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Momentum During Intraday Trading

Evidence from US NASDAQ

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Abstract

Both momentum and contrarian strategies have shown to provide investors with high risk-adjusted returns when applied on daily, weekly and monthly data. This study examines the effect of the underreaction phenomenon on the US NASDAQ stock market between November 2016 and February 2017. I implement a simple relative strength strategy, which identifies the strongest and weakest performing stocks and invest in the assets momentum. The portfolios formed yields abnormal risk-adjusted returns during mid-day trading when applied to intraday data. These abnormal returns are consistent when market frictions are low, and after testing for market, size and value factors.

Keywords: Momentum, Contrarian, Relative strength, Intraday ,Trading strategy, Abnormal returns

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1. Introduction

Whether an active investment strategy can outperform the market in the long run have been discussed for decades. Assuming efficient markets (Fama, 1970), the task would be impossible, since the aggregated market participants are rational. While few trading strategies have yielded returns that exceed the market over time, most notably small sized firms and firms with a high book-to-market value (Fama and French, 1993), there are two strategies that have consistently outperformed the market over longer periods. These strategies are contrarian (De Bondt and Thaler, 1985, 1987) and momentum (Jegadeesh and Titman, 1993) strategies. The first implies that investors overreact to information, and the second states that investors underreact to new information. Both theories rely on investors not being able to process information accurately within a given time frame, and as a group they act biased. While they do contradict each other, both have been shown to effectively outperform the market over longer time periods using different time frames for investing. Typically, investors following the over- and underreaction theory are faced with a dilemma: Which strategy to implement (contrarian or momentum) and at which timing investing is optimal. As digitalization have given investors the ability to access information with practically no delay, opportunities for exploiting market over- or underreactions have naturally entered the intraday arena.

I examine a well-documented psychological trait among investors, the underreaction phenomenon. Simply put, the theory states that investors underreact to market information, and can be exploited by going long in past winners and short in past losers (Jegadeesh and Titman, 1993). The implemented strategy utilizes the relative strength past winners have over losers to achieve abnormal returns. By observing US NASDAQ stocks returns from the day before investing, I am able to create portfolios with high abnormal returns. These portfolios yield abnormal return when controlling for market, size and value factors.

While empirical evidence is plenty for daily, weekly and monthly price movements, the documentation is scarce when observing intraday data. The over- and underreaction theory relies on investors making irrational decisions, and individuals tend to be less rational when given less time to react. In this context, observing intraday price movements lets us observe investors when they are most irrational. For a day trader, the first thing one observes when

looking through their list of stocks are the returns from last day's closing price. Naturally, stocks with large price movements are particularly interesting.

Assume for a moment that the overreaction phenomenon is present among day traders. Generally, news for any stocks is reported off market hours. This implies that the first hours of trading each day are a reaction to new information. For news which results in significant positive (negative) returns, investors have overreacted and asset prices are higher (lower) than they would be if investors had acted rationally. On the contrary, if the underreaction phenomenon is present, asset prices would be lower (higher) for positive (negative) returns.

So, which phenomena, if any, dominate during the intraday? In this study, I present new evidence from the US NASDAQ stock market by utilizing the relative strength model presented by Jegadeesh and Titman (1993). After calibrating the model to identify winners and losers by their current daily return, I create portfolios who exploit the underreaction phenomena. The mid-day portfolios exhibit significant abnormal returns, even after regressing the returns against the Fama-French three-factor model. The high returns hold up after risk-adjustment. After observing stock price movement between November 2016 and February 2017, I present three major findings:

1. Momentum portfolios vastly outperforms contrarian portfolios during intraday trading, implying that investors underreact to information. The best performing portfolio have a daily mean return of over 50 basis points.
2. Intraday momentum portfolio returns exhibit normal distribution with high kurtosis and positive skew, implying that tail events are more likely to yield positive returns than negative.
3. The abnormal returns achieved by implementing a momentum strategy are not explained by either market, size or value factors. Instead, we credit the relative strength of momentum portfolios.

2. Literature review

The literature covering the phenomenon of "contrarian" and "momentum" strategies are extensive. Early documentations dates to Levy (1967) where he observed that stocks that have performed well continues to do so in the upcoming weeks, the conclusion being "…that the theory of random walks have been refuted.". This was one of the earlier studies that argued that stock prices could be predicted with only historical data to back it up. The report, however, was criticized for making conclusions that lacked sufficient results to back it up.

The overreaction hypothesis was introduced by De Bondt and Thaler (1985, 1987); where they concluded that stock generally is over- or undervalued, and can be exploited to consistently achieve abnormal returns through reversals. The stocks that were determined to be overvalued were previous winners, and previous losers were documented to be undervalued. Originally, this was a psychological effect considered to be persistent over longer holding periods (3-5 years), where previous "losers" had outperformed "winners" significantly. These "contrarian strategies" have been studied closer and Jegadeesh (1990) as well as Lehmann (1990) provided documentation that the effect was persistent on a shorter-term (weekly) basis. Atkins and Dyl (1990) also points out that after large losses (gains) following bad (good) news, the reversal effect is still present the upcoming days. One of the strongest contradictor to this hypothesis was presented by Jegadeesh and Titman (1993), where they find that during mid-term holding periods (3-6 months), an underreaction did better in explaining stock returns for US stocks. Their suggestion was that this underreaction phenomenon occurs because investors are slow to react to news. The study uses a relative strength strategy. That is, buying past winners and selling past losers "for free" (assuming no transaction costs) to document the differences between winners and losers in terms of performance, thus creating a zero-cost portfolio. The technique of building zero-cost portfolios is diligently used in research today. This was evidently labeled as a "momentum strategy". Noteworthy they found that portfolios with medium-sized firms only had stronger performance than portfolios with small-sized firms only. While the initial results from the study points to the fact that the relative strength of momentum portfolios performs well, critics argued that the strategy did not perform above average when adjusting for risk, arguing that while returns are higher, so is the overall volatility of the portfolios.

If the overreaction hypothesis is consistent, one would be able to outperform the market by buying past losers and selling past winners. After these initial findings, the overreaction hypothesis has been tested and is still debated. The momentum strategy has been preferred in

multiple studies over the years across different markets (see Rouwenhorst 1998, 1999 and Chan, Jegadeesh and Lakonishok 1996). Jegadeesh and Titman (2001) also documents decreasing momentum after 12 months of holding. Moskowitz and Grinblatt (1999) identify winning and losing industries as main drivers for momentum profits. Daniel, Hirshleifer and Subrahmanyam (1998) suggest that these over- and underreactions are attributed to two psychological traits: investor overconfidence and biased self-attribution. McInish, Ding, Pyun and Wongchoti (2008) find that winners show significant short-term reversals while losers keep their momentum across multiple Asian markets when using weekly formation and holding periods. While these studies find that monthly momentum strategies yield abnormal risk-adjusted returns, the strategy have its weakness in crashes, which occurs following market declines where market volatility is high (Daniel and Moskowitz 2016). Similar conclusions were made by Daniel, Jagannathan and Kim (2017). If this is true, the distribution of momentum returns would be expected to have a positive mean with negatively skewed normal distribution, where the negative outliers are the biggest risk factors. Barroso and Santa-Clara (2015) breaks down the anatomy of momentum risk and find it highly predictable, which suggests that you can minimize your risk exposure while still implementing a momentum strategy. There is, to my knowledge, no documentation of the distribution profile when applied to intraday trading.

Nam, Pyun and Kim (2001) documents that market reactions are asymmetrical between winners and loser, i.e. that investors react differently depending on the assets current momentum, using monthly data. They report that reversals on winners are slower than reversals on loser in the markets they included in their study.

While there have been numerous studies performed on monthly, weekly and daily data, momentum and contrarian strategies are less documented on intraday activity. Fung, Mok and Lam (2000) find that there are notable reversals following large price changes during opening on the S&P 500 Futures market and the HSI (Hang Seng Index) Futures market. Similar results are found for Hong Kong Index Features by Fung and Lam (2004), and again on US Stock Index futures by Grant, Wolf and Yu (2005). It is generally accepted that reversals and momentum occur given different timeframes. Reversals tend to be dominating on a yearly, weekly and daily basis while momentum is stronger on a monthly basis. It is reasonable to suspect that the phenomenon is present within intradays, but there is little evidence to back this up.

One of the few studies dealing with intraday stock data is Kang (2005), where he finds that large stocks have a "momentum-reversal" pattern, which means that large stocks keep their momentum for the first part of the day, and reverts after a couple of hours. He observed that small stocks have a "continued-momentum" pattern, i.e. keep their momentum throughout the day. The study is performed on the NYSE, but large and small stocks are only treated separately. Fabozzi, Ma, Chittenden and Pace (1995) find that both winners and losers experience significant reversals for both winners and losers when an event (i.e. large intraday price movements) occurs on the S&P 500. They also observed that reactions are stronger for losers, and so are the following reversals. A third intraday study, on the South African market, is Venter (2009), where he finds that while the biggest winners and losers show potential for excess returns during intraday trading, the returns seems to be stochastic and hard to predict whether winners and losers go into reversal or keep their momentum. The study concluded that one would need an "oracle" that knew which strategy to implement in order to achieve risk-adjusted abnormal returns. The method of implementing an "oracle trader", which knew if stocks were going up or down, provides no evidence of the predictability of stocks, and the only valuable result from this method is that top winners and bottom losers stocks do experience a higher volatility than stocks with past returns closer to zero. However, these studies do not consider price movements from over-night price development, and only within the same day.

One of the advantages with speculation during intraday is that you hold no overnight risk. When then market is closed, so is all your positions and micro- and macro events that happens outside market hours does not affect you as an intraday investor. Since most big news (reports, announcement of mergers etc.) usually goes public before market open, you are automatically protected from initial market reactions, and could possibly take advantage of the markets initial reactions during the same day by taking advantage of the over- or underreaction phenomenon. Studies (Jain and Joh (1988); Foster and Viswanathan (1993)) show that trading volume and price volatility are significantly higher during market open and closure for NYSE stocks. The disadvantage of investing on an intraday basis is the accumulated transaction costs and the daily impact one would have on the market. Korajczyk and Sadka (2004) develop a model which includes liquidity induced by trading. Their conclusion was, unsurprisingly, that returns decline with portfolio size. They also find that equally weighted portfolios perform significantly worse than liquidity-weighted and value-weighted portfolios as portfolio size increases.

3. Data

This study includes all stocks active at the US NASDAQ as of the first of March 2017. This includes all three NASDAQ tiers: Global Select, Global market as well as the Capital market. The data gathered is 10-minute intervals during opening hours (9:30-16:00 Eastern Standard Time) of trading. The selected time period is November 2016 to February 2017. Since the timespan is rather short, only four months, the effects of survivorship bias are assumed to be minimal. The total number of trading days in this timespan was 81. Since US NASDAQ closed 13.00 on November 25th, all portfolios which are holding after 13.00 have this day excluded, resulting in 80 trading days for these portfolios. While a weighted average price within the intervals would be preferred, due to limitations in available data the highest traded price and its corresponding volume within the intervals are retrieved. All stock pricing data is directly gathered from the Bloomberg database[1]. There are 39 sets of 10 minute intervals for any given day of our sample.

When converting the stock price data into return, we use the following formulas, where P denotes price at time i, $r_t$denotes return between two intervals t$-j \rightarrow t$ and R_t denotes the return of the observed period, that is the return from day 1 to day T .

$$r_t = (P_t - P_{t-j})/P_{t-j}, \quad \text{and} \quad \prod_{t=1}^{T}[r_t + 1] - 1 = R_t$$

To avoid including influence from low-liquidity stocks, we apply three simple rules: (1) Stocks must have a price above $1; (2) firms must have a total market value above $100 million and (3) the firms must trade for at least $200,000 during the last 10 minutes of the last day observed. The first two rules are implemented for sorting out stocks with "unnatural" characteristics. The total number of firms listed at the time of data extraction was 2536. After removing stocks that violated rule number one and, 1810 stocks remained. After rule number three, the remaining 1192 firms were selected as our list of companies. Since rule number three adjusts for stock liquidity, we can adjust this rule to increase or decrease our stock selection. The trade-off is between capturing the market effects as a whole and capturing the practical use of our chosen strategies. Rule number three will be tightened to $2,000,000 (552 stocks remaining) to see the effects of investing in higher liquidity stocks only significantly effects our results.

[1] Since all data is of secondary nature, there is no guarantee that every observation is correct. While it is possible to control with other secondary sources, the value of possibly changed results are hardly worth the effort. Therefore, we assume that all data gathered are correct.

The daily Fama-French factors (Market, SML and HML), together with our suggested risk-free rate are all gathered from Kenneth R. French's website[2]. This data is used for hypothesis testing regarding risk-adjusted returns. These three factors do not account for transaction costs. When performing hypothesis test we use portfolios who has not yet been subjected to transaction costs.

The difference between my list of companies and the underlying data from French website is the following: Our lists of companies are limited to our three rules and only applies for US NASDAQ equities. The Fama-French factors are derived from all stocks listed on NYSE, AMEX as well as the US NASDAQ, resulting in a wider selection of stocks. This, however poses little to no problems since we are comparing the passive strategy of investing in the factors with an active strategy of investing in intraday momentum.

[2] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html for access to the Fama-French factors used in this study.

4. Methodology

The formations of portfolios are similar to the version implemented by Jegadeesh and Titman (1993). The main focus is on the top and bottom 1% in regard to current momentum, but we do examine the top and bottom 10% to control for patterns. We start out with focusing on taking long positions in stocks to investigate if you consistently could outperform the market with an intraday based momentum or contrarian strategy using 1% portfolios for winners or losers. After this we implement the optimal strategy for our relative strength portfolio, the momentum (WML) portfolio. Finally, we test if profits are consistent after adjusting for market, size and book-to-market value with the Fama-French three factor model.

4.1 Assumptions

Before building the model, we do a few simple assumptions:

1. The models' investor is in no way the market maker. This means that we can buy and sell stocks without having an impact on the stock prices. Since we are retroactively studying price changes, accounting for the effect a single (big) investor could have on market prices are hard, if not impossible to approximate. The effects could be both positive and negative on the stock price, but since this is not within the scope of the paper, we simply assume that we have no impact on market prices.
2. There is no friction in the market, i.e. there are no transaction costs. This assumption is later relaxed when examining if high-performing portfolios can be utilized for abnormal returns.
3. When there is no liquidity in a specific stock, the return is assumed to be zero. If we were to exclude all stocks with no liquidity at any given time during market hours, there would 165 stocks remaining out of our original sample of over 2.500 stocks. Since we want to capture market reactions as accurate as possible, excluding all but the very top stocks would drastically decrease the value of our results. The effects of this assumption will be explained below.

4.2 Portfolio formation – Building the model

After gathering and processing the US NASDAQ stock price data into return data, we apply a straightforward model originally used by Jegadeesh and Titman (1993) where the stocks are sorted after their price development (i.e. momentum) on each given day, and are placed in order from worst (losers) performers to best (winners) performers. The formation period is the period observed before investing, so for example when investing at 10.00, 30 minutes after

market open, we observe the price development from 16.00PM the day before holding to 09.59AM. All formation periods start in this way, at the previous day closing price. There is no lag from observing before holding any stocks for any of the portfolios. For each day, the stocks are sorted in this way. Thereafter we create a number of equally weighted portfolios representing the returns of each set of stocks.

