASDAQ firms that fall into the smallest market-size decile, based on NYSE market-size cutoffs, and all stocks with prices of $5.00 or less. We found that the inclusion of NASDAQ stocks does not change the results,[12] and we report results for NYSE/AMEX stocks so that we can compare our results to past papers.

We test monthly returns for 1946-2002 and in three subperiods. We break the full sample first at the end of 1962 so that the 1946-1962 returns can be entirely from the NYSE. We break the 1963-2002 into two parts, 1963-1982 and 1983-2002. This

[12] One advantage of excluding NASDAQ stocks is that trade costs are higher on the NASDAQ (Christie and Shultz (1994) and Huang and Stoll (1996)).

second break point splits the sample with NYSE/AMEX stocks into equal halves.

D'Avolio (2002) finds that the rebate rate earned on the short-sale cash is 25 basis points lower than the Federal Funds rates. For the rebate rate, we subtract 25 basis points from the Federal Funds rate, which we obtain from the St. Louis Federal Reserve website. Their Federal Funds data start on July 1954. Federal Funds data before July 1954 were hand collected from the *Wall Street Journal*.

The call money rate, sometimes called the broker's loan rate, is the most favorable loan rate for large margin positions. For example, on November 18, 2005, the *Wall Street Journal* reported a call money rate of 6%. If the loan balance was less than $1,000,000 and equal to or more than $200,000, an additional 1% was added to the 6% base. If the loan balance was less than the $200,000, 2% was added to the 6% base. We define the *net-margin cost* as the difference between the call money and the estimated rebate rate. Call money rate data from 1946 forward were hand collected from the *Wall Street Journal*.

Table I shows rates for call money, Federal Funds, 30-day T-bill in the secondary market, and estimates of the net-margin cost. Table I breaks the full period into 1946-1962, 1963-1982, and 1983-2002 subperiods. Table I shows that the call money rates are higher than the Federal Funds rates, which are higher than the T-bill rates. For 1946 through 2002, the net-margin cost is 139 bp. In the last 20-year period, 1983-2002, the net-margin cost is 177 bp.

[Insert Table I about here.]

2.2 Ranking methods

P10 are the past winners, and P1 are the past losers. The momentum strategy is the triple (J,S,K) where J are the months of the ranking period, S are the months skipped between the rank and test periods, and K are the months of the holding period. We start at month t, rank stocks by past performance, group firms into 10 past-performance groups, skip S months between the ranking and test periods, and hold positions for the next K months. We then repeat the process using month $t+1$ as the portfolio formation date. For example, in the (6,0,6) and (6,1,6) strategies, the momentum return is the sum of six different long-short portfolios, 1/6 formed one month prior, 1/6 formed two months prior, and so forth. At the end of each month, the investor closes the oldest positions and opens new long and short positions.

We also rank stocks by NYSE market-size rankings to test the influence of small stocks in the P1 and P10 portfolios. MV1 is the smallest and MV10 the largest market-size deciles.

2.3 Momentum strategies

To gain more compact terminology, we call winner-loser *P10-P1*, winner-loser+rebate *P10-P1+REB*, winner-loser-netmargin *P10-P1-NM*, winner buys *P10*, and rebate-loser as *REB-P1*. P10-P1 is the traditional momentum strategy. P10-P1+REB and P10 are capital investing strategies. P10-P1-NM and REB-P1 are near self-financing. P10-P1-NM requires borrowing. REB-P1 is the loser short return. We define these strategies in more detail below.

2.3.1 Frictionless: P10-P1

P10-P1 is the standard, frictionless momentum return measure.

2.3.2 Capital investing: P10 buy and P10-P1+REB

P10 buy is long in winners. P10-P1+REB is long in winners, short in losers, and earns the rebate return on the cash from the collateral. We decompose the P10-P1+REB return into its two trade components: the P10 buy and REB-P1.

2.3.3 Near self-financing: REB-P1 and P10-P1-NM

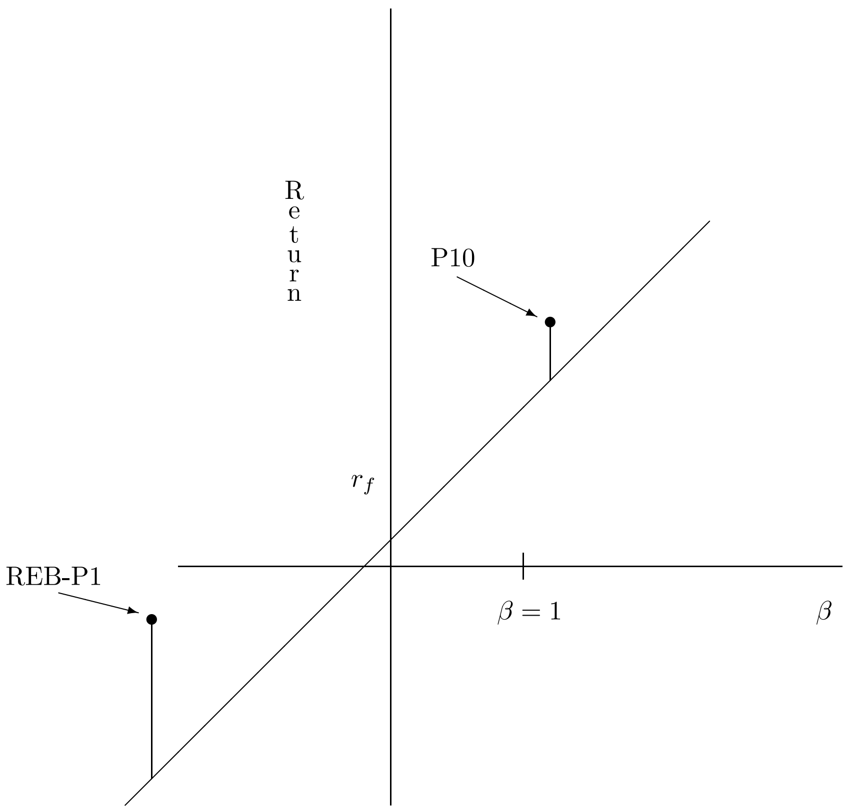
The large-stock P10-P1-NM strategy does not require capital but requires other long positions and borrowing. REB-P1 is nearly self-financing because one receives the cash from the loser short that is invested at the rebate rate. P10-P1-NM shorts losers, invests the cash at the rebate rate, and borrows capital on margin to buy winners. The strategy faces a Regulation T margin limit. While the investor can borrow up to a 1:1 capital-to-loan ratio, the maximum level of borrowing will not provide financing slack if the strategy should have a short term loss.

