Dash for Cash: Monthly Market Impact of Institutional Liquidity Needs

Erkko Etula
Goldman, Sachs & Co.

Kalle Rinne
Mandatum Life

Matti Suominen
School of Business, Aalto University

Lauri Vaittinen
Mandatum Life

We present broad-based evidence that the monthly payment cycle induces systematic patterns in liquid markets around the globe. First, we document temporary increases in the costs of debt and equity capital that coincide with key dates associated with month-end cash needs. Second, we present direct and indirect evidence on the role of institutions in the genesis of these patterns and derive estimates of the associated costs borne by market participants. Third, and finally, we investigate the limits to arbitrage that prevent markets from functioning efficiently. Our results indicate that many investors and their agents, including mutual funds, suffer from liquidity-related trading. (*JEL* G10, G11, G12, G15)

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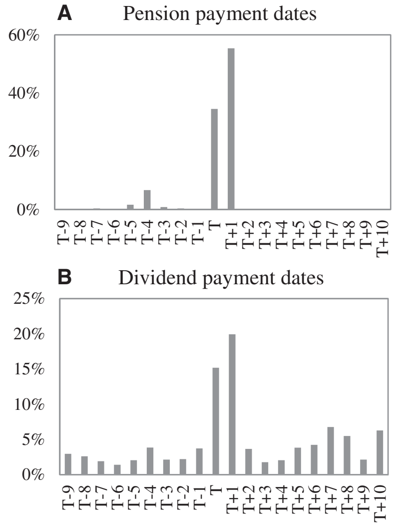

Figure 1
Payment dates of pensions and corporate dividends around the turn of the month
Panel A shows the proportion of pension payment dates occurring on specific days around the turn of the month, based on data from the 20 largest U.S. public pension plans in 2012. Panel B shows the proportion of annual dividend payments (in dollars) by CRSP companies occurring on specific days around the turn of the month. Day T denotes the last trading day of the month, $T-1$ the trading day before that, and so on. The pension payment date data come from Pension & Investment 300 Analysis by Tower Watson and from individual pension funds' Web sites. The dividend data come from CRSP. The sample period in panel B is from July 1995 (start of the 3-day settlement period in U.S. equity and corporate bond markets) to December 2013.

The value of nonbank payment transfers in the U.S. exceeds 170 trillion dollars annually, which corresponds to roughly seven times the U.S. stock market capitalization or 4 times the annual trading volume in the U.S. equity market.[1] Many of the largest transfers are repeated payments such as pensions and dividends, which are heavily clustered around the turn of the month (Figures 1A and 1B). Payments require cash, so economy participants "dash for cash" at the month end.[2] We find that this excess demand for cash predictably increases short-term borrowing costs, as depicted by elevated Repo, Libor, and Federal Funds rates (Figure 2), and it is also associated with temporary increases in the costs of equity and longer-term debt capital, as reflected by elevated stock and bond yields right before the month end (Figure 3).

In this paper, we study the causes and implications of these anticipated and monthly repeated price pressures that occur in liquid markets. First, we provide

[1] This is the value of all transactions with cashless payment instruments issued in the United States and account transfers based on 2015 data. Payments initiated by banks are excluded, unless they are related to the bank's own retail payments. *Sources*: CPMI - BIS Red Book and the World Bank.

[2] A dash for cash can be otherwise described as a large systemic liquidity demand within the economy. This liquidity demand is reflected, for instance, in a rise in the aggregate amount of checkable deposits and a decline in savings deposits, on average, a few days prior to the month end. See the Internet Appendix for these results. More generally, the Internet Appendix offers several results and statistics that complement our analysis.

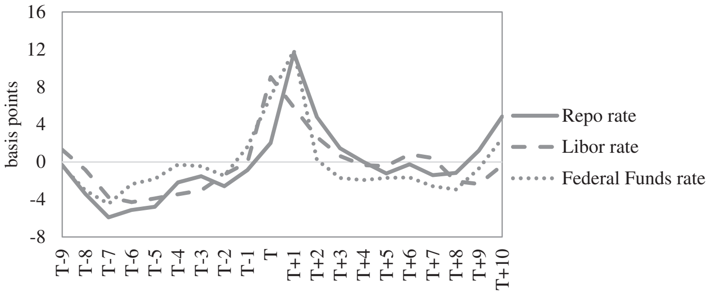

Figure 2
Repo, Libor, and Federal Funds rates around the turn of the month
This figure shows the differences between the Repo (overnight general collateral), Libor (overnight), and effective Federal Funds rates and their monthly averages, for the last and the first 10 trading days of the month. Here, day T denotes the last trading day of the month. The Repo rate data come from November 1995 to December 2013, the Libor rate data from January 2001 to December 2013, and the Federal Funds rate data from July 1995 (start of the 3-day settlement period in U.S. equity and corporate bond markets) to December 2013. *Sources*: FRED (Libor rate and Federal Funds rate) and Datastream (Repo rate).

evidence that links them to the monthly payment cycle. Second, we present both direct and indirect evidence on the role of institutional liquidity needs in the genesis of these patterns and derive estimates of the associated costs borne by market participants. Third, and finally, we investigate the limits to arbitrage that keep markets from functioning efficiently. We focus most of our analysis on equity markets where richer data enable us to crisply link the turn of the month return patterns to institutions' demand for month-end liquidity and settlement conventions. For example, utilizing trade-level data, we are able to identify institutions that systematically demand month-end liquidity and directly calculate the costs they incur from liquidity-driven trading.