Since we are processing almost 1200 different stocks, 12 different portfolios are formed. The top and bottom performers in regard to momentum are dubbed "winners" and "losers" respectively. Unlike Jegadeesh and Titman, who formed 10 different portfolios with 10% of the selected stocks in each, we narrow down the top and bottom 1% to their own unique portfolios, followed by portfolios consisting of almost 10% of the stock selection.

The portfolios are always observing from last (trading) day closing price up to the point of holding. We use portfolios with holding periods of 1, 1½, 2, 2½ and 3 hours. The first holding period starts at 10.00, the second at 10.30 and so on until each holding period reaches its last possible buy (e.g. for the 1 hour portfolios that is at 15.00, for 2 hours at 14.00). This gives us a total of 45 different portfolios for winners and losers each. Naturally, many of these portfolios are highly correlated since they deal the same stocks during almost the same time-frame. Portfolios for percentile between 11% and 90% percent are assumed to be harder to predict in terms of momentum, and generally have returns closer to zero, as have been shown by Venter (2009). We therefore assume that momentum are more predictable within the top and bottom 10%, and the portfolios in between are ignored.

4.2.1 The relative strength strategy

After running our model, we end up with returns for 45 different winner and loser portfolios. By scrutinizing these returns, and identifying which portfolios (winners or losers) which have performed best in relation to their counterpart, it is simple to apply a relative strength portfolio like the one implemented by Jegadeesh and Titman (1993). This zero-cost portfolio is built as you take a long position in the selection of stocks where you predict higher returns and a short position in the selection of stocks where returns are expected to be lower. The underlying assumption is that one selection of stocks consistently performs better than the other, and you would always expect a positive return in the long run. This creates, without accounting for transaction cost, a portfolio without any initial investment cost. Two of our Fama-French factors, the SMB and HML, are constructed in this way.

4.2.2 The effect of low liquidity within the model

The model itself deals with illiquidity in a specific way. When there are no trades to be observed within any given time frame, the difference in price is, as well as the assets return, assumed to be zero. This influences the model such that the return goes towards zero in a portfolio for each stock used which have zero liquidity within the time-frame invested. For the outliers, the top and bottom 1% portfolios, this problem is expected to be low and are essentially ignored. This problem is assumed to be present in a larger extent in the 10% portfolios, due to the fact that these stocks, while performing well/poor, are more likely to be low liquidity stocks being traded sporadically than the top/bottom 1% are. With this stated, the indications given by the top and bottom 10% portfolios are only considered when cross-checking patterns between their corresponding 1% portfolios. Since the major assumption within the over- and underreaction phenomenon states that winners and loser will either continue their pattern or break their pattern and go in the opposite direction, it is necessary to control if the phenomenon is consistent over more than only the 1% portfolios. Note that when referring to "10% portfolios", we refer to the top or bottom 10% excluding the top and bottom 1%.

4.3 Fama, French and the three-factor model and hypothesis testing

Fama and French proposed in 1993 that returns are driven by three major factors. Along with the market risk factor from the CAPM model (Sharpe, 1964), they added company size and book-to-market ratio (book value). They documented that these two factors outperform the market factor.

The model controls for cross-sectional patterns in the included variables. Simply put, if you would present any of your portfolios return, Fama and French states that your returns are a combination of investing in these three factors. The model is constructed as such:

$$r_p - R_f = \alpha + \beta(R_M - R_f) + \gamma_s * SMB + \gamma_v * HML$$

Where r_p represents the return of the portfolio, R_f the risk-free rate and R_M the market return. SMB stands for Small minus Big portfolios, referring to company size and HML represents High minus Low portfolios, referring to book value. The last portfolio is the market portfolio minus the risk-free rate. For more information on these factors, see the original study from Fama and French (1993). The values $\beta, \gamma_s \; and \; \gamma_v$ are constants that show how much their corresponding variable affects your portfolios returns. When testing, the first null hypothesis

is that the intersect is zero, i.e. $H_{0,1}: \alpha = 0$.

If the intersect is significantly larger than 0, it suggests that your portfolio is performing better than the model factors predicts. The other three null hypotheses are that the three constants are zero, i.e.

$$H_{0,2}: \beta = 0, H_{0,3}: \gamma_s = 0 \; and \; H_{0,4}: \gamma_v = 0.$$

If this joint hypothesis cannot be rejected, we have created a portfolio which returns are explained by something that is not the market factor, the SMB factor or the HML factor. For this study, we credit the relative strength of momentum portfolios, i.e. that investors underreact to new information.

4.4 Transaction costs

Transaction cost is a reality for every investor. Many studies naturally assume no transaction costs, but since it is present in the real world we do account for it in the top and bottom 1% portfolios.

Since a trading strategy as active as the one proposed, tallying a total of 24 transactions every day for the long-only (either buying winners or losers), and 48 transactions for the zero-cost portfolios, transaction costs should be accounted for. US internet brokers are varying between a set fee for each trade, which usually varies from $5-10 and commissions based on a price per bought share– ranging from as little as 5 basis points to the dollar up to (from a few brokers) 50 basis points. With this stated, it is not clear which type of commission one should choose to minimize their transaction costs. The fixed fee is highly dependent on the volume invested, while price-per-share is highly dependent on the individual stock price for the asset bought. A more common technique in academic work is to apply transaction costs as a percentage base cost for the transactions. This method ignores price of shares as well as volume bought, and is more convenient to use for an international standard. When accounting for transaction cost, we deduct the value of the investment with a basis points scheme similar to the one Venter (2009) implement.

Using a starting index, denoted I, we can determine the returns of our portfolios with transaction costs, denoted TC, included. Recall from previous section that r_t denotes the return of a portfolio on day t.

$$\big((I * (1 - TC)(r_1 + 1)\big) * (1 - TC) = V_1, Value\ after\ day\ 1$$

$$\Big(\big(V_1 * (1 - TC)\big)(r_2 + 1)\Big) * (1 - TC) = V_2 \ \ldots$$

$$\ldots\big((V_{t-1} * (1 - TC))(r_t + 1)\big) * (1 - TC) = V_T\ ,\ Value\ after\ last\ day\ T$$

This method of accounting for transaction costs will only be implemented for the strongest performing portfolios, which we will see is the relative strength WML portfolios. Transaction costs tested are 10, 20 and 30 basis points of total value invested.

5. Empirical Results

This section is divided into five subsections. Starting off with a brief analysis of the correlation between 1% and 10% portfolios to confirm that stocks within the same segment (winners or losers) show similar patterns. This is followed by analysis of the buy-only portfolios and the strongest performing relative strength strategy, which in our sample is the relative strength WML portfolio. We also test whether the momentum portfolio returns hold up when adjusting for risk with the Fama-French three factor model. Third, we implement transaction costs within our WML portfolios to see if the high-intensity trading strategy can be exploited for abnormal returns when comparing to more passive strategies. Since the statistical test does generate a lot of data, all tests can be found in the appendix. Following this we analyze our top performing portfolios distribution. Finally, the third rule for our stocks is tightened to require a $2,000,000 volume for the last 10 minutes, decreasing our selection to 552 stocks with relatively high liquidity.

5.1 The Correlation between 1% and 10% portfolios

We compare returns from the buy-only 1% portfolios with their corresponding 10%[3] with a simple OLS regression. The reasoning behind this comparison is to control if the top 1% of winners and losers behave similarly to their corresponding 10% winners and losers. While the 10% winner and loser portfolios are considered to be unreliable in terms of their returns due to the models' interaction with no-liquidity stocks, they do show significant positive correlation with their corresponding 1% portfolios through every test performed. This form of correlation indicates that the over- and underreaction phenomenon is consistent with our proposed model, and implies that investor behavior is consistent with the overreaction hypothesis. This is, however, only documentation that winners and losers consistently have the same patterns. Whether they can be exploited to achieve abnormal returns or not remain to be examined.

[3] See Appendix A: Testing correlation between 1% and 10% portfolio

5.2 Winners, losers and the WML portfolio

During our tested period, winners and losers do both show a consistent pattern. We start with examining the equally weighted buy-only portfolios for winners and losers. Table 1 contains the total returns for the buy-only winner portfolios.

Table 1: Winner portfolios

Holding period	1 Hour	1.5 Hours	2 Hours	2.5 Hours	3 Hours
10:00	-12.61	-15.45	-19.55	-20.27	-17.92
10:30	-13.26	-15.87	-15.00	-10.53	-6.21
11:00	-4.95	-5.88	-1.67	1.51	9.64
11:30	-2.24	1.46	6.74	17.57	23.96
12:00	1.98	10.13	21.23	29.05	27.80
12:30	15.10	25.13	31.29	29.99	23.85
13:00	17.30	23.18	23.18	20.33	29.72
13:30	15.64	13.77	10.78	27.77	
14:00	1.54	-0.85	5.56		
14:30	-3.18	4.74			
15:00	5.78				

Table 1 presents the total return for the five different buy-only winner portfolios. The leftmost column represents time of purchase. Returns are presented in percentage points.

The initial market reactions for the aggregated winners are generally negative, suggesting that many investors prefer to capitalize on their investment when the market has gone up rather than keeping their investment for the long term. This is in line with the findings of Fabozzi et al. (1995), who observed reversals after large intraday price movements. After the initial reversal the first couple of hours, winners stocks tend to regain their momentum, and perform well during the mid-day to fall off before the last couple of hours. These patterns are somewhat contradicting with Kang (2005) documentation of large stocks showing "momentum-reversal" patterns, although we do not necessarily capture the same effect since we are reallocating our portfolios. One way to interpret these patterns is that investors that capitalize their investment do it at faster rate than buyers are able to react, hence the initial price decline for winners. Nonetheless, this is a strong indicator that investors both overreact and underreact to winner stocks within the same day, and as the stock markets reaches its final opening hours it returns to an efficient market. Just as in the study by Venter (2009), returns are generally amplified with increased holding period.

Table 2 contains the total returns for the buy-only loser portfolios.

Table 2: Loser portfolios

Holding period	1 Hour	1.5 Hours	2 Hours	2.5 Hours	3 Hours
10:00	-28.65	-27.22	-31.13	-29.68	-30.50
10:30	-11.72	-16.45	-13.18	-11.98	-15.51
11:00	-5.46	-0.72	-1.80	-4.52	-4.09
11:30	-2.26	-2.48	-4.96	-5.39	-12.14
12:00	0.34	0.06	-0.81	-8.27	-9.48
12:30	-0.60	-2.14	-9.82	-13.11	-17.53
13:00	0.41	-9.20	-10.59	-14.16	-5.74
13:30	-11.50	-13.42	-17.23	-10.16	
14:00	-10.07	-14.24	-4.93		
14:30	-9.78	-0.35			
15:00	7.69				

Table 2 present the total return for the five different buy-only loser portfolios. The leftmost column represents time of purchase. Returns are expressed in percentage points.

Losers, however, show little to no signs of recovering their losses within the same day. Unlike the winner portfolios, no reversal occurs within the first hours of trading. This is an interesting observation, since it contradicts with the findings Fabozzi et al. (1995). The aggregated returns of the equally weighted loser portfolios are usually in the red, implying that the momentum effect more often than not continues throughout the day. This could be interpreted as investors are "abandoning ship" after negative information becomes available, and are not returning during the same day. This is the same "continued-momentum" pattern that Kang (2005) observed for small stocks.

These results show that investors do in fact react asymmetrical between winners and losers within the intraday, but not in the sense Nam, Pyun and Kim (2003) describes. Rather than having faster/slower reaction in terms of reversals, investors behave differently whether they deal with winners (early reversal, mid-day momentum) or losers (continuous momentum throughout the day). However, both winners and losers show similar curves. That is, the returns are at their worst in the start of the day, and at their best during the mid-day. Just as the winner portfolios, returns are amplified with increased holding period.

These 90 portfolios are all very poorly explained by the Fama-French three factor model, as our statistical testing having a very low adjusted R-squared and F-statistic[4]. Out of the 90 different portfolios observed, only 26 portfolios had a return higher than the model predicted,

[4] See Appendix F: Statistical output for Buy-only portfolios using Fama-French three factor model

and out of these 26, only 9 were of statistical significance within the 95%-level. This could be credited to the relatively small number of observations set in a specific time period. A harsher explanation would be that the portfolios in general simply do not perform well enough, and if this is true it would be no point in investing in this trading strategy, and sticking with small and/or value stocks would be more efficient over time. In summation, only 10% of our winner and loser portfolios outperformed Fama and French's three factors with statistical significance. The common factor for these nine portfolios was that they were all winners.

These results, while having low significance overall, suggests that winners are performing with positive returns and losers in general have a negative return, i.e. there seems to be an overall underreaction in the market, suggesting that the relative strength of momentum strategies are optimal. To test this, we implemented the momentum strategy's WML zero-cost portfolio and do a cross-sectional test with the three Fama-French factors. The total return of the factors was 12.74% for the market, 6.95% for the HML and 2.58% for the SMB portfolios during the observed period. Notable, the returns of the three factors are contradicting the theory that HML and SMB portfolios outperform the market. However, this is not an unexpected result, since the theory states that HML and SMB portfolios outperform the market over longer time-periods than our sample of four months. These portfolios are multiple times larger than our own winner and loser portfolios, and are expected to have significantly lower standard deviations. Table 3 contains the total returns for our equally-weighted WML portfolios.

Table 3: WML Portfolios

Holding Period	1 Hour	1.5 Hours	2 Hours	2.5 Hours	3 Hours
10:00	21.61	15.41	15.90	12.42	17.01
10:30	-2.04	0.22	-2.66	0.91	10.28
11:00	0.07	-5.88	-0.70	5.47	13.37
11:30	-0.28	3.54	11.70	23.61	40.52
12:00	1.48	9.86	21.99	40.60	40.95
12:30	15.67	27.65	45.31	49.24	49.57
13:00	16.60	35.31	37.42	39.58	36.91
13:30	30.40	31.05	33.28	41.38	
14:00	12.71	15.24	10.58		
14:30	7.11	4.80			
15:00	-1.98				

Table 3 presents the total return for the five different zero-cost WML portfolios. The leftmost column represents time of purchase. Returns are expressed in percentage points. Standard deviations for all WML portfolio returns are presented in the Appendix, along with the standard deviation of the three Fama-French factors.

As can be seen, the WML portfolios are performing extremely well during the mid-day, with both the long and short side contributing. The strongest portfolios average a return over 50 basis points per day (not presented) before accounting for transaction costs.