Assume that the rebate rate is positive and that the P1 return is less than the rebate rate. In such circumstances, shorts are profitable. Next assume that the P1 return is greater than the rebate return. In our sample from 1946-2002, we will show that REB-P1 trade, after trade costs, lose 3-4% per year. In the Ross (1976) model of efficient market pricing, smart investors gain by shorts in overvalued stocks and drive their prices down. But here shorts are unprofitable as stand-alone trades. Shorts may have value for hedging risk from long positions. However, the strategy assumes that shorts are naked (firms do not own the loser stocks), and institutional investors are typically reluctant to make naked shorts (Faulkner).

Figure 1 summarizes the results graphically for the two trade-based components of the P10-P1+REB strategy. Both the P10 and REB-P1 components are above the security market line and represent mispricing. The REB-P1 is a loss, as a stand-alone trade, but it is an overpriced security. One can extract the profits when one couples the short sale with another long position, such as long in P10.

Figure 1: Momentum Premia and the Security Market Line

Figure 1 shows the security market line for the winner buys (P10) and loser short sales (REB-P1). The figure shows the abnormal positive performance relative to the security market line. The P10 return is positive and the REB-P1 return is negative but in both cases the returns are above the security market line. The majority of the abnormal premium is on the loser side, even though the REB-P1 returns, as stand-alone trades lose money.



3 1946-2002 raw returns, without trade-execution costs

Table II reports the 1946-2002 monthly return distributions for P10-P1 for the (6,0,6), (6,1,6), (6,0,12), and (6,1,12) strategies. For the 1946-2002 period, (6,0,6) earns 0.750% and (6,1,6) earns 0.989%. The (6,0,12) and (6,1,12) strategies earn somewhat less; (6,0,12) earns 0.655%, and (6,1,12) earns 0.605%. These returns are consistent with the results of past papers, such as Jegadeesh and Titman (1993, 2001).

Table II also provides several of the higher moments of the return distributions. The P1 portfolios have the largest standard deviation. The lowest standard deviations are for P5 and P6. The P10-P1 standard deviation is about the same as that of the P4, P5, and P6 portfolios. Momentum strategies have high excess kurtosis.[13] The (6,0,6) excess kurtosis is 21.8; in contrast, the EW momentum-neutral portfolio excess kurtosis is 3.9. We will return to the kurtosis question when we consider risk-based tests.

[Insert Table II about here.]

Large trade-execution costs will limit the usefulness of the strategy. Indeed, Lesmond, Schill, and Zhou show that small stocks dominate standard P10-P1 tests. Their tests are from 1980 to 1998. We first look at the small stock influence on standard momentum strategies. For 1946-2002, we independently sort with the (6,0,6) momentum strategy and market size. Table III reports the percentage results of the independent, two-way sorts. Panel A reports the results for 1946-1962, which includes only NYSE firms. In 1946-1962, 21.2% of P1 stocks are MV1 stocks. Panel B reports the results for 1963-2002, which includes both AMEX and NYSE stocks. Recall that the market-size break points are from NYSE cutoffs. In 1963-2002, 53.7% of the P1 stocks are MV1 stocks.

Table III shows that past momentum strategies rely heavily on small stocks, which we know are costly to trade. Fama argues that anomalies are often driven by small stocks that are expensive to trade. For this reason, we concentrate most of our tests

[13]Excess kurtosis is the standard kurtosis less 3. A normal distribution has a kurtosis of 3, and the normal distribution has an excess kurtosis of 0.

on stocks in the larger half of the market. Trades in large stocks assure us that shorts are unlikely and have no "special" costs,[14] and face no likelihood of a short squeeze.[15]

[Insert Table III about here.]

We tested two ways to measure large-stock momentum. First, we ranked stocks by market size, dropped the smaller half, sorted the larger half by past performance, and formed 10 test portfolios. Second, we independently ranked stocks by past performance and market size. We then trimmed the smaller half stocks from the 10 test portfolios. We found the second strategy more profitable and use that strategy for future tests.

Table IV reports the 1946-2002 large-stock return distributions for P10-P1 for the four (J, S, K) strategies. Table IV follows the same setup as Table II. The large-stock means are slightly higher and the excess kurtosis is lower than those of full-sample stocks Table II. Table IV shows that (6,0,6) earns 0.914% and (6,1,6) earns 1.084%; (6,0,12) earns 0.794%, and (6,1,12) earns 0.711%. The excess kurtosis is still quite high.

[Insert Table IV about here.]

Table V provides more details on the returns for the four (J, S, K) strategies. We show the full-sample returns in Panel A and large-stock returns in Panel B. The table reports the P10-P1, P10-P1-NM, and REB-P1 returns. None of the results include trade costs, which we introduce in section 4. Our discussion focuses on (6,1,6) because the returns are somewhat stronger, and other strategies follow similar patterns. We note four results.

First, the full sample, or untrimmed sample (in Panel A), the P10-P1 premia are relatively constant across time. The 1946-2002 monthly P10-P1 return is 0.989%. The 1947-1962, 1963-1982, and 1983-2002 returns are 0.931%, 0.956%, and 1.048% respectively. In contrast, the large-stock portfolio premia (in Panel B) are large but the premia fall in the most recent period. The 1946-2002 large-stock monthly P10-P1 return is 1.084%. The 1947-1962, 1963-1982, and 1983-2002 returns are 1.118%,

[14]The term "special" implies a lower rebate return. See Jones and Lamont (2004).

[15]See D'Avolio and Geczy, Musto, and Reed.

1.313%, and 0.796% respectively. Trade commissions began to fall after May 1, 1975, the date of the deregulation of stock commissions. In a time series test of large-stock P10-P1, which we report but do not include in tables to save space, we find that the final period large-stock momentum is lower than the other two periods.

Second, the REB-P1 returns stand-alone trades show losses. The 1946-2002 large-stock REB-P1 monthly return is -0.038%. In 1946-1962, 1963-1982, and 1983-2002, the returns are -0.210%, 0.234%, and -0.145%. The REB-P1 is positive in the 1963-1982 period, but because of these return patterns, we should expect that, after we introduce trade-execution costs, all REB-P1 stand-alone trades will show losses.

Third, the 1946-2002 large-stock P10-P1-NM monthly return is 0.969%. The 1947-1962, 1963-1982, and 1983-2002 returns are 1.005%, 1.228%, and 0.649% respectively. The P10-P1-NM return, while slightly less than the P10-P1 return, is economically large.

[Insert Table V about here.]

4 Trade costs

We call "trade costs" as the one-way proportional cost per trade. Papers group trade costs into direct and indirect costs. Direct costs are commissions. Indirect costs are from the bid-ask spread and price impacts. We call the "trade-execution cost" as the cost per month to implement the specific momentum strategy.