While investing early at 10.00 seems lucrative, the results are only significant for a holding period of one hour. Out of the 45 portfolios, 39 have a positive return and 25 of the portfolios beats all three factors. 18 of these 25 portfolios are investing at 12:00 or later. Again, the Fama-French model does a poor job explaining the return, and the t-statistics for practically all three factors are insignificant for all 45 portfolios. This means that we cannot reject the joint null hypothesis $H_{0,2}$, $H_{0,3}$ and $H_{0,4}$, stating that the Fama-French factors do not influence our momentum portfolio. However, we do find that the WML portfolios do significantly outperform their predicted values consistently during the mid-day, and as the holding period increases, the number of portfolios that have a statistically ensured abnormal return goes up[5]. Therefore, we reject the null hypothesis $H_{0,1}$ for portfolios with two or more hours of holding period that invest during the mid-day. This is a strong indicator that abnormal returns using WML portfolios are viable. However, the standard deviations of the WML portfolios are significantly higher[6] compared to the Fama-French factors. In terms of Sharpe ratio, the portfolio investing at 12.30 and holds for 2.5 hours perform best with a ratio of 0.44, compared to the market portfolios Sharpe ratio of 0.28. This implies that even with a higher risk, measured by standard deviation, you do obtain a higher risk-adjusted return with WML portfolios compared to investing in either of the three Fama-French factors. Out of the 25 portfolios that beat the market, 14 have a lower Sharpe ratio. The common factor in these 14 portfolios are that they are investing during the mid-day.

[5] See Appendix E: Statistical output for WML portfolios using Fama-French three factor model
[6] See Appendix B: Standard deviation and Sharpe Ratio for WML and the Fama-French factors

5.3 Accounting for transaction costs

As clearly shown, the relative strength portfolio using a momentum strategy is optimal in our study by a large margin. When accounting for transaction costs at 10, 20 and 30 basis points it is clear that the rapid turnover of stocks highly influence our returns. Table 4 presents the total return of our WML portfolios which have been subjected to the lowest of our tested transaction costs, 10 basis points.

Table 4: WML Portfolios with transaction costs

Holding Period	1 Hour	1.5 Hours	2 Hours	2.5 Hours	3 Hours
10:00	3.41	-1.86	-1.89	-4.40	-0.50
10:30	-16.70	-14.78	-17.22	-14.18	-6.03
11:00	-14.91	-19.96	-15.55	-10.13	-3.40
11:30	-15.20	-11.95	-4.83	5.33	19.73
12:00	-13.70	-6.39	3.94	19.80	20.10
12:30	-1.44	8.77	23.82	27.16	27.44
13:00	-0.64	15.29	17.09	18.93	16.65
13:30	11.11	11.66	13.57	20.47	
14:00	-3.96	-1.81	-5.78		
14:30	-8.73	-10.71			
15:00	-16.48				

Table 4 present total returns for the five different zero cost WML portfolios which trades with a transaction cost of 10 basis points. For transaction costs of 20 and 30 basis points, see Appendix C: Returns for WML portfolios with transaction costs. The leftmost column represents time of purchase. Returns are expressed in percentage points.

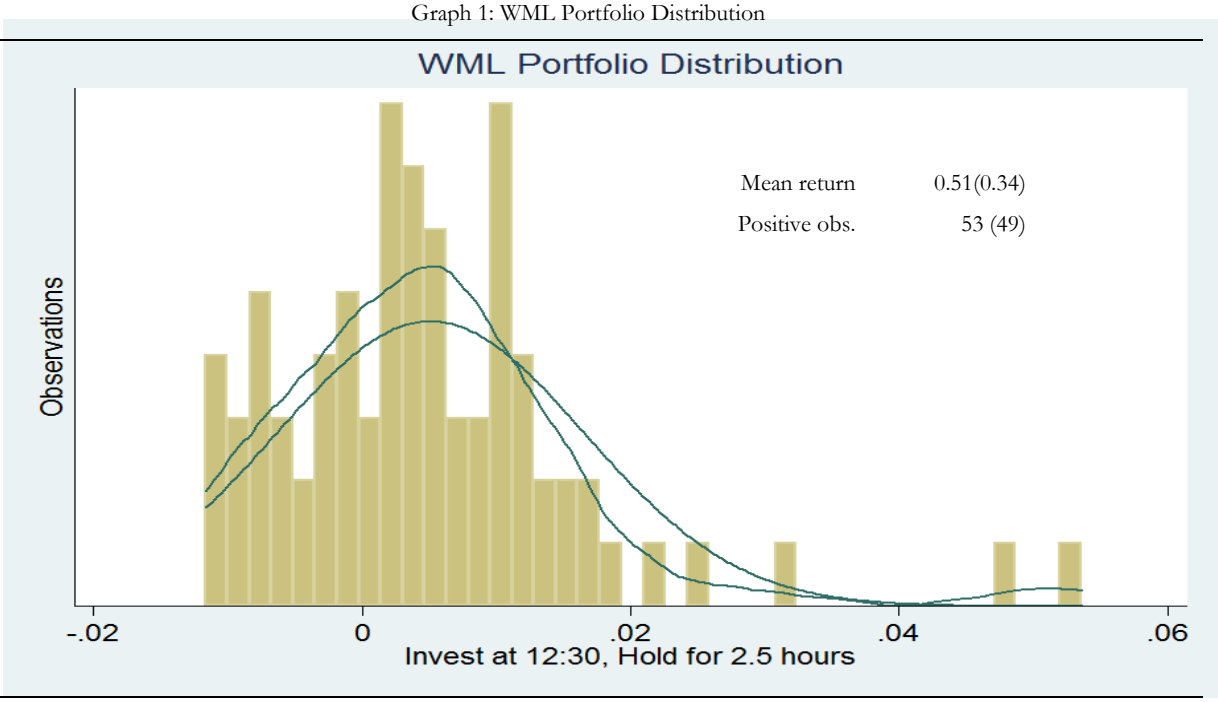
Out of the previous 39 portfolios with a positive return, only 18 are still turning profit after transaction costs as low as 10 basis points. For 20 basis points, only 8 portfolios remain and for costs of 30 basis points, every portfolio has negative returns. Out of the 18 profitable portfolios with relatively low transaction costs, there are only 12 that outperform the strongest Fama-French factor, the market factor, within our studied period. The vast majority of these portfolios are holding for at least two hours, and invests during the mid-day. In the next sections, we refer to these portfolios as “well performing portfolios”.

5.4 Distribution and risk profile of strong relative strength portfolios

As we have seen, the relative strength portfolios that perform well are investing a couple of hours after market open, and hold for at least 2 hours. This section focuses on these well performing portfolios and their distribution. Graph 1 show the distribution of one of the

portfolios which outperforms the market factor after including a 10 basis points transaction cost[7].

Graph 1: WML Portfolio Distribution



Distribution for WML portfolio which invests at 12:30 and holds for 2.5 hours with Normal Distribution and Kernel Density Approximation lines drawn. Total number of observations is 80. The observed portfolio returns are before transaction costs. Mean return are presented in percentage points. The parenthesis represents mean return and number of positive observations when accounting for a trading cost of 10 basis points.

Our well performing portfolios exhibit a similar pattern. That is, the return distribution is somewhat normally distributed, with a high kurtosis and a positive skew. This contradicts with the monthly return distribution for WML portfolios observed by Daniel and Moskowitz (2016), which were negatively skewed. While our sample size might be small, the empirical data implies that the return profile for these specific mid-day portfolios have a positive mean return and little risk for large losses. For a potential intraday investor, the implementation of a stop-loss strategy could potentially remove the threat of large losses completely, avoiding left tail events at the cost of a potentially lower mean return.

[7] Histograms can be found in Appendix D: Histograms for Mid-day WML Portfolios. The portfolios presented in the appendix are the portfolios that outperformed all Fama-French factors with a 10 basis point transaction cost.

5.5 Returns when trading in high-liquidity stocks

As we have shown, the portfolios created from our pool of stocks generate significant abnormal returns with high Sharpe ratios. While this is encouraging, we are not certain that the stocks in our 1% portfolios are liquid enough to be efficient for an investor utilizing the strategy. As previously mentioned, we tighten the third rule from the data section to only include stocks that are trading for over $2,000,00. This reduces our sample to 552 stocks. Table 5 presents the equally-weighted WML portfolios total return after this change for the well performing portfolios from previous sections.

Table 5: WML Portfolios with $2,000,000 restriction on rule three

Holding Period	1 Hour	1.5 Hours	2 Hours	2.5 Hours	3 Hours
11:30	-	-	-	-	12.42
12:00	-	-	-	12.14	10.32
12:30	-	-	9.21	8.87	10.20
13:00	-	8.44	5.99	9.52	5.78
13:30	-	-	11.24	4.09	

Table 5 presents total returns for the five different zero cost WML portfolios without transaction costs. The table only accounts for the 12 portfolios who previously outperformed all Fama-French factors. The leftmost column represents time of purchase. Returns are expressed in percentage points. Transaction costs are excluded.

As is clear from the table, the portfolios still exhibit a positive return, but the best portfolio returns are now comparable to the returns achieved by the market portfolio. Naturally, these portfolios behave similarly to our WML portfolios using 1192 stocks.

The model performs noticeably worse when we are trading with stocks that are assumed to have higher liquidity. This can be narrowed down to two reasons: First, the higher liquidity requirement for firms to be eligible for selection removes illiquid stocks, which implies that the high returns from our larger sample model draws its high returns from stocks that are predominantly illiquid. Secondly, the high returns from the larger stock sample draws from stocks which are normally trading with a relatively low liquidity, but see a high turnover when an event occurs, which only then makes them eligible for either the winner or loser portfolios. A combination of these two reasoning's is most likely true.

6. Conclusions

As stated by Jegadeesh and Titman (1993): "Trading strategies that buy past winners and sell past losers realize significant abnormal returns…". This study examines if reversals or momentum effects are significantly present on an intraday basis on the US NASDAQ, and if returns are predictable enough to achieve abnormal risk-adjusted returns. We find that momentum strategies applied during mid-day yields significant abnormal returns which are fairly consistent when market frictions are low. While there is a vast amount of studies dealing with momentum and contrarian strategies, only a very small part has examined the effects on the intraday. By studying winners and losers separately, we confirm that investors react differently to winners and losers, however not with different reaction times as observed by Nam, Pyun and Kim (2003), but rather that reversals only apply to winner portfolios during early market hours, similar to how Fabozzi et al. (1995) observed reversals during intradays. Losers keep their momentum more or less throughout the entire day. Our results were more in line with the findings of McInish, Ding, Pyun and Wongchoti (2008) study, which concluded that only winners experience short-term reversals. This is an interesting observation, since it contradicts with both Grant, Wolf and Yu (2005) and Fabozzi et al. (1995), which observed reversals for both winners and losers within the intraday.

By showing that our 1% and 10% portfolios show significant positive correlation between each other is a strong indicator that the 1% portfolios are more than mere outliers, and that their patterns are consistent with the over/underreaction phenomena. This, of course, is after we narrowed down our selection of stocks to 1192, with the goal of excluding as many outliers as possible. In this sense, the exclusion process seems to have given us the desired results. When lowering the number of stocks to 552, the returns are at best on the same level as the market.

By implementing the relative strength portfolios used by Jegadeesh and Titman (1993), we find that winners on average perform significantly better than losers. In our sample, winners outperform losers in over 80% of the portfolios. While this is very high, it is important to keep in mind that many of these portfolios are highly correlated. Since they invest in the same stocks at the same time, for example the WML portfolio investing at 11:30 could have the exact same selection of stocks as the WML portfolio investing at 12:00. In terms of risk-adjusted performance, our portfolios seem to be far from explained by the Fama-French three factor model, suggesting that a momentum portfolio does not behave with respect to either market, SMB or HML. Therefore, we can conclude that the relative strength of momentum

portfolios behaves in a unique way, and if market frictions are low enough, one could gain significant abnormal returns when implementing these relative strength strategies on an intraday basis.

6.1 Further research

While my results may have been consistent with the underreaction hypothesis for relative strength portfolios, the most obvious shortcoming in the model is the short observed time frame. While the obtained results give an indication for how momentum portfolios behave after large overnight price development, it is possible that this type of movement is unique to the observed time period, and thus the results could hold poorly over time. The short period is too short to be divided into subsections, making testing for seasonality impractical. I also fail to obtain enough observations to get a clear picture of the return distribution of our relative strength strategy. While there are studies dealing with the risk profile of momentum portfolios, I have not found any sources dealing with intra-day strategies, and the conclusions made from earlier literature in this regard does not align with my observations.

The study could, of course, be replicated on other markets, such as the NYSE, AMEX, European markets or Asian markets. Since NYSE and AMEX are American stock markets, the results are likely to be similar to mine, assuming that investor behavior are similar in the same geographic region.

The model used in this study could be improved, with the illiquidity problem as our most prominent disadvantage. If this problem could be solved, one would be able to relax all three rules when gathering stock price data and the number of stocks viable for a future study would increase significantly. This would also directly give more credit to the 10 percentile portfolios, as they would not suffer at all from the no-liquidity stocks, making their returns accurate.

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Appendix A: Testing correlation between 1% and 10% portfolio

Holding period	Time of purchase	Type of momentum	R-Squared	Adj R-squared	Coefficient	Standard Error	t-value	p-value
1 Hour	10:00:00	Loser	0.3703	0.3623	1.28085	0.1879171	6.82	0.000
1 Hour	10:00:00	Winner	0.298	0.2891	1.089473	0.1881424	5.79	0.000
1 Hour	10:30:00	Loser	0.2362	0.2266	0.75702	0.1531477	4.94	0.000
1 hour	10:30:00	Winner	0.1764	0.166	0.7446221	0.1810052	4.11	0.000
1 Hour	11:00:00	Loser	0.2819	0.2728	1.179439	0.2117826	5.57	0.000
1 Hour	11:00:00	Winner	0.2879	0.2789	1.148765	0.2032574	5.65	0.000
1 Hour	11:30:00	Loser	0.3265	0.318	1.178528	0.1904462	6.19	0.000
1 Hour	11:30:00	Winner	0.138	0.1271	0.817001	0.2297479	3.56	0.001
1 Hour	12:00:00	Loser	0.2995	0.2906	1.114084	0.1916909	5.81	0.000
1 Hour	12:00:00	Winner	0.2955	0.2866	1.488188	0.258543	5.76	0.000
1 Hour	12:30:00	Loser	0.282	0.2728	1.14235	0.2063789	5.54	0.000
1 Hour	12:30:00	Winner	0.2647	0.2552	1.641902	0.3098825	5.3	0.000
1 Hour	13:00:00	Loser	0.1368	0.1257	0.8160172	0.2321056	3.52	0.001
1 Hour	13:00:00	Winner	0.1325	0.1214	0.9713506	0.2814115	3.45	0.001
1 Hour	13:30:00	Loser	0.0532	0.0411	0.5985223	0.2858914	2.09	0.040
1 Hour	13:30:00	Winner	0.0765	0.0647	0.8966161	0.3526642	2.54	0.013
1 Hour	14:00:00	Loser	0.2392	0.2295	1.205255	0.2433593	4.95	0.000
1 Hour	14:00:00	Winner	0.1007	0.0892	0.7867722	0.2662132	2.96	0.004
1 Hour	14:30:00	Loser	0.2123	0.2022	0.8752304	0.19088	4.59	0.000
1 Hour	14:30:00	Winner	0.1233	0.1121	0.8361328	0.2524155	3.31	0.001
1 Hour	15:00:00	Loser	0.2435	0.2338	0.9343479	0.1864575	5.01	0.000
1 Hour	15:00:00	Winner	0.3183	0.3095	1.234936	0.2046378	6.03	0.000
1.5 Hours	10:00:00	Loser	0.3415	0.3331	1.181571	0.1846163	6.4	0.000
1.5 Hours	10:00:00	Winner	0.3433	0.335	1.223983	1.904532	6.43	0.000
1.5 Hours	10:30:00	Loser	0.2997	0.2908	0.9792132	0.1684104	5.81	0.000
1.5 Hours	10:30:00	Winner	0.1454	0.1345	0.6344601	0.1730805	3.67	0.000
1.5 Hours	11:00:00	Loser	0.3559	0.3478	1.358892	0.2056627	6.61	0.000
1.5 Hours	11:00:00	Winner	0.3244	0.3158	1.249879	0.2024624	6.16	0.000
1.5 Hours	11:30:00	Loser	0.2685	0.2592	1.166718	0.2166699	5.38	0.000
1.5 Hours	11:30:00	Winner	0.1384	0.1275	0.9465118	0.2657285	3.56	0.001
1.5 Hours	12:00:00	Loser	0.3038	0.2949	1.065613	0.1826613	5.83	0.000
1.5 Hours	12:00:00	Winner	0.2088	0.1986	1.274419	0.2809	4.54	0.000
1.5 Hours	12:30:00	Loser	0.1322	0.1211	0.7788804	0.2259659	3.45	0.001
1.5 Hours	12:30:00	Winner	0.1492	0.1383	1.14374	0.3092506	3.7	0.000
1.5 Hours	13:00:00	Loser	0.1296	0.1185	0.8518013	0.24991	3.41	0.001
1.5 Hours	13:00:00	Winner	0.0947	0.0831	0.930845	0.3259123	2.86	0.005
1.5 Hours	13:30:00	Loser	0.1483	0.1374	0.9733855	0.2641242	3.69	0.000
1.5 Hours	13:30:00	Winner	0.1302	0.119	0.8416588	0.2463464	3.42	0.001
1.5 Hours	14:00:00	Loser	0.2403	0.2305	1.021485	0.2056709	4.97	0.000
1.5 Hours	14:00:00	Winner	0.2214	0.2114	1.06005	0.2251069	4.71	0.000
1.5 Hours	14:30:00	Loser	0.1534	0.1426	0.7094015	0.1886737	3.76	0.000
1.5 Hours	14:30:00	Winner	0.1734	0.1628	0.9845547	0.2434056	4.04	0.000
2 Hours	10:00:00	Loser	0.3982	0.3906	1.356281	0.1875833	7.23	0.000
2 Hours	10:00:00	Winner	0.2973	0.2884	1.076067	0.1861164	5.78	0.000