Keim and Madhavan (1995, 1997, 1998) estimate trade costs for institutional trades with 1/91-3/93 trade-by-trade data. Keim and Madhavan (1998) divide costs into explicit and implicit components. The explicit cost is the commission. The implicit cost is from price impact and bid-ask spread costs. They also break trading costs into buyer-initiated and seller-initiated trades by market-size quintile. We use their estimates for our 1983-2002 tests. Even though short sales must be sold on an uptick, which slightly increases short-sale execution costs, we ignore this requirement. The large-stock ticks are small. The U.S. deregulated commissions on May 1, 1975. Jones (2002) notes commissions for NYSE stocks in 1962 are 0.82% of value and in 1997 fall to 0.12% of value, implying a 0.70% trade-cost change. Because of the higher commissions, for 1946-1982, we use the Keim and Madhavan (1998) trade costs plus 70 bp. The Keim and Madhavan (1998) estimates are consistent with other large-stock trade cost papers.[16] Using several of the other trade cost estimates for the most current period gives similar results.

The long-short strategy is trade intensive. Each month we (a) buy the recently ranked winners, (b) sell the winners that we bought six months ago, (c) sell the recently ranked losers, and (d) buy the losers that we sold short six months ago. Theoretically, for the 6-month (12-month) holding period, each month we trade 1/6 (1/12) of the long and short portfolios. However, some of the winners and losers repeat, which will reduce trade-execution costs, and we must include these repeat proportions in our trade-execution cost estimates.

We estimate repeat proportions separately for the buy and sell portfolios and compute stock turnover in the standard way. Table VI Panel A reports the cost per trade for P1 and P10 buys and sells. Panel B reports the turnover for P1 and P10 stocks. Panel C reports the monthly trade-execution costs. Table VI shows that (6,1,6) 1946-1982 trade-execution costs are 0.698% per month, or 8.4% per year. Trade-execution costs fall in 1983-2002 to 0.310%, or slightly less than 3.8% per year. The 3.8% trade-execution cost is similar to other costs estimates from other papers that study this period. The pre-deregulation trade-execution costs of 8.4% per year are higher from higher commissions. Note that, while deregulation comes in 1975, we continue to assign higher commissions through 1982, giving a reasonable time for the commission expenses to fall. This assumption may overstate commission costs for several years, which works against our ability to identify momentum premia.

[Insert Table VI about here.]

Table VII tests the raw returns, net of trade-execution costs, for P10-P1, P10-

[16] Berkowitz, Logue, and Noset (1988) also estimate trade costs during the post-deregulation period and test on large stocks. They estimate commissions paid to brokers at $0.07 per share. They estimate one-way trade costs at 0.50% of value. The Keim and Madhavan (1998) estimates for the largest market-size quintile are lower than those of Berkowitz, Logue, and Noset, but the Keim and Madhavan (1998) estimates for the second largest market-size quintile are slightly higher. Either the Berkowitz, Logue, and Noset or the Keim and Madhavan (1998) estimate works well for tests for large stocks after commission deregulation. Special adjustments are made for higher commissions in the pre-deregulation period to give us a fair estimate across the 1946-1982 period.

P1-NM, and REB-P1. (6,1,6) is more profitable than (6,0,6). The P10-P1 premium for 1946-2002 (6,1,6) is 0.529 (t value: 3.09). The P10-P1-NM (6,1,6) monthly raw-return premium is 0.414 (t value: 2.41). Net of trade costs, the REB-P1 strategy is unprofitable in every period.

[Insert Table VII about here.]

5 Returns, net of risk-based factors and trade-execution costs

One might object, quite reasonably, that the P10-P1 raw return is not the correct test because there is no risk-based model. However, the P10-P1 raw return is useful because it is not obvious what the appropriate risk-based model might be. It is also important as it serves as a benchmark for the tests that risk adjust. The Table VII results show losses for the REB-P1 strategy and gains for P10-P1 and P10-P1-NM. The (6,1,6) strategy has stronger performance than (6,0,6). We next turn to risk-based tests.

Jegadeesh and Titman (1993, 2001), Fama and French (1996), and Grundy and Martin show that P10-P1 strategies hedge out factor risks. To make our results compact for the reader, we report only $\hat{\alpha}$'s for CAPM and the 3-factor model and do not report slopes on factors to save space. (Our slope coefficients support the findings of previous work.) Table VI organizes the results into three strategies: (1) frictionless momentum (P10-P1), (2) strategies that require capital (P10-P1+REB and P10), and (3) strategies that mimic self-financing strategies (P10-P1-NM and REB-P1). We test with the (6,0,6) and (6,1,6) strategies because the returns, net of trade-execution costs, are slightly larger than those from the 12-month holding-period strategies.

5.1 The frictionless strategy

5.1.1 P10-P1

Table VIII reports for the large-stock (6,0,6) and (6,1,6) strategies. Without considering trade-execution costs, the (6,0,6) CAPM premium in Panel A is 0.976%, and the 3-factor premium is 1.044%. The (6,1,6) CAPM premium in Panel B is 1.107%, and the 3-factor premium is 1.205%. All performance measures are significant, $p < .01$ or less.

Net of trade-execution costs, the (6,0,6) CAPM premium is 0.419% and the 3-factor premium is 0.487%. The (6,1,6) CAPM P10-P1 premium is 0.552%, and the 3-factor premium is 0.651%. The full-sample performance measures are significant at $p < .01$ or less. Net of trade-execution costs, momentum earns per year 7% in CAPM and 8% in the 3-factor model.

5.2 Strategies that require capital

5.2.1 P10-P1+REB

Net of trade-execution costs, the (6,0,6) P10-P1+REB CAPM premium is 0.447, and the 3-factor premium is 0.516. For the (6,1,6) large-stock strategy, the premia are larger. The (6,1, 6) P10-P1+REB CAPM premium is 0.580 and the 3-factor premium is 0.680. All coefficients are significant at the 5% level. Recall that the P10-P1 risk-adjusted test is based on a premium and we do not subtract a risk-free return. The P10-P1+REB strategy invests capital and we subtract the risk-free return. The P10-P1+REB has a higher performance measure because the rebate rate is slightly higher than the risk-free rate.

5.2.2 P10 buys

The P10 buy strategies simulate Korajczyk and Sadka (2004). They use the conditional Fama and French (1993) model. Our tests use a longer period of time and unconditional factor models. Our after-trade cost performance measures for buying winners show no abnormal premia. The (6,0,6) CAPM performance is 0.127% (t: 1.09); the 3-factor performance is 0.086% (t: 0.97). The (6,1,6) large-stock CAPM performance is 0.167% (t: 1.44); the 3-factor performance is 0.134% (t: 1.53). Controlling for factor risk, the profit from the strategy, net of trade-execution costs, approximates 1.5% per year.

5.3 Strategies that mimic self-financing

5.3.1 REB-P1

Table IV shows that REB-P1 returns are negative. Table VIII shows that there are risk-based REB-P1 premia, net of trade-execution costs. For 1946-2002, the (6,0,6) the CAPM premium is 0.320, and the 3-factor premium is 0.431%. Both are significant at the 5% level. The (6,1,6) results are somewhat stronger. For (6,1,6), the CAPM premium is 0.413%, and the 3-factor premium is 0.546%. These results are also significant. The annual CAPM (3-factor) (6,1,6) premium is 5% (7%) per year. These results are also significant at $p < .05$ or less.

5.3.2 P10-P1-NM

Net of trade-execution costs, the P10-P1-NM (6,0,6) CAPM premium is 0.304%, and the 3-factor premium is 0.371%. For (6,1,6), the CAPM premium is 0.437%, and the 3-factor premium is 0.535%. The annual CAPM (3-factor) premium earns more than 5% (6%) per unit of borrowed capital.

[Insert Table VIII about here.]

6 Distributions and a brief discussion

Tables II and IV show that the P10-P1 have fat-tailed distributions. Table IX reports the distributions for the residuals for CAPM and the 3-factor regressions for the standard P10-P1 return. Both of these strategies are net of trade-execution costs.

The distributions of the residuals here are similar to those raw returns of Tables II and IV. The residuals are fat-tailed. The largest 3-factor residual for January 2001 is -32.03%. Typically, 5% of the residuals experience losses of greater than 10% per month. Thus, while the variance and kurtosis that we see may not be linked to a factor model, the strategy is not immune from short-run losses.

[Insert Table IX about here.]

Assume that the investor holds the market portfolio and engages in a small P10-P1-NM trade. Let γ ($0 < \gamma < 1$) be the proportion of capital committed to the momentum P10-P1-NM return. Assume then that the investor holds the market portfolio and engages in a small P10-P1-NM trade. Table X shows that for 1946-2002, for a γ of 5% or less, as one adds the momentum portfolio, the standard deviation of the return is unchanged but the return increases. For a γ greater than 5%, while the standard deviation of the combined portfolio increases, the Sharpe ratio continues to grow.

[Insert Table X about here.]

7 Conclusion

Our momentum tests concentrate on large stocks where price-impact costs are small and trade costs are straightforward to estimate. We test back to 1946, a longer time period than previous trade-cost studies. We first measure the frictionless momentum return P10-P1. We find that P10-P1, net of trade-execution costs, is profitable.

Second, we study two capital-investing strategies. It is necessary that we study these strategies because the frictionless momentum strategy is not implementable, given the real-world constraints. First, we buy winners, short losers, and earn the rebate return on short-sale cash. We refer to this strategy as P10-P1+REB. We find that the strategy earns, net of trade-execution costs, the return of holding an EW momentum-neutral portfolio; however, the P10-P1+REB strategy has no factor risk. Risk-adjusted premia show robust premia. The 3-factor α earns, net of trade-execution costs, 0.680 per month (8% per month annually). Second, we buy winners (and ignore losers), similar to Korajczyk and Sadka. Raw return and risk-adjusted return gains from buying winners and holding long positions for 6 months are small, on the order of 1.5% per year and not different than chance.

Third, we study two near-self-financing strategies. First, we buy winners, short losers, earn the rebate interest on the short-sale cash, and finance winners from margin. We call this strategy P10-P1-NM. The P10-P1-NM strategy earns an incremental 5% per year annually on each unit of borrowed capital, but the incremental long short strategy has no factor risk. The 3-factor α's somewhat stronger. The strategy earns, net of trade-execution costs, 0.535% per month (6.4% per year). Second, we short losers and earn the rebate rate on the short-sale cash proceeds. Because the investor is required to post 102% of the short sales as cash, this strategy is nearly self-financing. We call this strategy REB-P1. This strategy is not profitable on a raw return basis, but is profitable if coupled with a long position such as the P10 portfolio.

In an additional test, we combined at a small position of the momentum borrowing portfolio with a unit of the market portfolio. We found that the standard deviation of the combined portfolios falls slightly and the return increases. As one adds more of the momentum portfolio, the Sharpe ratio of the combined positions increases.

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Table I: Yearly Call Money Rates, Federal Funds Rates, 30-Day T-Bill Rates, and Net Margin Costs: 12/47-12/02

The call money rate, sometimes called the broker's loan rate, is the base rate for margin loans that brokers extend to their clients. The rate information was hand-collected from the *Wall Street Journal*. The call money rate that we use is the midpoint of the high and low estimates. For 7/54 through 12/02, The Federal Funds data are from the St. Louis Federal Reserve. For 12/47 through 6/54, we hand-collected Federal Funds rates from the *Wall Street Journal*. The 30-day T-bill rate is similar to the Federal Funds rate and we include it for comparative purposes. The 30-day T-bill data are from the St. Louis Federal Reserve.

In the winner-loser-margin strategy, the investor longs winners, shorts losers, and invests in winners through a margin position secured from other securities. We assume that the investor earns the rebate interest on the short position and pays the call money rate on the long position. D'Avolio (2002) estimates the rebate rate at the Federal Funds rate less 25 basis points, and we use that approach for estimating the rebate rates. The "net-margin cost" is the difference between the call money rate and the rebate rate estimate.

	Call money	Federal Funds	T-Bill	Average net-margin	Standard deviation of net-margin
1/46-12/02	6.366	5.229	4.798	1.387	0.723
1/46-12/62	2.890	1.775	1.833	1.365	0.666
1/63-12/82	8.117	7.348	6.542	1.019	0.678
1/83-12/02	7.568	6.045	5.574	1.773	0.614

Table II: Momentum Premia: 1946-2002

The return data are for the NYSE and AMEX from the Center for Research in Security Prices (CRSP) for 1946-2002. The momentum strategy is the triple (J,S,K) where J is the number of months of the ranking period, S is the number of months skipped between the rank and test periods, and K is number of months of the holding period. To increase power, Jegadeesh and Titman (1993) use an overlapping-period design, and we follow their setup. We start at month t and rank stocks by the previous J months ($t-J-1$ through t), accumulate returns by past performance, skip S periods, form portfolios based on past performance rankings, and hold the positions for the succeeding K months. We then repeat the process using month $t+1$ as the portfolio formation date. Thus, each month the investor holds K winner portfolios and K loser portfolios. The monthly momentum return is the average of the winner portfolios less the loser portfolios. The table presents the distribution characteristics for $(6,0,6)$, $(6,1,6)$, $(6,0,12)$, and $(6,1,12)$ for the portfolios, the P10-P1 portfolio, and the EW portfolio (the mean of the ten decile portfolios) for the test period stocks. The kurtosis is the excess kurtosis, which is three less than the standard kurtosis.