Holding period	Time of purchase	Type of momentum	R-Squared	Adj R-squared	Coefficient	Standard Error	t-value	p-value
2 Hours	10:30:00	Loser	0.3491	0.3408	1.121487	0.1723011	6.51	0.000
2 Hours	10:30:00	Winner	0.1346	0.1236	0.6671021	0.1903279	3.51	0.001
2 Hours	11:00:00	Loser	0.3268	0.3183	1.373733	0.2218262	6.19	0.000
2 Hours	11:00:00	Winner	0.2925	0.2836	1.295616	0.2267002	5.72	0.000
2 Hours	11:30:00	Loser	0.3356	0.327	1.207785	0.1924328	6.28	0.000
2 Hours	11:30:00	Winner	0.1233	0.1121	0.9241128	0.2789801	3.31	0.001
2 Hours	12:00:00	Loser	0.1858	0.1754	0.8398685	0.1990402	4.22	0.000
2 Hours	12:00:00	Winner	0.1712	0.1606	1.257563	0.3132434	4.01	0.000
2 Hours	12:30:00	Loser	0.1218	0.1105	0.7764224	0.2360658	3.29	0.002
2 Hours	12:30:00	Winner	0.1203	0.1091	1.195234	0.3658903	3.27	0.002
2 Hours	13:00:00	Loser	0.1759	0.1653	0.9257811	0.2268849	4.08	0.000
2 Hours	13:00:00	Winner	0.0831	0.0713	0.8115378	0.3052886	2.66	0.010
2 Hours	13:30:00	Loser	0.1778	0.1672	0.9461026	0.2303988	4.11	0.000
2 Hours	13:30:00	Winner	0.196	0.1857	1.031093	0.2364333	4.36	0.000
2 Hours	14:00:00	Loser	0.22	0.21	0.879749	0.1875652	4.69	0.000
2 Hours	14:00:00	Winner	0.2265	0.2166	1.018943	0.213214	4.78	0.000
2.5 Hours	10:00:00	Loser	0.4347	0.4275	1.348246	0.1729986	7.79	0.000
2.5Hours	10:00:00	Winner	0.2186	0.2087	0.8995155	0.193375	4.7	0.000
2.5 Hours	10:30:00	Loser	0.2781	0.2689	1.051449	0.1906189	5.52	0.000
2.5Hours	10:30:00	Winner	0.1137	0.1025	0.6312839	0.192629	3.18	0.002
2.5 Hours	11:00:00	Loser	0.401	0.3933	1.437234	0.1988866	7.23	0.000
2.5Hours	11:00:00	Winner	0.2607	0.2512	1.288759	0.2457169	5.24	0.000
2.5 Hours	11:30:00	Loser	0.2168	0.2068	0.9077024	0.1953243	4.65	0.000
2.5Hours	11:30:00	Winner	0.0893	0.0776	0.805694	0.291309	2.77	0.007
2.5 Hours	12:00:00	Loser	0.1588	0.148	0.7373916	0.1921527	3.84	0.000
2.5Hours	12:00:00	Winner	0.1319	0.1207	1.522627	0.4423422	3.44	0.001
2.5 Hours	12:30:00	Loser	0.1496	0.1387	0.8481419	0.2289356	3.7	0.000
2.5Hours	12:30:00	Winner	0.1154	0.1041	0.9806174	0.3073977	3.19	0.002
2.5 Hours	13:00:00	Loser	0.2471	0.2374	1.121432	0.2216728	5.06	0.000
2.5Hours	13:00:00	Winner	0.1415	0.1305	1.012181	0.282256	3.59	0.001
2.5 Hours	13:30:00	Loser	0.335	0.3265	1.264988	0.2018022	6.27	0.000
2.5Hours	13:30:00	Winner	0.2802	0.271	1.20177	0.2181019	5.51	0.000
3 Hours	10:00:00	Loser	0.4039	0.3964	1.324971	0.1810807	7.32	0.000
3 Hours	10:00:00	Winner	0.2041	0.194	0.2218744	0.049263	4.5	0.000
3 Hours	10:30:00	Loser	0.3889	0.3811	1.218295	0.172908	7.05	0.000
3 Hours	10:30:00	Winner	0.0738	0.0619	0.5420645	0.2173965	2.49	0.015
3 Hours	11:00:00	Loser	0.3068	0.2979	1.225754	0.208634	5.88	0.000
3 Hours	11:00:00	Winner	0.2304	0.2205	1.286971	0.2663154	4.83	0.000
3 Hours	11:30:00	Loser	0.1775	0.1669	0.7735227	0.1885425	4.1	0.000
3 Hours	11:30:00	Winner	0.0793	0.0675	0.9748932	0.3761928	2.59	0.011
3 Hours	12:00:00	Loser	0.1584	0.1476	0.7589761	0.1980647	3.83	0.000
3 Hours	12:00:00	Winner	0.1128	0.1014	1.169135	0.3712954	3.15	0.002
3 Hours	12:30:00	Loser	0.2045	0.1943	1.004333	0.2243134	4.48	0.000
3 Hours	12:30:00	Winner	0.1468	0.1358	1.012214	0.276335	3.66	0.000
3 Hours	13:00:00	Loser	0.1984	0.1881	0.9006907	0.2049763	4.39	0.000
3 Hours	13:00:00	Winner	0.172	0.1614	1.007163	0.2502144	4.03	0.000

Appendix B: Standard deviation and Sharpe Ratio for WML and the Fama-French factors

Time invested	Holding Period	Type of Portfolio	Standard Deviation	Sharpe Ratio
		Market Portfolio	0.0059681673573165	0.28418155657
		SMB	0.0052609386338031	0.04919917162
		HML	0.00652424916450114	0.139422827078066
10:00	1 HOUR	WML	0.0115270592458144	0.214189614406
10:30	1 HOUR	WML	0.00860292149569063	-0.027073986356
11:00	1 HOUR	WML	0.0104618070831879	0.004515986670
11:30	1 HOUR	WML	0.00858333181779238	-0.001575882185
12:00	1 HOUR	WML	0.00724459609194811	0.026557274615
12:30	1 HOUR	WML	0.00684021333858306	0.267383238744
13:00	1 HOUR	WML	0.00702908777035258	0.274792864763
13:30	1 HOUR	WML	0.00918556694660402	**0.364634648560**
14:00	1 HOUR	WML	0.00735663146606765	0.205042638466
14:30	1 HOUR	WML	0.00756258285292199	0.115420509839
15:00	1 HOUR	WML	0.00697684133781598	-0.034481264829
10:00	1. 5 HOURS	WML	0.0113463908622647	0.160386623750
10:30	1. 5 HOURS	WML	0.0102452676377225	0.006243055042
11:00	1. 5 HOURS	WML	0.0126452980678668	-0.054095283048
11:30	1. 5 HOURS	WML	0.0112538345161402	0.042394808066
12:00	1. 5 HOURS	WML	0.00850349165736674	0.140751834199
12:30	1. 5 HOURS	WML	0.00825512185332161	**0.372506231503**
13:00	1. 5 HOURS	WML	0.00971664555497139	**0.392918402901**
13:30	1. 5 HOURS	WML	0.00890903647180512	**0.382702314323**
14:00	1. 5 HOURS	WML	0.00960349192581254	0.187978058692
14:30	1. 5 HOURS	WML	0.00961952959351568	0.064082098286
10:00	2 HOURS	WML	0.0115624530618339	0.162136647450
10:30	2 HOURS	WML	0.011784291347746	-0.023643380156
11:00	2 HOURS	WML	0.0141927111131625	-0.000145763802
11:30	2 HOURS	WML	0.0126797134574458	0.114129330432
12:00	2 HOURS	WML	0.0097419413206581	0.258598470589
12:30	2 HOURS	WML	0.0112563410130593	**0.420092513727**
13:00	2 HOURS	WML	0.0103300168164215	**0.388974728372**
13:30	2 HOURS	WML	0.0111250324616988	**0.327509705901**
14:00	2 HOURS	WML	0.0110237067431041	0.118126206099
10:00	2.5 HOURS	WML	0.0129395167265493	0.117044413914
10:30	2.5 HOURS	WML	0.0130850579181965	0.013891998078
11:00	2.5 HOURS	WML	0.0150505064996407	0.050617411114
11:30	2.5 HOURS	WML	0.0133795647409459	0.203685958947
12:00	2.5 HOURS	WML	0.0140767709298765	**0.308868851700**
12:30	2.5 HOURS	WML	0.0114816225243546	**0.441236951982**
13:00	2.5 HOURS	WML	0.0121630347156658	**0.348108597189**
13:30	2.5 HOURS	WML	0.0118591938946237	**0.370336907159**
10:00	3 HOURS	WML	0.013935969829543	0.145092532879
10:30	3 HOURS	WML	0.0133752641889844	0.096917379939
11:00	3 HOURS	WML	0.0165962684196978	0.003465221202
11:30	3 HOURS	WML	0.0170286203114853	0.257479117754
12:00	3 HOURS	WML	0.0139115821478904	**0.314698196133**
12:30	3 HOURS	WML	0.0124913657078437	**0.408775417665**
13:00	3 HOURS	WML	0.0130964137888295	**0.305652306388**

Appendix C: Returns for WML portfolios with transaction costs

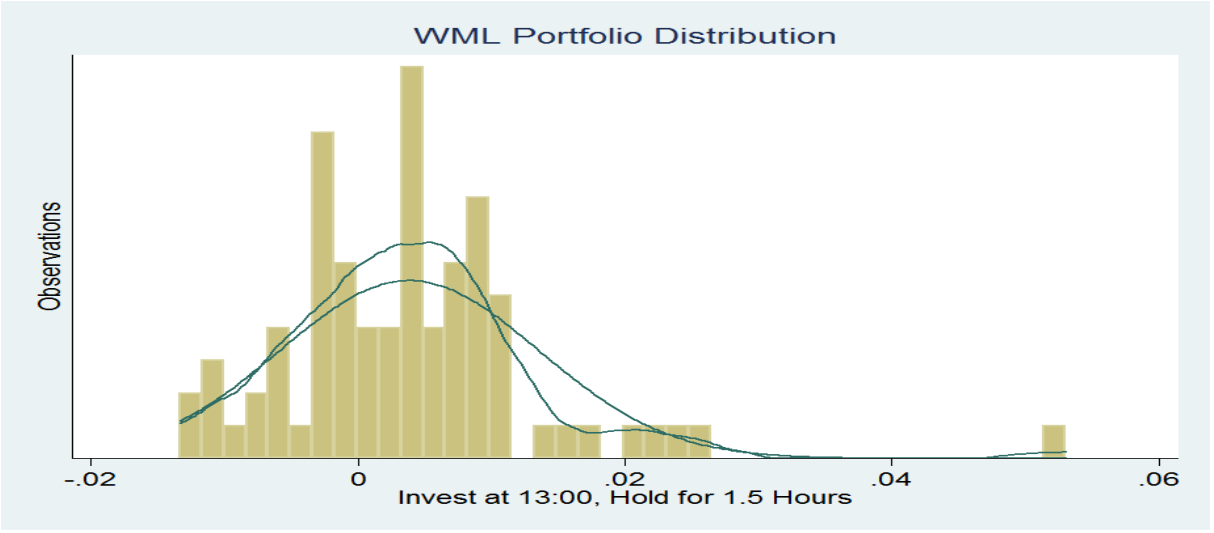
WML for 1% portfolios (20 basis point transaction cost)

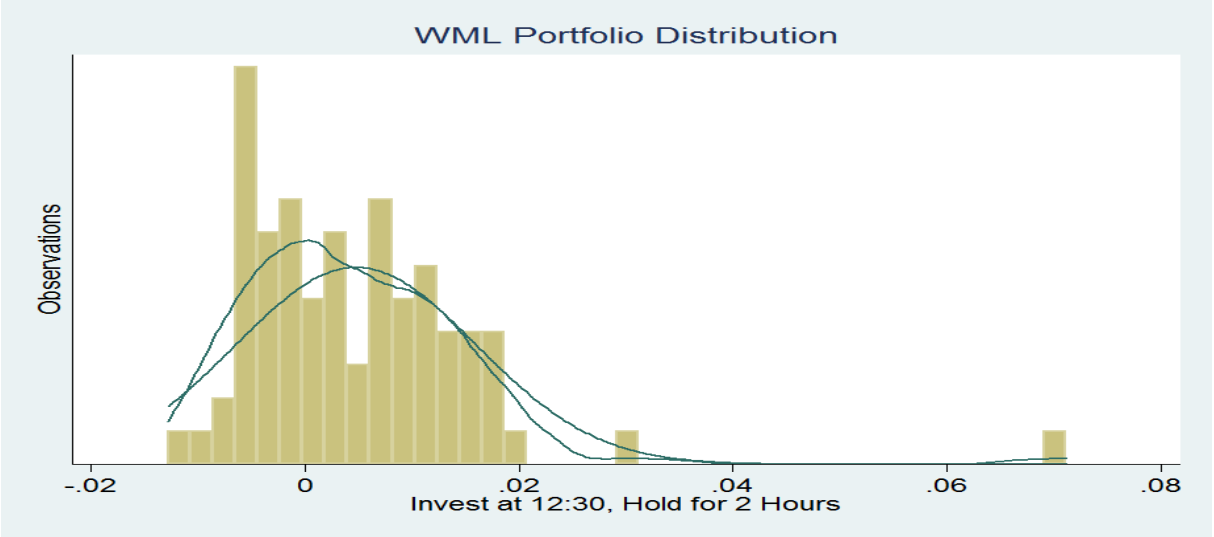
Holding Period	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00
1 Hour	-12.07	-29.18	-27.65	-27.90	-26.63	-16.04	-15.35	-5.34	-18.18	-22.24	-28.84
1.5 Hours	-16.56	-27.54	-31.95	-25.14	-20.25	-7.33	-1.78	-4.87	-16.35	-23.93	
2 Hours	-16.42	-29.62	-28.20	-18.92	-11.45	5.49	-0.25	-3.25	-19.73		
2.5 Hours	-18.72	-27.04	-23.44	-10.27	2.06	8.33	1.32	2.63			
3 Hours	-15.40	-19.95	-17.70	2.00	2.32	8.58	-0.62				