	(6,0,6)				**(6,1,6)**			
	Mean	Std Dev	Sk	Kr	Mean	Std Dev	Sk	Kr
P1	0.747	7.826	1.521	8.729	0.581	7.543	1.272	7.175
P2	0.957	5.892	0.678	5.614	0.899	5.771	0.531	4.882
P3	1.081	5.304	0.368	5.675	1.064	5.258	0.295	5.278
P4	1.122	4.976	0.185	5.409	1.125	4.944	0.135	5.474
P5	1.172	4.805	-0.130	4.599	1.190	4.801	-0.150	4.725
P6	1.222	4.742	-0.332	4.369	1.238	4.749	-0.320	4.363
P7	1.237	4.790	-0.449	4.315	1.273	4.819	-0.401	4.449
P8	1.287	4.925	-0.624	4.085	1.338	4.977	-0.529	4.036
P9	1.360	5.235	-0.714	3.843	1.418	5.295	-0.623	3.904
P10	1.497	6.082	-0.601	2.790	1.570	6.182	-0.506	2.726
P10-P1	0.750	5.024	-3.012	21.825	0.989	4.532	-2.356	15.893
EW	1.168	5.247	-0.115	3.879	1.170	5.244	-0.114	3.876

	(6,0,12)				**(6,1,12)**			
	Mean	Std Dev	Sk	Kr	Mean	Std Dev	Sk	Kr
P1	0.767	7.312	1.060	6.384	0.781	7.239	1.000	6.109
P2	0.969	5.705	0.376	4.805	0.983	5.684	0.348	4.732
P3	1.083	5.199	0.171	5.025	1.100	5.189	0.146	5.021
P4	1.127	4.916	0.057	5.089	1.143	4.907	0.025	5.112
P5	1.194	4.783	-0.150	4.618	1.203	4.782	-0.147	4.660
P6	1.222	4.735	-0.286	4.250	1.224	4.732	-0.284	4.225
P7	1.263	4.799	-0.344	4.090	1.262	4.800	-0.312	4.029
P8	1.310	4.955	-0.424	3.761	1.309	4.961	-0.383	3.608
P9	1.362	5.272	-0.477	3.316	1.346	5.286	-0.427	3.209
P10	1.422	6.155	-0.413	2.551	1.386	6.178	-0.384	2.445
P10-P1	0.655	3.827	-1.975	11.011	0.605	3.701	-1.770	9.318
EW	1.172	5.237	-0.114	3.862	1.174	5.234	-0.113	3.859

Table III: Distribution of Portfolios Formed By Independent Sorts on Market Size and 6-Month Past Performance: 1946-2002

Table III follows the setup of Table II. We use a momentum (6,0,6) setup. The return data are for the NYSE and AMEX from CRSP for 1946-2002. To increase power, Jegadeesh and Titman (1993) use an overlapping-period design, and we follow their setup. P10 is the winner portfolio and P1 is the loser portfolio. Independently, we rank stocks by NSYE market size and form deciles. MV1 is smallest decile and MV10 is the largest. AMEX stocks are often small, implying that the NYSE size cutoffs will generate a large number of stocks in the MV1 portfolio. In July 1962, CRSP adds AMEX stocks, and in January 1963 AMEX stocks enter the test-period portfolios.

For each past-performance ranking, as we move across the right, the table shows the percentage of the test-period stocks returns that fall into the 10 market-size groups. For example, for Panel A (only NYSE stocks), 21.2% of the P1 (past losers) are MV1 stocks and 4.6% of the P1 are MV10 stocks. In Panel B, (both NYSE/AMEX stocks), 53.7% of the P1 stocks are MV1 and 2.5% of the P1 stocks are MV10 stocks.

Panel A: 1946-1962 (NYSE stocks only)

	MV1 (Small)	MV2	MV3	MV4	MV5	MV6	MV7	MV8	MV9	MV10 (Large)
P1 (Losers)	21.2	14.2	11.6	10.7	9.4	7.8	7.6	7.0	5.9	4.6
P2	12.5	11.6	11.0	10.4	9.8	9.9	9.3	8.8	8.8	8.0
P3	9.7	10.7	10.4	9.8	10.6	9.8	9.6	9.7	9.5	10.1
P4	8.2	10.0	9.8	10.2	10.3	10.1	10.2	10.1	10.5	10.6
P5	7.9	9.6	9.6	9.6	9.7	10.4	10.4	10.3	11.2	11.5
P6	7.2	8.8	9.6	9.6	10.0	10.6	10.7	10.5	11.0	11.9
P7	7.0	8.3	9.4	9.3	9.6	9.9	11.3	11.1	11.6	12.6
P8	6.9	8.2	9.1	9.7	9.6	10.6	10.7	11.2	11.6	12.4
P9	7.4	8.2	9.5	9.5	10.1	10.3	10.8	11.4	11.2	11.6
P10 (Winners)	10.9	9.9	10.1	11.1	10.9	10.5	9.8	10.2	8.8	7.6
Av.	9.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.1

Panel B: 1963-2002 (NYSE and AMEX stocks)

	MV1 (Small)	MV2	MV3	MV4	MV5	MV6	MV7	MV8	MV9	MV10 (Large)
P1 (Losers)	53.7	11.5	7.8	6.0	5.0	3.9	3.6	3.3	2.7	2.5
P2	38.2	11.6	8.7	7.3	6.4	6.0	6.0	5.6	5.2	5.0
P3	31.5	11.3	8.6	7.7	7.3	7.0	6.8	6.7	6.6	6.4
P4	27.8	10.6	8.5	7.7	7.7	7.5	7.5	7.5	7.6	7.5
P5	25.2	10.1	8.5	7.9	7.9	8.0	8.1	8.0	8.2	8.2
P6	23.7	9.9	8.6	8.0	8.0	8.1	8.1	8.4	8.4	8.8
P7	23.3	10.0	8.5	8.0	8.2	8.1	8.2	8.4	8.6	8.9
P8	24.2	9.9	8.6	8.1	8.2	7.9	8.0	8.1	8.3	8.7
P9	26.9	10.9	9.0	8.5	8.0	7.7	7.5	7.3	7.2	7.0
P10 (Winners)	39.0	12.9	9.4	8.1	7.0	5.9	5.4	4.6	3.9	3.6
Av.	31.4	10.9	8.6	7.7	7.4	7.0	6.9	6.8	6.7	6.7

Table IV: Large-Stock Momentum Premia: 1946-2002

The return data are for the NYSE and AMEX from CRSP for 1946-2002. The momentum strategy is the triple (J,S,K) where J is the number of months of the ranking period, S is the number of months skipped between the rank and test periods, and K is number of months of the holding period. We sort independently by past 6-month performance and market size. From the 10 past performance portfolios, we trim off stocks below the market capitalization median. The table follows the setup in Table II. Table IV presents the distribution characteristics for $(6,0,6)$, $(6,1,6)$, $(6,0,12)$, and $(6,1,12)$ for the portfolios, the P10-P1 portfolio, and the EW portfolio (the mean of the ten decile portfolios) for the test period stocks. The kurtosis is the excess kurtosis, which is three less than the standard kurtosis.