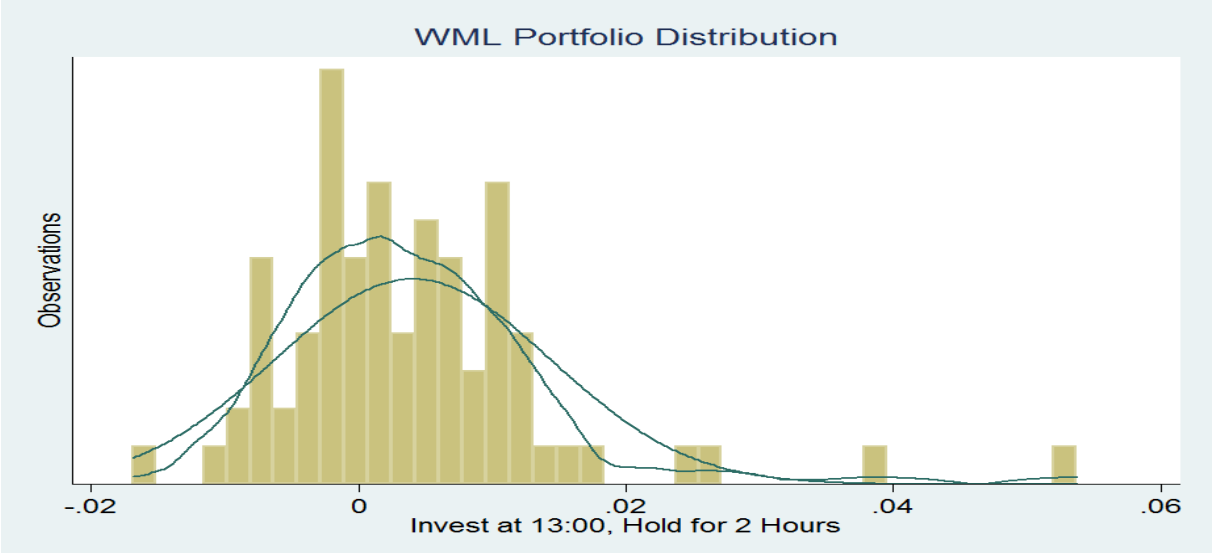
WML for 1% portfolios (30 basis point transaction cost)

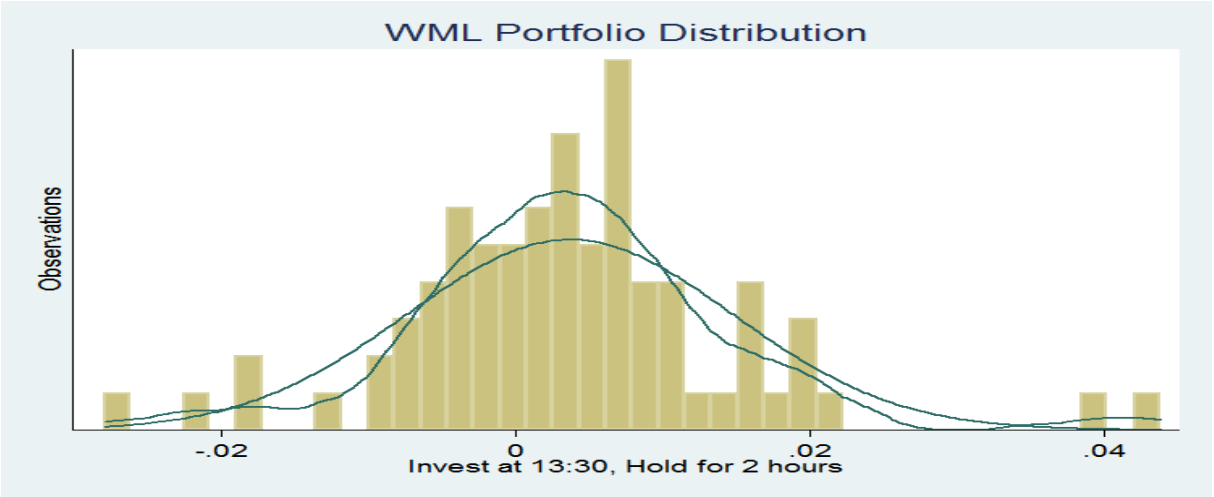
Holding Period	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00
1 Hour	-25.25	-39.79	-38.50	-38.71	-37.63	-28.48	-27.90	-19.37	-30.31	-33.77	-39.39
1.5 Hours	-29.06	-38.40	-42.15	-36.36	-32.07	-21.07	-16.34	-18.97	-28.74	-35.20	
2 Hours	-28.80	-40.17	-38.96	-30.93	-24.57	-10.15	-15.03	-17.59	-31.63		
2.5 Hours	-30.90	-37.97	-34.78	-23.57	-13.06	-7.72	-13.69	-38.17			
3 Hours	-28.08	-31.81	-29.90	-13.11	-12.85	-7.52	-15.35				

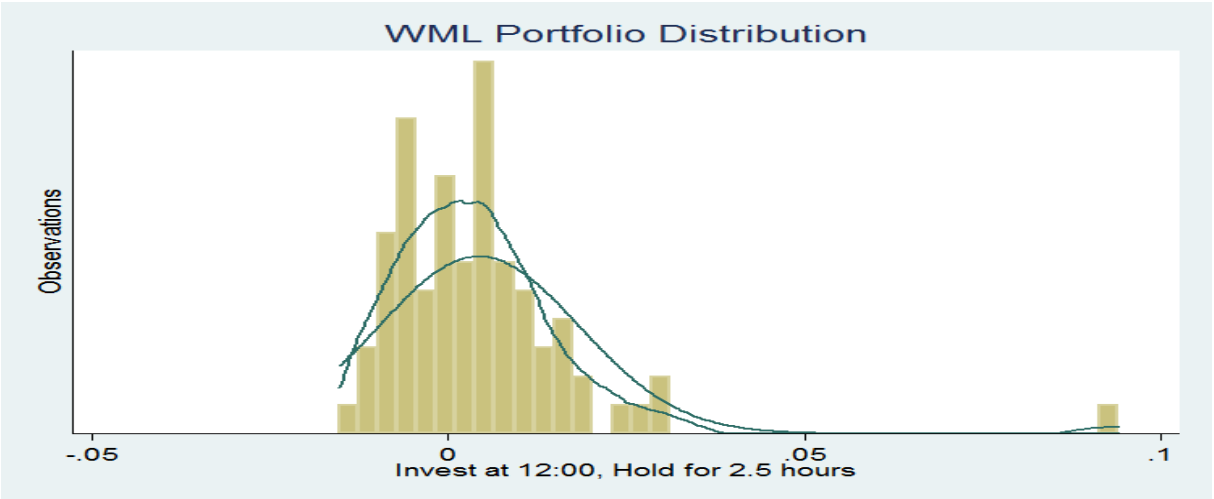
Appendix D: Histograms for Mid-day WML Portfolios

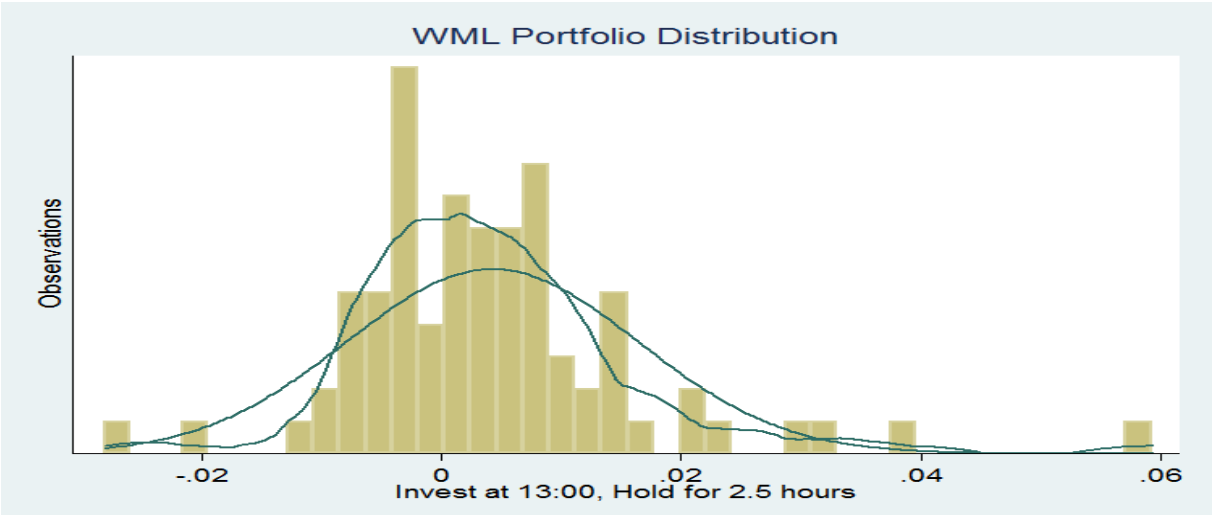


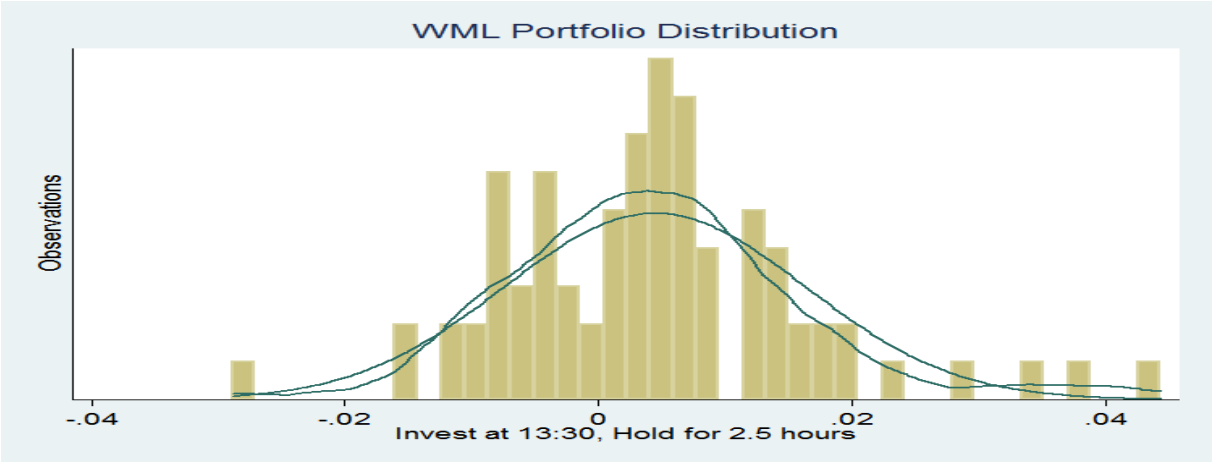


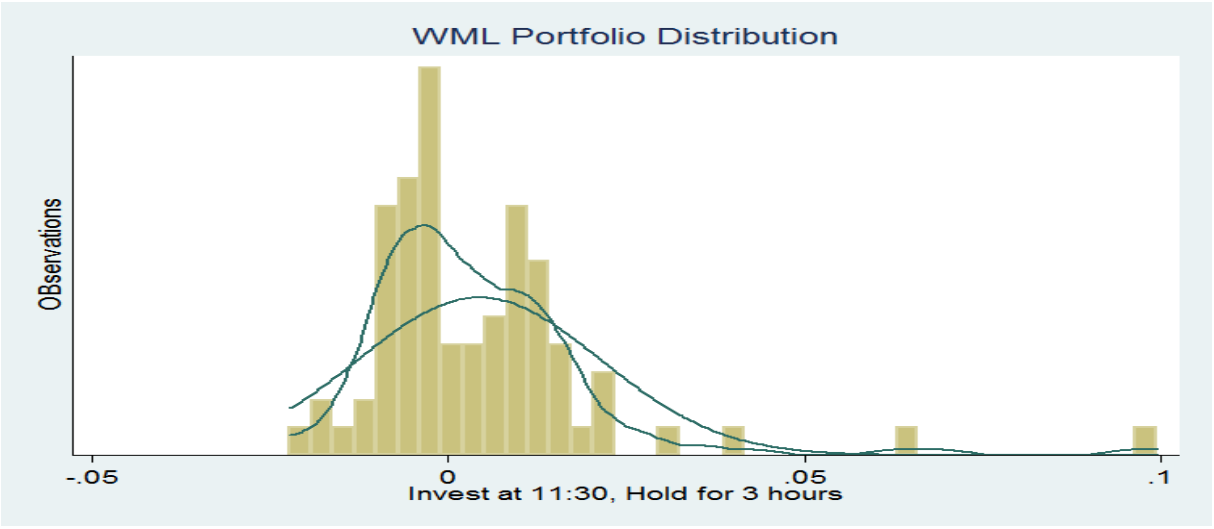


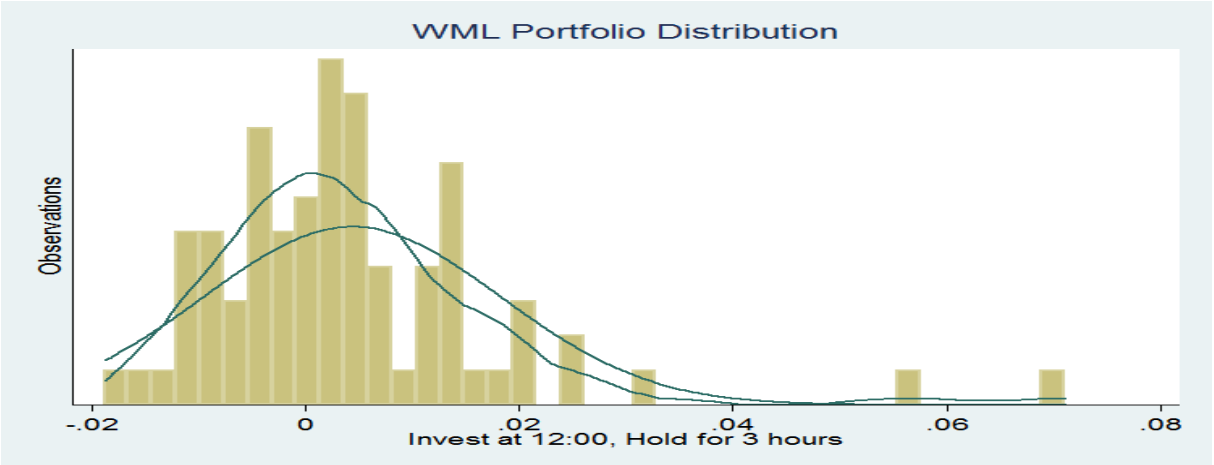

WML Portfolio Distribution
Observations
-.02
0
.02
.04
Invest at 13:30, Hold for 2 hours

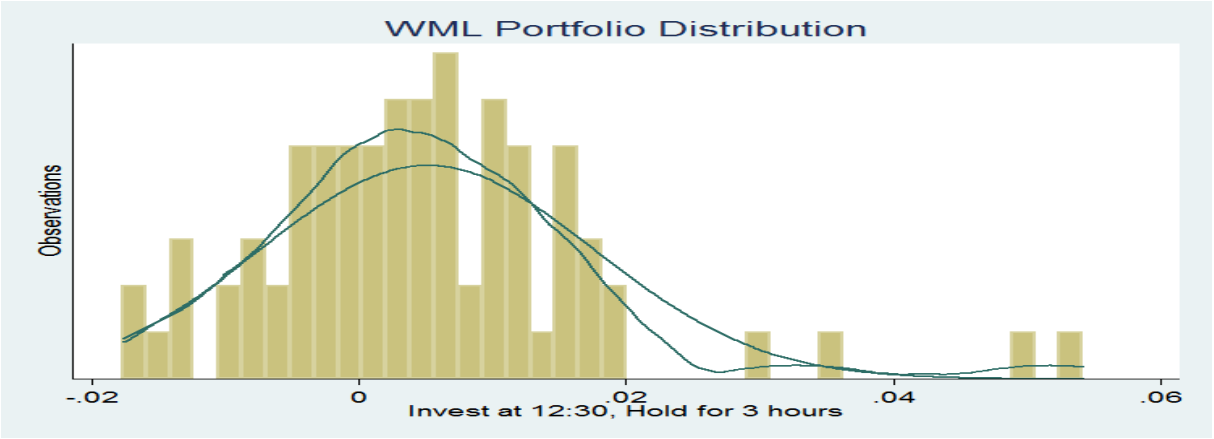

WML Portfolio Distribution
Observations
-.05
0
.05
.1
Invest at 12:00, Hold for 2.5 hours

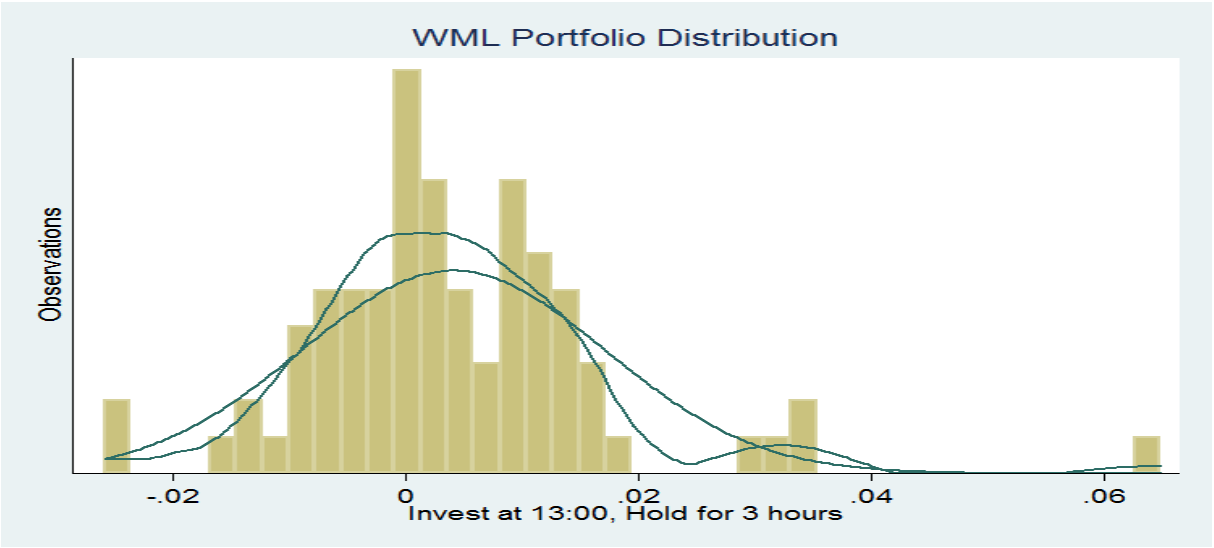

WML Portfolio Distribution
Observations
-.02
0
.02
.04
.06
Invest at 13:00, Hold for 2.5 hours


WML Portfolio Distribution
Observations
-.04
-.02
0
.02
.04
Invest at 13:30, Hold for 2.5 hours


WML Portfolio Distribution
OBservations
-.05
0
.05
.1
Invest at 11:30, Hold for 3 hours


WML Portfolio Distribution
Observations
-.02
0
.02
.04
.06
.08
Invest at 12:00, Hold for 3 hours


WML Portfolio Distribution
Observations
-.02
0
.02
.04
.06
Invest at 12:30, Hold for 3 hours


WML Portfolio Distribution
Observations
-.02
0
.02
.04
.06
Invest at 13:00, Hold for 3 hours

Appendix E: Statistical output for WML portfolios using Fama-French three factor model

Holding period	Time of purchase	R-squared	Adj. R-squared	F-stat	Prob > F	alpha	SE alpha	t-stat alpha	p-value alpha	beta	SE beta	beta t	beta p	SMB-gamma	SMB-SE	SMB t	SMB p	HML-gamma	HML-SE	HML t	HML p
1 Hour	10:00:00	0.009	-0.0296	0.23	0.8729	0.0027716	0.0013634	2.03	0.046	-0.1447288	0.2786715	-0.52	0.605	-0.029643	0.2247309	-0.13	0.895	-0.0900683	0.2229401	-0.4	0.687
1 Hour	10:30:00	0.0271	-0.0108	0.71	0.5465	-0.0003419	0.0010083	-0.34	0.735	-0.0143858	0.2060983	-0.07	0.945	-0.1349694	0.1662052	-0.81	0.419	0.2076213	0.1648808	1.26	0.212
1 Hour	11:00:00	0.0223	-0.0158	0.59	0.6262	-0.0001207	0.001229	-0.1	0.922	-0.0134276	0.2512127	-0.05	0.958	-0.0907107	0.2025871	-0.45	0.656	0.2579232	0.2009728	1.28	0.203
1 Hour	11:30:00	0.0122	-0.0262	0.32	0.8123	-0.0001546	0.0010134	-0.15	0.879	0.0670427	0.2071462	0.32	0.747	-0.1358452	0.1670502	-0.81	0.419	0.102044	0.1657191	0.62	0.540
1 Hour	12:00:00	0.0327	-0.005	0.87	0.462	-0.000016	0.0008465	-0.02	0.985	0.0509641	0.17303	0.29	0.769	0.1407488	0.1395378	1.01	0.316	0.1003396	0.1384258	0.72	0.471
1 Hour	12:30:00	0.0369	-0.0012	0.97	0.4116	0.0019504	0.0008015	2.43	0.017	-0.1731708	0.163536	-1.06	0.293	0.200719	0.1316153	1.53	0.131	0.0698328	0.1307511	0.53	0.595
1 Hour	13:00:00	0.0364	-0.0016	0.96	0.4174	0.0020488	0.0008238	2.49	0.015	-0.0871859	0.1681017	-0.52	0.606	0.2216956	0.1352899	1.64	0.105	-0.0755535	0.1344015	-0.56	0.576
1 Hour	13:30:00	0.0551	0.0178	1.48	0.2272	0.0031013	0.001066	2.91	0.005	0.046101	0.2175092	0.21	0.833	0.2860254	0.1750535	1.63	0.106	0.0910073	0.173904	0.52	0.602
1 Hour	14:00:00	0.1298	0.0954	3.78	0.0139	0.001136	0.0008193	1.39	0.170	-0.0209324	0.1671803	-0.13	0.901	0.1224387	0.1345483	0.91	0.366	0.4059764	0.1336648	3.04	0.003
1 Hour	14:30:00	0.0005	-0.039	0.01	0.9981	0.0008571	0.0009025	0.95	0.345	-0.0032842	0.1841497	-0.02	0.986	-0.0101997	0.1482054	-0.07	0.945	0.0271307	0.1472323	0.18	0.854
1 Hour	15:00:00	0.0168	-0.022	0.43	0.7294	-0.0003323	0.0008258	-0.4	0.688	0.1437173	0.1684937	0.85	0.396	-0.0687028	0.1356053	-0.51	0.614	-0.1067353	0.1347149	-0.79	0.431
1.5 Hours	10:00:00	0.0076	-0.0311	0.2	0.8987	0.0019829	0.001343	1.48	0.144	-0.11332	0.2745045	-0.41	0.681	-0.0895761	0.2213704	-0.4	0.687	0.0430209	0.2196065	0.2	0.845
1.5 Hours	10:30:00	0.0541	0.0173	1.47	0.2297	-0.00000395	0.0011839	0.00	0.997	-0.0150085	0.2419929	-0.06	0.951	-0.3258294	0.1951519	-1.67	0.099	0.235868	0.1935969	1.22	0.227
1.5 Hours	11:00:00	0.0196	-0.0186	0.51	0.6752	-0.0009427	0.0014876	-0.63	0.528	0.022884	0.3040658	0.08	0.940	-0.0784252	0.2452098	-0.32	0.750	0.2960834	0.2432558	1.22	0.227
1.5 Hours	11:30:00	0.0153	-0.0231	0.4	0.7552	0.0002562	0.0013268	0.19	0.847	0.0587075	0.2711878	0.22	0.829	-0.1306866	0.2186958	-0.6	0.552	0.2089887	0.2169531	0.96	0.338
1.5 Hours	12:00:00	0.0236	-0.0149	0.61	0.6086	0.0012268	0.0010031	1.22	0.225	-0.1025024	0.2046766	-0.5	0.618	0.2098836	0.1647256	1.27	0.206	0.0528223	0.163644	0.32	0.748
1.5 Hours	12:30:00	0.0543	0.017	1.46	0.2334	0.0031857	0.0009585	3.32	0.001	-0.1106555	0.1955715	-0.57	0.573	0.3228167	0.1573978	2.05	0.044	-0.0690087	0.1563643	-0.44	0.660
1.5 Hours	13:00:00	0.0683	0.0315	1.86	0.1441	0.0036805	0.0011198	3.29	0.002	-0.1288783	0.2284932	-0.56	0.574	0.3261053	0.1838935	1.77	0.080	0.2391546	0.182686	1.31	0.194
1.5 Hours	13:30:00	0.0598	0.0227	1.61	0.1939	0.0031266	0.0010313	3.03	0.003	0.0590309	0.2104364	0.28	0.780	0.2739106	0.1693612	1.62	0.110	0.113686	0.1682492	0.68	0.501
1.5 Hours	14:00:00	0.0755	0.039	2.07	0.1114	0.0014224	0.0011023	1.29	0.201	-0.0099854	0.2249271	-0.04	0.965	0.0340407	0.1810235	0.19	0.851	0.4344259	0.1798348	2.42	0.018
1.5 Hours	14:30:00	0.0009	-0.0385	0.02	0.9951	0.0005425	0.0011478	0.47	0.638	0.0535094	0.2341995	0.23	0.820	0.004002	0.188486	0.02	0.983	-0.0066126	0.1872484	-0.04	0.972
2 Hours	10:00:00	0.0111	-0.0274	0.29	0.8339	0.0019852	0.0013661	1.45	0.150	-0.035773	0.279228	-0.13	0.898	-0.1722674	0.2251797	-0.77	0.447	0.0009738	0.2233853	0.00	0.997
2 Hours	10:30:00	0.0487	0.0116	1.31	0.276	-0.0005312	0.0013656	-0.39	0.698	0.0439453	0.2791287	0.16	0.875	-0.309389	0.2250996	-1.37	0.173	0.3433197	0.2233058	1.54	0.128
2 Hours	11:00:00	0.0162	-0.0221	0.42	0.7365	-0.0002181	0.0016724	-0.13	0.897	-0.0205143	0.3418462	-0.06	0.952	-0.0421259	0.2756773	-0.15	0.879	0.3079909	0.2734806	1.13	0.264
2 Hours	11:30:00	0.0089	-0.0302	0.23	0.877	0.0014086	0.0015069	0.93	0.353	-0.0620139	0.3074773	-0.2	0.841	-0.0847749	0.2474606	-0.34	0.733	0.1788936	0.2458358	0.73	0.469
2 Hours	12:00:00	0.0506	0.0131	1.35	0.2646	0.00249	0.0011332	2.20	0.031	-0.0720686	0.2312351	-0.31	0.756	0.3537419	0.1861002	1.9	0.061	0.0127189	0.1848783	0.07	0.945
2 Hours	12:30:00	0.0901	0.0542	2.51	0.0652	0.0045145	0.001282	3.52	0.001	-0.1463712	0.2615828	-0.56	0.577	0.4324885	0.2105243	2.05	0.043	0.3217612	0.209142	1.5	0.139
2 Hours	13:00:00	0.0672	0.0304	1.82	0.1498	0.003829	0.0011911	3.21	0.002	-0.115182	0.2430495	-0.47	0.637	0.3199254	0.1956085	1.64	0.106	0.2772852	0.1943241	1.43	0.158