	(6,0,6)				**(6,1,6)**			
	Mean	Std Dev	Sk	Kr	Mean	Std Dev	Sk	Kr
P1	0.564	6.894	0.472	2.722	0.453	6.671	0.346	2.118
P2	0.857	5.436	0.180	2.150	0.785	5.327	0.091	1.950
P3	0.979	4.869	0.098	2.355	0.920	4.804	0.030	2.246
P4	1.004	4.577	-0.011	2.211	0.981	4.546	-0.080	2.251
P5	1.048	4.478	-0.150	2.569	1.034	4.462	-0.210	2.759
P6	1.079	4.420	-0.271	2.636	1.089	4.414	-0.299	2.627
P7	1.097	4.471	-0.473	2.618	1.125	4.476	-0.473	2.649
P8	1.149	4.575	-0.592	2.657	1.184	4.616	-0.529	2.481
P9	1.219	4.971	-0.637	2.620	1.268	5.014	-0.569	2.467
P10	1.478	5.827	-0.498	1.888	1.537	5.936	-0.450	1.817
P10-P1	0.914	5.209	-1.162	6.545	1.084	4.933	-0.801	3.930
EW	1.047	4.789	-0.271	1.820	1.038	4.779	-0.280	1.791

	(6,0,12)				**(6,1,12)**			
	Mean	Std Dev	Sk	Kr	Mean	Std Dev	Sk	Kr
P1	0.544	6.513	0.356	3.120	0.587	6.337	0.245	2.160
P2	0.838	5.258	-0.021	2.093	0.855	5.153	-0.051	2.106
P3	0.949	4.761	-0.087	2.296	0.951	4.698	-0.113	2.377
P4	0.993	4.516	-0.139	2.301	1.003	4.486	-0.176	2.499
P5	1.048	4.430	-0.231	2.679	1.056	4.410	-0.232	2.869
P6	1.072	4.397	-0.307	2.537	1.078	4.378	-0.307	2.544
P7	1.125	4.451	-0.399	2.373	1.127	4.437	-0.382	2.326
P8	1.156	4.603	-0.455	2.164	1.153	4.602	-0.402	2.023
P9	1.220	4.967	-0.465	1.893	1.197	4.970	-0.419	1.710
P10	1.339	5.840	-0.414	1.532	1.298	5.870	-0.403	1.490
P10-P1	0.794	4.266	-0.937	6.067	0.711	4.086	-0.667	3.754
EW	1.028	4.785	-0.294	1.904	1.031	4.754	-0.299	1.958

Table V: Momentum Monthly Raw Returns Without Trade-Execution Costs: Four Test Strategies for the Full-Sample and Large-Stock Portfolios: 1946-2002

The return data are from the NYSE and AMEX from CRSP for 1946-2002. The momentum strategy is the triple (J,S,K) where J is the number of months of the ranking period, S is the number of months between the rank and test periods, and K is number of months of the holding period. We start at month t and rank stocks by the previous J months past performance, skip S periods, and invest K months. Tests repeat the process using month $t+1$ as the past performance ranking date. Each month the investor holds K winner portfolios and K loser portfolios. The table presents the results for (6,0,6), (6,1,6), (6,0,12), (6,1,12) strategies. Panel A reports the returns for all stocks. Panel B reports the returns for large-stock portfolios. For the large-stock portfolio, tests independently sort stocks by NYSE market-size deciles and past performance and drop stocks below the market-size median. P10 is the portfolio of past winners and P1 is the portfolio of past losers. All monthly returns are multiplied times 100. Thus, a 1.00 performance measure is 1.00% per month.

Tests assume that investors earn the rebate cash rate on their short sales and estimates the rebate return at the Federal Funds rate less 25 basis points. REB-P1 is the return from the strategy that shorts losers and earns the rebate rate on the short sale cash. P10-P1-NM is the strategy that longs winners, shorts losers, earns the rebate return on the short sale cash, and finances the long position at the broker's call rate. Tests call the difference between the broker's call rate and the rebate rate as "net margin." No transaction costs are included in the monthly returns. To sum up, tests measure three types of self-financing or near self-financing strategies: (1) standard momentum (P10-P1), which has been actively studied, (2) P10-P1-NM, which borrows to finance long positions, and (3) REB-P1, which sells losers short and earns the rebate cash rate.

Panel A: All stocks

	(6,0,6)				**(6,1,6)**			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
Standard P10-P1	0.750	0.867	0.651	0.729	0.989	0.931	0.956	1.045
Strategies that mimic self-financing								
P10-P1-NM	0.634	0.754	0.566	0.582	0.873	0.817	0.871	0.898
REB-P1	-0.332	-0.334	-0.500	-0.127	-0.167	-0.285	-0.294	0.095

	(6,0,12)				**(6,1,12)**			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
Standard P10-P1	0.655	0.561	0.651	0.720	0.605	0.501	0.664	0.614
Strategies that mimic self-financing								
P10-P1-NM	0.540	0.447	0.566	0.572	0.489	0.387	0.579	0.467
REB-P1	-0.352	-0.470	-0.466	-0.103	-0.366	-0.491	-0.435	-0.156

Panel B: Large-stock strategies

	(6,0,6)				(6,1,6)			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
Standard P10-P1	0.914	1.099	1.116	0.527	1.084	1.118	1.313	0.796
Strategies that mimic self-financing								
P10-P1-NM	0.798	0.985	1.031	0.379	0.969	1.005	1.228	0.649
REB-P1	-0.149	-0.237	0.074	-0.279	-0.038	-0.210	0.234	-0.145

	(6,0,12)				(6,1,12)			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
Standard P10-P1	0.794	0.736	0.999	0.621	0.711	0.665	0.926	0.517
Strategies that mimic self-financing								
P10-P1-NM	0.679	0.623	0.914	0.473	0.595	0.551	0.841	0.369
REB-P1	-0.129	-0.383	0.164	-0.186	-0.173	-0.408	0.158	-0.283

Table VI: Trade-Execution Costs

We look at four large-stock strategies, (6,0,6), (6,0,12), (6,1,6), and (6,1,12). We first rank stocks by past performance and independently rank all stocks by market size. We trim the stocks in the smaller half of the market from the past-performance-ranked portfolios.

Keim and Madhavan (1998) estimate transaction costs for large institutional traders. These estimates are based on the effective spread and estimates of commissions. We use their estimates from Table 2 (p. 59) for our 1983-2002 tests. The U.S. deregulated commissions on May 1, 1975. Jones (2002) notes commissions for NYSE stocks in 1962 are 0.82% of value and in 1997 fall to 0.12% of value, implying a 0.70% trade cost change. For 1926-1982, we use the Keim and Madhavan (1998) costs plus 70 bp. Keim and Madhavan (1998) report trading estimates based on market-size quintiles and we use their market-size quintile structure to assign costs. They organize the results for buyer-initiated and seller-initiated trades and divide costs into explicit (trade commissions) and implicit (price impact, bid-ask spread) costs.

	Buyer-initiated			Seller-initiated		
Market-size quintile	Implicit	Explicit cost	Total cost	Implicit	Explicit	Total cost
MV5-MV6	.41	.24	.64	.72	.30	1.02
MV7-MV8	.28	.17	.43	.41	.23	.63
MV9-MV10	.17	.13	.31	.11	.15	.26

source: Keim and Madhavan (1998).

To estimate trade-execution costs, Panel A reports the P1 and P10 trade-execution costs for each test period. We compute the proportion of the P1 (loser) and P10 (winner) portfolios times the Keim and Madhavan (1998) costs and sum the results to obtain a weighted-average cost for each period for P1 and P10 buys and sells. Panel B reports the P1 and P10 buy and sell turnovers. We define these turnover as the proportion of the long or short portfolio that is bought or sold each month to execute the strategy. We multiply turnovers times the trade-execution cost in Panel A for each buy and sell. Panel C shows the trade-execution costs per month. We use this trade-execution cost in the subsequent asset pricing tests.

Panel A: P1 and P10 cost per trade

Period	P1 sell	P1 buy	P10 buy	P10 sell
1946-1982	1.311	1.104	1.094	1.289
1983-2002	0.605	0.442	0.441	0.605

Panel B: Stock turnover

	(6,0,6)		**(6,1,6)**		**(6,0,12)**		**(6,1,12)**	
Period	P1	P10	P1	P10	P1	P10	P1	P10
1946-1962	0.146	0.145	0.145	0.145	0.074	0.074	0.075	0.075
1963-1982	0.144	0.147	0.143	0.148	0.071	0.076	0.073	0.077
1983-2002	0.148	0.149	0.147	0.149	0.074	0.077	0.075	0.077

Panel C: Estimates of *monthly* trade-execution costs

	(6,0,6)			**(6,1,6)**		
Period	P10	P1	P10-P1	P10	P1	P10-P1
1946-1962	0.345	0.344	0.688	0.345	0.342	0.687
1963-1982	0.351	0.340	0.691	0.353	0.335	0.688
1983-2002	0.156	0.155	0.311	0.155	0.154	0.309

	(6,0,12)			**(6,1,12)**		
Period	P10	P1	P10-P1	P10	P1	P10-P1
1946-1962	0.177	0.174	0.351	0.179	0.176	0.355
1963-1982	0.182	0.167	0.349	0.184	0.171	0.354
1983-2002	0.080	0.077	0.158	0.081	0.078	0.159

Table VII: Momentum Monthly Raw Returns: Momentum Strategies for Large Market-Size Half, With Trade-Execution Costs: 1946-2002

The return data are from the NYSE and AMEX from CRSP for 1946-2002. The table presents the results for (6,0,6) and (6,1,6) strategies for the large stock tests. In defining the large-stock portfolio, tests independently sort stocks by NYSE market-size deciles and past performance. Tests keep the large half of the market. P10 is the portfolio of past winners and P1 is the portfolio of past losers. Tests assume that investors earn the rebate cash rate on their short sales. Tests estimate the rebate return at the Federal Funds rate less 25 basis points. REB-P1 is the return from the strategy that shorts losers and earns the rebate rate on the short sale cash. P10-P1-NM longs winners, shorts losers, and earns the rebate return on the short sale cash, and finances the long position at the broker's call rate. The strategy requires borrowing. We call the difference between the broker's call rate and the rebate rate as "net margin." The table shows the P10-P1, P10-P1-NM, and REB-P1 with and without trade-execution costs. The t values use the Newey and West adjustments.

	(6,0,6)				**(6,1,6)**			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
P10-P1	0.357	0.444	0.361	0.216	0.529	0.468	0.624	0.487
	[1.88]	[2.44]	[1.02]	[0.59]	[3.09]	[2.68]	[1.99]	[1.36]
P10-P1-NM	0.241	0.330	0.340	0.068	0.414	0.354	0.539	0.340
	[1.34]	[1.81]	[1.00]	[0.19]	[2.41]	[2.03]	[1.72]	[0.95]
REB-P1	-0.425	-0.601	-0.274	-0.678	-0.311	-0.572	-0.099	-0.302
	[-1.63]	[-1.57]	[-0.53]	[-2.29]	[-1.23]	[-1.51]	[-0.21]	[-0.67]

Table VIII: Momentum Performance Measures, With and Without Controlling for Trade-Execution Costs: 1946-2002

The return data are from the NYSE and AMEX from CRSP for 1946-2002. Test report results for the full period and for the 1946-1962, 1963-1982, 1983-2002 subperiods. Tests use the large-stock (6,0,6) and (6,1,6) strategies in Panels A and B respectively. P10 is the portfolio of past winners and P1 is the portfolio of past losers. Tests use the unconditional CAPM and the Fama and French (1993) 3-factor models,

$$\begin{aligned} \mathrm{r} - \mathrm{r}_f &= \alpha + \beta(\mathrm{CRSPVW} - \mathrm{r}_f) \\ \mathrm{r} - \mathrm{r}_f &= \alpha + \beta(\mathrm{CRSPVW} - \mathrm{r}_f) + s\mathrm{SMB} + h\mathrm{HML} \end{aligned}$$

where CRSPVW is the CRSP Value weighted index, r_f is the risk-free rate, and SMB and HML are the Fama and French (1993) factors. Newey-West t-values are shown in brackets.

We consider three types of strategies that we isolate in the subpanels of each of the panels. First, tests show the P10-P1 premium. This is the standard return and we report with adjusting for trade-execution costs as a reference return. Second, tests consider strategies that invest capital. We show all other returns net of trade-exectution costs. P10-P1+REB is the strategy of investing a unit of capital in winners, selling short losers, and investing the short-sale cash at the rebate return. (Tests estimate the rebate return from the Federal Funds rate less 25 basis points.) P10 is the strategy of buying winners. Third, tests report strategies that are close to self-financing. The REB-P1 return is from a strategy that shorts P1 and earns cash at the rebate rate. This strategy is close to self-financing. The strategy that shorts losers and buys winners through margin is P10-P1-NM. Asset pricing tests for P10-P1+REB and P10 require capital, and thus, tests subtract the risk-free rate. Other tests, that are based on self-financing assumptions or are near self-financing, are tests with risk premia and do not subtract the risk-free rate.