Holding period	Time of purchase	R-squared	Adj. R-squared	F-stat	Prob > F	alpha	SE alpha	t-stat alpha	p-value alpha	beta	SE beta	beta t	beta p	SMB-gamma	SMB-SE	SMB t	SMB p	HML-gamma	HML-SE	HML t	HML p
2 Hours	13:30:00	0.0337	-0.0044	0.88	0.4532	0.0033091	0.0013055	2.53	0.013	0.0581464	0.266379	0.22	0.828	0.1938032	0.2143843	0.9	0.369	0.2046767	0.2129766	0.96	0.340
2 Hours	14:00:00	0.0432	0.0054	1.14	0.3368	0.0008085	0.0012873	0.63	0.532	0.1253938	0.2626608	0.48	0.634	0.011267	0.2113919	0.05	0.958	0.3449668	0.2100039	1.64	0.105
2.5 Hours	10:00:00	0.0156	-0.0228	0.41	0.7487	0.0012043	0.0015253	0.79	0.432	0.1211808	0.311766	0.39	0.699	-0.1754431	0.2514195	-0.7	0.487	0.2218653	0.2494161	0.89	0.376
2.5 Hours	10:30:00	0.0518	0.149	1.4	0.2483	-0.0001575	0.0015138	-0.1	0.917	.063.6062	0.3094218	0.21	0.838	-0.3279999	0.2495291	-1.31	0.193	0.4183755	0.2475407	1.69	0.095
2.5 Hours	11:00:00	0.0113	-0.0277	0.29	0.8326	0.0006566	0.0017865	0.37	0.714	-0.0682017	0.3645327	-0.19	0.852	-0.0762838	0.2933794	-0.26	0.796	0.2609092	0.291453	0.9	0.374
2.5 Hours	11:30:00	0.0487	0.0111	1.3	0.2818	0.0019932	0.0015625	1.28	0.206	0.4785115	0.3170938	1.51	0.135	-0.3887502	0.2610737	-1.49	0.141	0.2113769	0.2538503	0.83	0.408
2.5 Hours	12:00:00	0.0961	0.0604	2.69	0.052	0.0040354	0.0015978	2.53	0.014	-0.1772949	0.3260286	-0.54	0.588	0.5320962	0.263909	2.03	0.046	0.4353626	0.260668	1.67	0.099
2.5 Hours	12:30:00	0.0968	0.0611	2.71	0.0506	0.0048683	0.0013028	3.74	0.000	-0.1919234	0.2658262	-0.72	0.473	0.4361631	0.2139394	2.04	0.045	0.3679398	0.2125347	1.73	0.087
2.5 Hours	13:00:00	0.0674	0.0306	1.83	0.1487	0.0040751	0.0014023	2.91	0.005	-0.2223521	0.2861337	-0.78	0.440	0.2569875	0.2302831	1.12	0.268	0.444729	0.228771	1.94	0.056
2.5 Hours	13:30:00	0.0157	-0.0231	0.4	0.7504	0.0047238	0.0014046	3.36	0.001	-0.3051907	0.2866085	-1.06	0.290	0.1039051	0.2306653	0.45	0.654	0.0884919	0.2291507	0.39	0.700
3 Hours	10:00:00	0.0395	0.0021	1.06	0.3729	0.0013901	0.0016227	0.86	0.394	0.2800481	0.3316724	0.84	0.401	-0.2851784	0.2674728	-1.07	0.29	0.3647915	0.2653414	1.37	0.173
3 Hours	10:30:00	0.0421	0.0043	1.11	0.3492	0.0010376	0.0015628	0.66	0.509	0.0109233	0.3188901	0.03	0.973	-0.2880953	0.2566458	-1.12	0.265	0.3866327	0.2549606	1.52	0.134
3 Hours	11:00:00	0.0053	-0.034	0.14	0.9387	0.0016109	0.001976	0.82	0.417	-0.0703907	0.4031957	-0.17	0.862	0.1115496	0.3244957	0.34	0.732	0.1605068	0.322365	0.5	0.620
3 Hours	11:30:00	0.0449	0.0072	1.19	0.3188	0.0039527	0.0019867	1.99	0.050	-0.0861569	0.405383	-0.21	0.832	0.1701816	0.3262561	0.52	0.603	0.5617254	0.3241138	1.73	0.087
3 Hours	12:00:00	0.0976	0.062	2.74	0.0491	0.0039916	0.0015777	2.53	0.013	-0.1458454	0.3219313	-0.45	0.652	0.4743608	0.2590934	1.83	0.071	0.4893772	0.2573921	1.9	0.061
3 Hours	12:30:00	0.0793	0.0429	2.18	0.0972	0.0049905	0.001431	3.49	0.001	-0.2680456	0.2919828	-0.92	0.362	0.3816845	0.2349906	1.62	0.108	0.4223888	0.2334476	1.81	0.074
3 Hours	13:00:00	0.0551	0.0178	1.48	0.2276	0.003795	0.0015198	2.5	0.015	-0.1619367	0.3101195	-0.52	0.603	0.3183633	0.2495871	1.28	0.206	0.3762286	0.2479483	1.52	0.133

Appendix F: Statistical output for Buy-only portfolios using Fama-French three factor model

Holding period	Time of purchase	Type of portfolio	R-squared	Adj. R-squared	F-stat	Prob > F	alpha	SE alpha	t-stat alpha	p-value alpha	Market beta	Market-SE	Market t	Market p	SMB-gamma	SMB-SE	SMB t	SMB p	HML-gamma	HML-SE	HML t	HML p
1 Hour	10:00:00	Loser	0.1	0.0649	2.85	0.0428	-0.0044503	0.0011437	-3.89	0.000	0.3127559	0.2337782	1.34	0.185	0.2986076	0.1885273	1.58	0.117	-0.286742	0.187025	-1.51	0.135
1 Hour	10:00:00	Winner	0.1056	0.0708	3.03	0.0343	-0.0016638	0.0009989	-1.67	0.100	0.1681193	0.2041742	0.82	0.413	0.2688527	0.1646535	1.63	0.107	-0.3730045	0.1633415	-2.28	0.025
1 Hour	10:30:00	Loser	0.0757	0.0397	2.1	0.107	-0.0013832	0.0008133	-1.7	0.093	0.0086199	0.1662416	0.05	0.959	0.2121986	0.1340633	1.58	0.118	-0.2692594	0.132995	-2.02	0.046
1 hour	10:30:00	Winner	0.0066	-0.0321	0.17	0.9166	-0.0017101	0.0008297	-2.06	0.043	-0.0056737	0.1695955	-0.03	0.973	0.0771173	0.136768	0.56	0.574	-0.0619001	0.1356782	-0.46	0.650
1 Hour	11:00:00	Loser	0.0668	0.0304	1.84	0.1476	-0.0010509	0.000933	-1.13	0.263	0.2406722	0.1907032	1.26	0.211	0.1913548	0.15379	1.24	0.217	-0.0568027	0.1525645	-0.37	0.711
1 Hour	11:00:00	Winner	0.0826	0.0469	2.31	0.0827	-0.0011567	0.0008572	-1.35	0.181	0.2273368	0.1752122	1.3	0.198	0.1005321	0.1412976	0.71	0.479	0.2008584	0.1401716	1.43	0.156
1 Hour	11:30:00	Loser	0.1076	0.0728	3.09	0.0318	-0.000823	0.0008355	-0.98	0.328	0.2797546	0.1707779	1.64	0.105	0.1884602	0.1377211	1.37	0.175	0.0843922	0.1366236	0.62	0.539
1 Hour	11:30:00	Winner	0.114	0.0795	3.3	0.0246	-0.0009	0.0008106	-1.19	0.239	0.3468895	0.1656945	2.09	0.040	0.052503	0.1336221	0.39	0.695	0.1861741	0.1325573	1.4	0.164
1 Hour	12:00:00	Loser	0.0496	0.0125	1.34	0.268	-0.0000951	0.0007169	-0.13	0.895	0.0104549	0.1465362	0.07	0.943	0.1852158	0.1181722	1.57	0.121	0.0749275	0.1172305	0.64	0.525
1 Hour	12:00:00	Winner	0.133	0.0993	3.94	0.0114	-0.0000962	0.0008097	-0.12	0.906	0.0615111	0.1655046	0.37	0.711	0.3258527	0.133469	2.44	0.017	0.175005	0.1324055	1.32	0.190
1 Hour	12:30:00	Loser	0.021	-0.0177	0.54	0.6544	-0.0002766	0.0005965	-0.46	0.644	0.0839136	0.1217069	0.69	0.493	0.0000644	0.0979509	0.00	0.999	0.0858545	0.0973077	0.88	0.380
1 Hour	12:30:00	Winner	0.0563	0.0191	1.51	0.21883	0.0016888	0.000775	2.18	0.032	-0.0891541	0.1581344	-0.56	0.575	0.2006668	0.1272681	1.58	0.119	0.1554175	0.1264324	1.23	0.223
1 Hour	13:00:00	Loser	0.0569	0.0196	1.53	0.2142	-0.0000562	0.00062	-0.09	0.928	-0.0115752	0.1265	-0.09	0.927	-0.1206289	0.1018084	-1.18	0.240	0.1865707	0.1011399	1.84	0.069
1 Hour	13:00:00	Winner	0.0284	-0.0099	0.74	0.5309	0.0020077	0.0006513	3.08	0.003	-0.098658	0.1328983	-0.74	0.460	0.1009501	0.1069578	0.94	0.348	0.1107475	0.1062555	1.04	0.301
1 Hour	13:30:00	Loser	0.0208	-0.0178	0.54	0.6573	-0.0014333	0.0006297	-2.28	0.026	-0.0238801	0.1284817	-0.19	0.853	-0.1007452	0.1034033	-0.97	0.333	-0.0263132	0.1027243	-0.26	0.799
1 Hour	13:30:00	Winner	0.0274	-0.011	0.71	0.5474	0.001683	0.0009886	1.7	0.093	0.0223239	0.2017211	0.11	0.912	0.1851636	0.162347	1.14	0.258	0.0644244	0.161281	0.4	0.691
1 Hour	14:00:00	Loser	0.0143	-0.0246	0.37	0.7764	-0.0013759	0.0006782	-2.03	0.046	0.0991441	0.138393	0.72	0.476	-0.0588894	0.11138	-0.53	0.599	-0.0831324	0.1106487	-0.75	0.455
1 Hour	14:00:00	Winner	0.1033	0.0679	2.92	0.0395	-0.0002249	0.0007662	-0.29	0.770	0.0783148	0.1563324	0.5	0.618	0.0634628	0.1258178	0.5	0.616	0.3225742	0.1249917	2.58	0.012
1 Hour	14:30:00	Loser	0.024	-0.0145	0.62	0.6017	-0.0013855	0.0006002	-2.31	0.024	0.0638449	0.1224739	0.52	0.604	0.0902648	0.0985681	0.92	0.363	-0.0299928	0.0979209	-0.31	0.760
1 Hour	14:30:00	Winner	0.0135	-0.0254	0.35	0.7918	-0.005134	0.0007385	-0.7	0.489	0.0606637	0.1506897	0.4	0.688	0.0799485	0.1212765	0.66	0.512	-0.0031319	0.1204802	-0.03	0.979
1 Hour	15:00:00	Loser	0.0632	0.0262	1.71	0.1725	0.001024	0.0006812	1.5	0.137	-0.1482636	0.1389994	-1.07	0.290	0.2445181	0.111868	2.19	0.032	0.0416158	0.1111335	0.37	0.709
1 Hour	15:00:00	Winner	0.0404	0.0025	1.07	0.3682	0.0007067	0.0006689	1.06	0.294	-0.0044432	0.1364805	-0.03	0.974	0.1756987	0.1098408	1.6	0.114	-0.0653893	0.1091196	-0.6	0.551
1.5 Hours	10:00:00	Loser	0.1221	0.0879	3.57	0.0178	-0.0042573	0.0011565	-3.68	0.000	0.3213975	0.2363861	1.36	0.178	0.3796196	0.1906304	1.99	0.050	-0.268161	0.1891114	-1.42	0.160
1.5 Hours	10:00:00	Winner	0.0831	0.0474	2.33	0.0812	-0.0022595	0.0010563	-2.14	0.036	0.2081697	0.2159034	0.96	0.338	0.2899315	0.1741124	1.67	0.100	-0.2254023	0.172725	-1.3	0.196
1.5 Hours	10:30:00	Loser	0.1452	0.1119	4.36	0.0069	-0.0024836	0.0009865	-2.52	0.014	0.2809437	0.2016382	1.39	0.168	0.3590089	0.1626084	2.21	0.030	-0.2931349	0.1613127	-1.82	0.073
1.5 Hours	10:30:00	Winner	0.0327	-0.005	0.87	0.4611	-0.0024726	0.0009617	-2.57	0.012	0.2660274	0.1965695	1.35	0.180	0.0330676	0.1585209	0.21	0.835	-0.0575291	0.1572577	-0.37	0.715
1.5 Hours	11:00:00	Loser	0.079	0.0431	2.2	0.0946	-0.0005528	0.0011368	-0.49	0.628	0.2514709	0.2323532	1.08	0.283	0.2932417	0.1873781	1.56	0.122	0.0282444	0.185885	0.15	0.880
1.5 Hours	11:00:00	Winner	0.1421	0.1087	4.25	0.0078	-0.0014805	0.0009815	-1.51	0.136	0.2744471	0.2006159	1.37	0.136	0.2147046	0.16784	1.33	0.188	0.3240657	0.1604949	2.02	0.047
1.5 Hours	11:30:00	Loser	0.1206	0.0864	3.52	0.0189	-0.0008534	0.0010239	-0.83	0.407	0.2761955	0.209277	1.32	0.191	0.3359005	0.1687686	1.99	0.050	0.0520509	0.1674238	0.31	0.757