Panel A: **(6,0,6)**

	CAPM				3-FACTOR			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
Panel A1: Frictionless strategy: P10-P1	0.976	1.109	1.130	0.755	1.044	1.034	1.327	0.727
	[5.42]	[5.72]	[3.37]	[2.13]	[5.48]	[4.70]	[3.98]	[1.79]
P10-P1 (net of implementation costs)	0.419	0.421	0.439	0.425	0.487	0.350	0.636	0.416
	[2.34]	[2.17]	[1.31]	[1.21]	[2.57]	[1.57]	[1.91]	[1.02]
Panel A2: Capital-investing strategies								
P10-P1+REB (net of implementation costs)	0.447	0.408	0.506	0.452	0.516	0.333	0.709	0.436
	[2.50]	[2.10]	[1.50]	[1.28]	[2.72]	[1.50]	[2.11]	[1.07]
P10 (net of implementation costs)	0.127	-0.074	0.394	0.086	0.086	-0.004	0.324	-0.080
	[1.09]	[-0.52]	[1.86]	[0.44]	[0.97]	[-0.03]	[1.87]	[-0.55]
Panel A3: Near self-financing strategies								
REB-P1 (net of implementation costs)	0.320	0.482	0.112	0.366	0.431	0.337	0.385	0.516
	[2.13]	[3.44]	[0.47]	[1.15]	[2.87]	[2.77]	[1.78]	[1.49]
P10-P1-NM (net of implementation costs)	0.304	0.257	0.354	0.281	0.371	0.232	0.552	0.277
	[1.70]	[1.33]	[1.05]	[0.78]	[1.96]	[1.06]	[1.65]	[0.66]

Panel B: **(6,1,6)**

	CAPM				3-FACTOR			
	1946-2002	1946-1962	1963-1982	1983-2002	1946-2002	1946-1962	1963-1982	1983-2002
Panel B1: Frictionless strategy: P10-P1	1.107	1.110	1.314	0.868	1.205	1.047	1.517	0.968
	[6.36]	[5.90]	[4.21]	[2.41]	[6.65]	[4.84]	[4.79]	[2.48]
P10-P1 (net of implementation costs)	0.552	0.423	0.625	0.559	0.651	0.360	0.828	0.659
	[3.18]	[2.25]	[2.00]	[1.55]	[3.60]	[1.66]	[2.62]	[1.69]
Panel B2: Capital-investing strategies								
P10-P1+REB (net of implementation costs)	0.580	0.410	0.693	0.58	0.680	0.347	0.901	0.679
	[3.34]	[2.17]	[2.21]	[1.61]	[3.75]	[1.60]	[2.82]	[1.74]
P10 (net of implementation costs)	0.167	-0.092	0.431	0.160	0.134	-0.015	0.354	0.036
	[1.44]	[-0.67]	[2.01]	[0.79]	[1.53]	[-0.11]	[2.06]	[0.25]
Panel B3: Near self-financing strategies								
REB-P1 (net of implementation costs)	0.413	0.502	0.271	0.420	0.546	0.363	0.547	0.643
	[2.87]	[3.67]	[1.25]	[1.28]	[3.81]	[2.98]	[2.71]	[1.92]
P10-P1-NM (net of implementation costs)	0.437	0.309	0.540	0.412	0.535	0.246	0.744	0.511
	[2.52]	[1.64]	[1.73]	[1.14]	[2.96]	[1.14]	[2.35]	[1.31]

Table IX: Distributions of Momentum Residuals from CAPM and 3-Factor Regressions: 1946-2002

This table examines the regression residuals for the (6,1,6) momentum strategies for the CAPM and the Fama and French (1993) 3-factor regressions for the test period 1946 through 2002. The unconditional CAPM and the Fama and French (1993) 3-factor models are,

$$\begin{aligned} \text{P10-P1} &= \alpha + \beta(\text{CRSPVW - r}_f) \\ \text{P10-P1} &= \alpha + \beta(\text{CRSPVW - r}_f) + s\text{SMB} + h\text{HML} \end{aligned}$$

where CRSPVW is the CRSP Value weighted index, r_f is the risk-free rate, SMB, and HML are the Fama and French market size and book-to-market factors. The table reports the mean residuals, the standard deviation, skewness, and kurtosis. The table then reports the quantile points: the maximum, 95%, median, 5%, and minimum values. All the residuals have a zero mean.

	1946-2002		1946-1962		1963-1983		1983-2002	
	CAPM	3-factor	CAPM	3-factor	CAPM	3-factor	CAPM	3-factor
Standard Deviation	4.10	4.93	3.16	3.01	5.05	4.98	5.93	5.89
Skewness	-0.81	-0.79	-0.30	-0.05	-0.68	-0.60	-0.76	-0.92
Kurtosis	4.04	3.88	0.95	0.73	2.60	2.25	3.13	3.60
Quantiles								
Maximum	17.57	15.96	9.27	9.10	14.46	14.67	18.05	14.06
95%	7.30	7.47	5.30	5.09	7.29	7.76	9.73	9.49
Median	0.13	0.14	0.22	-0.30	0.03	0.11	0.39	0.40
5%	-8.20	-8.07	-5.80	-4.67	-8.58	-8.14	-10.08	-10.62
Minimum	-31.17	-32.01	-10.35	-9.41	-21.47	-18.87	-30.64	-32.03

Table X: Linear Combinations of the Market Portfolio and P10-P1-NM: 1946-2002

This table shows the monthly returns for portfolios that combine the market portfolio, less the risk-free rate, and increments of the momentum P10-P1-NM portfolio, net of trade execution costs. The term γ represents a proportion of the P10-P1-NM that is combined with one unit of the value weighted CRSP market portfolio, less the risk free rate. The table shows the monthly returns, the standard deviation, and the Sharpe ratios (the ratio of the portfolio less its risk-free rate to its standard deviation). The table first sets γ equal to zero, and then increases γ to 0.05, 0.10, 0.25, and 0.50. Larger positions of γ may trigger a risk for liquidation, if the portfolio may draw a bad return.

	1946-2002	1946-1962	1963-1982	1983-2002
$\gamma = 0.00$				
Mean	0.569	0.879	0.274	0.573
Standard Deviation	4.292	3.731	4.461	4.546
Sharpe ratio	0.133	0.236	0.061	0.126
$\gamma = 0.05$				
Mean	0.595	0.901	0.305	0.598
Standard Deviation	4.291	3.741	4.468	4.528
Sharpe ratio	0.139	0.241	0.068	0.132
$\gamma = 0.10$				
Mean	0.622	0.922	0.337	0.622
Standard Deviation	4.303	3.757	4.488	4.528
Sharpe ratio	0.145	0.245	0.075	0.137
$\gamma = 0.25$				
Mean	0.701	0.987	0.43	0.695
Standard Deviation	4.424	3.844	4.633	4.646
Sharpe ratio	0.158	0.257	0.093	0.150
$\gamma = 0.50$				
Mean	0.834	1.094	0.586	0.817
Standard Deviation	4.874	4.106	5.121	5.190
Sharpe ratio	0.171	0.266	0.114	0.157