Holding period	Time of purchase	Type of portfolio	R-squared	Adj. R-squared	F-stat	Prob > F	alpha	SE alpha	t-stat alpha	p-value alpha	Market beta	Market-SE	Market t	Market p	SMB-gamma	SMB-SE	SMB t	SMB p	HML-gamma	HML-SE	HML t	HML p
1.5 Hours	11:30:00	Winner	0.1194	0.0851	3.48	0.0198	-0.0005822	0.0010662	-0.55	0.587	0.3349952	0.2179276	1.54	0.128	0.205102	0.1757448	1.17	0.247	0.2607776	0.1743444	1.5	0.139
1.5 Hours	12:00:00	Loser	0.0713	0.0347	1.95	0.1294	-0.0003753	0.0008393	-0.45	0.656	0.1035076	0.1712623	0.6	0.547	0.1291613	0.1378335	0.94	0.352	0.2224539	0.1369285	1.62	0.108
1.5 Hours	12:00:00	Winner	0.1115	0.0764	3.18	0.0287	0.0008665	0.0010012	0.87	0.390	0.0011082	0.2042955	0.01	0.996	0.3389283	0.164419	2.06	0.043	0.2750064	0.1633394	1.68	0.096
1.5 Hours	12:30:00	Loser	0.0316	-0.0066	0.83	0.4735	-0.0003562	0.0006709	-0.53	0.597	-0.0211865	0.1369034	-0.15	0.877	-0.0703493	0.1101812	-0.64	0.525	0.1610638	0.1094577	1.47	0.145
1.5 Hours	12:30:00	Winner	0.0445	0.0068	1.18	0.3231	0.0028445	0.0009034	3.15	0.002	-0.1317389	0.1843323	-0.71	0.477	0.2523508	0.1483524	1.7	0.093	0.0917854	0.1473783	0.62	0.535
1.5 Hours	13:00:00	Loser	0.0224	-0.0162	0.58	0.6292	-0.0013819	0.0007724	-1.79	0.078	0.1106676	0.1576119	0.7	0.485	-0.1476658	0.1268476	-1.16	0.247	0.081678	0.1260147	0.65	0.519
1.5 Hours	13:00:00	Winner	0.0702	0.0335	1.91	0.1346	0.0023136	0.0010294	2.25	0.028	-0.0181077	0.2100481	-0.09	0.932	0.1783229	0.1690487	1.05	0.295	0.3205628	0.1679387	1.91	0.060
1.5 Hours	13:30:00	Loser	0.0208	-0.0178	0.54	0.6568	-0.0017012	0.000801	-2.12	0.037	-0.0101399	0.1634507	-0.06	0.951	-0.1379816	0.1315467	-1.05	0.298	-0.0314713	0.1306829	-0.24	0.810
1.5 Hours	13:30:00	Winner	0.0222	-0.0164	0.58	0.6331	0.0014404	0.0009658	1.49	0.140	0.048994	0.1970706	0.25	0.804	0.1358124	0.1586043	0.86	0.395	0.0219449	0.1575629	0.52	0.605
1.5 Hours	14:00:00	Loser	0.0319	-0.0063	0.83	0.4791	-0.0019894	0.000806	-2.47	0.016	0.11899933	0.1644613	0.72	0.472	0.091951	0.13236	0.69	0.489	-0.143348	0.1314909	-1.09	0.279
1.5 Hours	14:00:00	Winner	0.0818	0.0456	2.26	0.0885	-0.0005521	0.0009163	-0.6	0.549	0.1091109	0.1869753	0.58	0.561	0.1258751	0.1504795	0.84	0.405	0.2908082	0.1494914	1.95	0.055
1.5 Hours	14:30:00	Loser	0.0185	-0.0203	0.48	0.6993	-0.0000904	0.0008149	-0.11	0.912	0.0018187	0.1662817	0.01	0.991	0.1415802	0.1338251	1.06	0.293	0.0029378	0.1329463	0.02	0.982
1.5 Hours	14:30:00	Winner	0.0194	-0.0193	0.5	0.6831	0.0004671	0.000945	0.49	0.623	0.0554311	0.1928302	0.229	0.775	0.1454657	0.1551916	0.94	0.352	-0.0039446	0.1541726	-0.03	0.980
2 Hours	10:00:00	Loser	0.1666	0.1341	5.13	0.0027	-0.0052954	0.0012882	-4.11	0.000	0.5297873	0.2633071	2.01	0.048	0.4590068	0.2123405	2.16	0.034	-0.2231211	0.2106484	-1.06	0.293
2 Hours	10:00:00	Winner	0.1463	0.113	4.4	0.0066	-0.0032953	0.0010919	-3.02	0.003	0.4941065	0.2231804	2.21	0.030	0.2866275	0.1799808	1.59	0.115	-0.2224094	0.1785466	-1.25	0.217
2 Hours	10:30:00	Loser	0.1349	0.1012	4.0	0.0105	-0.0021286	0.0011376	-1.87	0.065	0.3084902	0.2325241	1.33	0.189	0.4274176	0.1875159	2.28	0.025	-0.2153345	0.1860217	-1.16	0.251
2 Hours	10:30:00	Winner	0.0654	0.029	1.8	0.1551	-0.0026449	0.0011456	-2.31	0.024	0.3525277	0.234153	1.51	0.136	0.1179166	0.1888295	0.62	0.534	0.1277231	0.1873249	0.68	0.497
2 Hours	11:00:00	Loser	0.1055	0.0707	3.03	0.0344	-0.0007166	0.0012685	-0.56	0.574	0.247348	0.2592736	0.95	0.343	0.4391773	0.2090877	2.1	0.039	0.0272072	0.2074216	0.13	0.896
2 Hours	11:00:00	Winner	0.1432	0.1098	4.29	0.0075	-0.0009198	0.0012068	-0.76	0.448	0.2269259	0.2466685	0.92	0.360	0.3969394	0.1989225	2.0	0.050	0.334936	0.1973374	1.7	0.094
2 Hours	11:30:00	Loser	0.1098	0.0747	3.12	0.0307	-0.0013741	0.0011575	-1.19	0.239	0.3545769	0.2361761	1.5	0.137	0.2518524	0.1900768	1.33	0.189	0.1910549	0.1888287	1.01	0.315
2 Hours	11:30:00	Winner	0.0909	0.055	2.53	0.0632	0.0000496	0.0013006	0.04	0.970	0.292666	0.2653916	1.1	0.274	0.166961	0.2135897	0.78	0.437	0.3696787	0.2121872	1.74	0.086
2 Hours	12:00:00	Loser	0.0523	0.0149	1.4	0.2502	-0.0003879	0.0008734	-0.44	0.658	0.03218831	0.1782102	0.18	0.857	0.0268214	0.1434252	0.19	0.852	0.273394	0.1424835	1.92	0.059
2 Hours	12:00:00	Winner	0.0947	0.0589	2.65	0.0549	0.0021171	0.0011658	1.82	0.073	-0.0397773	0.2378744	-0.17	0.868	0.3804468	0.1914436	1.99	0.050	0.2858431	0.1901865	1.5	0.137
2 Hours	12:30:00	Loser	0.0066	-0.0326	0.17	0.9173	-0.0014182	0.0007969	-1.78	0.079	0.0721118	0.1626022	0.44	0.659	-0.0643586	0.1308638	-0.49	0.624	0.0576533	0.1300045	0.44	0.659
2 Hours	12:30:00	Winner	0.0833	0.0471	2.3	0.0838	0.0031113	0.0013407	2.32	0.023	-0.0741564	0.2735735	-0.27	0.787	0.3680133	0.2201745	1.67	0.099	0.3701447	0.2187288	1.69	0.095
2 Hours	13:00:00	Loser	0.0266	-0.0119	0.69	0.5602	-0.0015952	0.0008611	-1.85	0.068	0.1156633	0.1757092	0.66	0.512	-0.1749534	0.1414125	-1.24	0.220	0.1134574	0.1404839	0.81	0.422
2 Hours	13:00:00	Winner	0.066	0.0291	1.79	0.1565	0.0022488	0.0011957	1.88	0.064	0.0005843	0.2439691	0.00	0.998	0.1448555	0.1963487	0.74	0.463	0.3904728	0.1950594	2.00	0.049
2 Hours	13:30:00	Loser	0.0072	-0.032	0.18	0.9068	-0.0022487	0.0009246	-2.43	0.017	-0.0034495	0.1886533	-0.02	0.985	0.0174402	0.15183	0.11	0.909	-0.111252	0.1508331	-0.74	0.463
2 Hours	13:30:00	Winner	0.0312	-0.007	0.82	0.4885	0.0010754	0.0011452	0.94	0.351	0.0547999	0.233668	0.23	0.815	0.2111268	0.1880582	1.12	0.265	0.0931549	0.1868234	0.5	0.619
2 Hours	14:00:00	Loser	0.0197	-0.019	0.51	0.6765	-0.0006334	0.0009681	-0.65	0.515	0.0416431	0.1975308	0.21	0.864	0.1469872	0.1589746	0.92	0.358	-0.1037292	0.1579308	-0.66	0.513

Holding period	Time of purchase	Type of portfolio	R-squared	Adj. R-squared	F-stat	Prob > F	alpha	SE alpha	t-stat alpha	p-value alpha	Market beta	Market-SE	Market t	Market p	SMB-gamma	SMB-SE	SMB t	SMB p	HML-gamma	HML-SE	HML t	HML p
2 Hours	14:00:00	Winner	0.0663	0.0294	1.8	0.1547	0.0001901	0.001064	0.18	0.859	0.16714	0.2171115	0.77	0.444	0.1581376	0.1747334	0.91	0.368	0.2409679	0.1735861	1.39	0.169
2.5 Hours	10:00:00	Loser	0.1699	0.1376	5.25	0.0024	-0.004982	0.0013563	-3.67	0.000	0.4961908	0.2772308	1.79	0.077	0.538421	0.2235691	2.41	0.018	-0.2542705	0.2217875	-1.15	0.255
2.5Hours	10:00:00	Winner	0.1806	0.1487	5.66	0.0015	-0.0037627	0.001205	-3.12	0.003	0.6174638	0.2462929	2.51	0.014	0.362866	0.1986196	1.83	0.072	-0.0326673	0.1970369	-0.17	0.869
2.5 Hours	10:30:00	Loser	0.1643	0.1317	5.04	0.003	-0.0019012	0.0012347	-1.54	0.128	0.260634	0.2523732	1.03	0.305	0.591144	0.203523	2.9	0.005	-0.2501352	0.2019012	-1.24	0.219
2.5Hours	10:30:00	Winner	0.0868	0.0512	2.44	0.0709	-0.0020438	0.001251	-1.63	0.106	0.3243324	0.2557035	1.27	0.208	0.2630321	0.2062087	1.28	0.206	0.1679782	0.2045655	0.82	0.414
2.5 Hours	11:00:00	Loser	0.1119	0.0769	3.19	0.0282	-0.0011835	0.0013049	-0.91	0.367	0.2544056	0.2662594	0.96	0.342	0.4270408	0.2142881	1.99	0.050	0.1529599	0.2128811	0.72	0.475
2.5Hours	11:00:00	Winner	0.1078	0.0726	3.06	0.0332	-0.0005118	0.001416	-0.36	0.719	0.186307	0.2889299	0.64	0.521	0.3506404	0.2325335	1.51	0.136	0.4135993	0.2310067	1.79	0.077
2.5 Hours	11:30:00	Loser	0.0743	0.0378	2.03	0.1162	-0.001298	0.0011453	-1.13	0.261	0.2685483	0.2336927	1.15	0.254	0.1757001	0.1880781	0.93	0.353	0.2087528	0.1868432	1.12	0.267
2.5Hours	11:30:00	Winner	0.083	0.0468	2.29	0.0849	0.0013165	0.0013949	0.94	0.348	0.2531307	0.284623	0.89	0.377	0.2330661	0.2290673	1.02	0.312	0.3530945	0.2275632	1.55	0.125
2.5 Hours	12:00:00	Loser	0.0354	-0.0027	0.93	0.4312	-0.001497	0.0009457	-1.57	0.118	0.2053014	0.1929764	1.06	0.291	-0.0128628	0.1553092	-0.08	0.934	0.1576792	0.1542894	1.02	0.31
2.5Hours	12:00:00	Winner	0.1085	0.0733	3.08	0.0323	0.0025534	0.0018323	1.39	0.168	0.0281095	0.3738823	0.08	0.940	0.5191168	0.300904	1.73	0.089	0.592772	0.2989282	1.98	0.051
2.5 Hours	12:30:00	Loser	0.0099	-0.0291	0.25	0.8581	-0.001921	0.0009035	-2.13	0.037	0.102266	0.1843558	0.55	0.581	-0.0980085	0.1483713	-0.66	0.511	0.0727467	0.1473971	0.49	0.623
2.5Hours	12:30:00	Winner	0.0858	0.0498	2.38	0.0763	0.0029623	0.0013835	2.14	0.035	-0.0895544	0.25822934	-0.32	0.752	0.3380381	0.2271924	1.49	0.141	0.4404167	0.2257006	1.95	0.055
2.5 Hours	13:00:00	Loser	0.012	-0.0271	0.31	0.8207	-0.0021544	0.001015	-2.12	0.037	0.1920707	0.2071083	0.93	0.357	-0.036039	0.1666827	-0.22	0.829	0.0008386	0.1655882	0.01	0.996
2.5Hours	13:00:00	Winner	0.0787	0.0423	2.16	0.0993	0.0019357	0.0012995	1.49	0.140	-0.0301783	0.2651616	-0.11	0.910	0.2208319	0.2134046	1.03	0.304	0.4452979	0.2120033	2.1	0.039
2.5 Hours	13:30:00	Loser	0.0674	0.0306	1.83	0.1486	-0.0016438	0.0011025	-1.49	0.140	0.2169808	0.2249701	0.96	0.338	0.2736682	0.1810581	1.51	0.135	-0.087034	0.1798692	-0.48	0.630
2.5Hours	13:30:00	Winner	0.0576	0.0204	1.55	0.2091	0.003095	0.0011154	2.77	0.007	-0.0881068	0.2275902	-0.39	0.700	0.3774568	0.1831667	2.06	0.043	0.0011881	0.181964	0.01	0.995
3 Hours	10:00:00	Loser	0.2122	0.1815	6.91	0.0003	-0.0049858	0.0013785	-3.62	0.001	1.3799268	0.2817602	1.35	0.181	0.7552541	0.2272218	3.32	0.001	-0.2924285	0.2254111	-1.3	0.198
3 Hours	10:00:00	Winner	0.211	0.1802	6.86	0.0004	-0.0035807	0.0012991	-2.76	0.007	0.660067	0.2655373	2.49	0.015	0.4699637	0.214139	2.19	0.031	0.0721009	0.2124326	0.34	0.735
3 Hours	10:30:00	Loser	0.1412	0.1074	4.17	0.0087	-0.0025806	0.0012608	-2.05	0.044	0.3053964	0.257266	1.19	0.239	0.5161829	0.2070501	2.49	0.015	-0.1146253	0.2056906	-0.56	0.579
3 Hours	10:30:00	Winner	0.0788	0.0425	2.17	0.0987	-0.0015281	0.001387	-1.1	0.274	0.3164228	0.2830221	1.12	0.267	0.227971	0.2277789	1.00	0.320	0.2717377	0.2262832	1.2	0.234
3 Hours	11:00:00	Loser	0.0887	0.0527	2.47	0.0687	-0.001124	0.0013117	-0.86	0.394	0.2329687	0.2676512	0.87	0.387	0.3284961	0.2154082	1.52	0.131	0.2232024	0.2139938	1.04	0.300
3 Hours	11:00:00	Winner	0.0962	0.0605	2.7	0.0518	0.0005019	0.0016068	0.31	0.756	0.1626811	0.3278648	0.5	0.621	0.4399291	0.2638687	1.67	0.100	0.3834394	0.2621361	1.46	0.148
3 Hours	11:30:00	Loser	0.0816	0.0454	2.25	0.0892	-0.0022944	0.0011663	-1.97	0.053	0.382235	0.2379886	1.61	0.112	0.1738215	0.1915355	0.91	0.367	0.1063513	0.1902778	0.56	0.578
3 Hours	11:30:00	Winner	0.1012	0.0657	2.85	0.0428	0.0016733	0.0019981	0.84	0.405	0.2961811	0.4076989	0.73	0.470	0.3438866	0.32812	1.05	0.298	0.667807	0.3259655	2.05	2.044
3 Hours	12:00:00	Loser	0.0302	-0.0081	0.79	0.504	-0.0016591	0.0010425	-1.59	0.116	0.2020133	0.2127112	0.95	0.345	-0.0167416	0.171192	-0.1	0.922	0.1681076	0.1700679	0.99	0.326
3 Hours	12:00:00	Winner	0.1196	0.0848	3.44	0.0209	0.0023475	0.001759	1.33	0.186	0.056271	0.3589179	0.16	0.876	0.4575026	0.2888605	1.58	0.117	0.657215	0.2869638	2.29	0.025
3 Hours	12:30:00	Loser	0.0132	-0.0258	0.34	0.7978	-0.0026121	0.0010336	-2.53	0.014	0.1403933	0.2108953	0.67	0.508	0.0633707	0.1697306	0.37	0.710	0.0007828	0.1686161	0.00	0.996
3 Hours	12:30:00	Winner	0.1003	0.0647	2.82	0.0444	0.0023934	0.0014045	1.7	0.092	-0.1275492	0.2865785	-0.45	0.658	0.4449387	0.2306411	1.93	0.057	0.4229017	0.2291267	1.85	0.069
3 Hours	13:00:00	Loser	0.0078	-0.0314	0.2	0.8974	-0.0009613	0.0011325	-0.85	0.399	0.1660578	0.2310898	0.72	0.475	-0.0677916	0.1859833	-0.36	0.716	0.037571	0.1847621	0.2	0.839
3 Hours	13:00:00	Winner	0.0749	0.0384	2.05	0.1139	0.0028487	0.0013382	2.13	0.037	0.0042242	0.273059	0.02	0.988	0.2504552	0.2197605	1.14	0.258	0.4135298	0.2183175	1.89	0.062