Market-specific settlement conventions provide us with a starting point for understanding the timing of liquidity-motivated trading and any resultant impact on market prices at the turn of the month. In the U.S. equity and corporate bond markets, the 3-day settlement convention that prevails during our sample period dictates that an institution that needs cash on the morning of the last day of the month (T) must sell securities at least 4 business days ("days" henceforth) before the month end; that is, before the market closes on $T-4$.[3,4] In the U.S. Treasury market, the shorter 1-day settlement convention permits liquidity-driven selling until the close of $T-2$. These conventions help explain the differences in timing observed in Figure 3's yield patterns: Treasury yields tend

[3] In the United States, the settlement period was fixed to 3 days in June 1995. Prior to this, a 5-day settlement convention was common, although practices varied across time and exchanges. See, for example, Thomas Murray (2014) and the Financial Industry Regulatory Authority's Web site (http://www.finra.org/). See Table 1 for information on the settlement conventions used outside the United States.

[4] For instance, pension payments must be in the recipients' accounts on the morning of the last day of the month. To make these payments, pension funds need to sell stocks by the market close on day $T-4$, to receive cash by the market close on day $T-1$. Figure A3 in the Internet Appendix provides further details on the mechanics of making payments around the turn of the month.

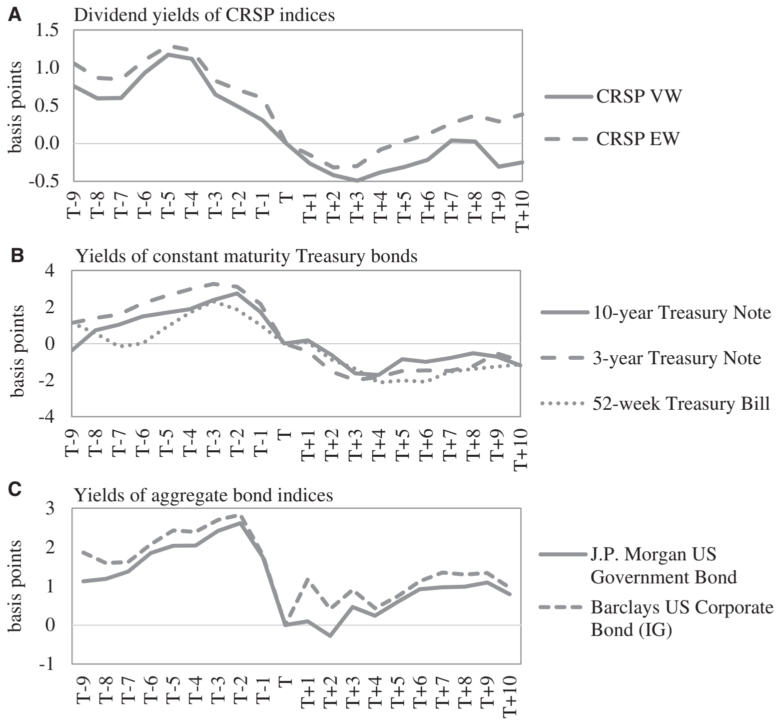

Figure 3
Dividend yields and bond yields around the turn of the month
Panel A shows the dividend yields of CRSP value-weighted and equal-weighted indices in excess of their value on the last trading day of the month. Panel B shows the same for the yields of the 52-week Treasury bill, 3-year Treasury note, and 10-year Treasury note, and panel C for the yields of the Barclays Aggregate, Barclays U.S. Corporate (IG), and J. P. Morgan U.S. Government Bond indices. Panel B excludes all 10-day periods around Treasury auctions. Because of this restriction, we have excluded 2- and 5-year Treasury notes from our analysis altogether as their auctions are arranged commonly near the end of the month. Day T denotes the last trading day of the month. The sample period ranges from July 1995 (start of the 3-day settlement period in U.S. equity and corporate bond markets) to December 2013. *Sources*: CRSP, Datastream, and FRED.

to rise and remain elevated until $T-2$, whereas stock yields peak earlier, around $T-4$. In other words, Treasury markets experience negative price pressure closer to the month end thanks to the shorter settlement window. Once the liquidity related selling pressure eases, yields decline on the back of recovering prices. The patterns in corporate bond yields seem to derive characteristics from both stocks and Treasury bonds, despite their 3-day settlement convention. This hybrid behavior is likely due to arbitrage activity between corporate bonds and Treasury bonds.

Figure 4 summarizes our understanding of the timing of events for U.S. stocks and documents the average daily returns for the market around the turn of the month. Note that returns are low in the period from $T-8$ to $T-4$ labeled "selling pressure" and high during the 7 days that follow, which include the "positive reversal" period $T-3$ to $T-1$, the last day of the month T, and the first 3 days

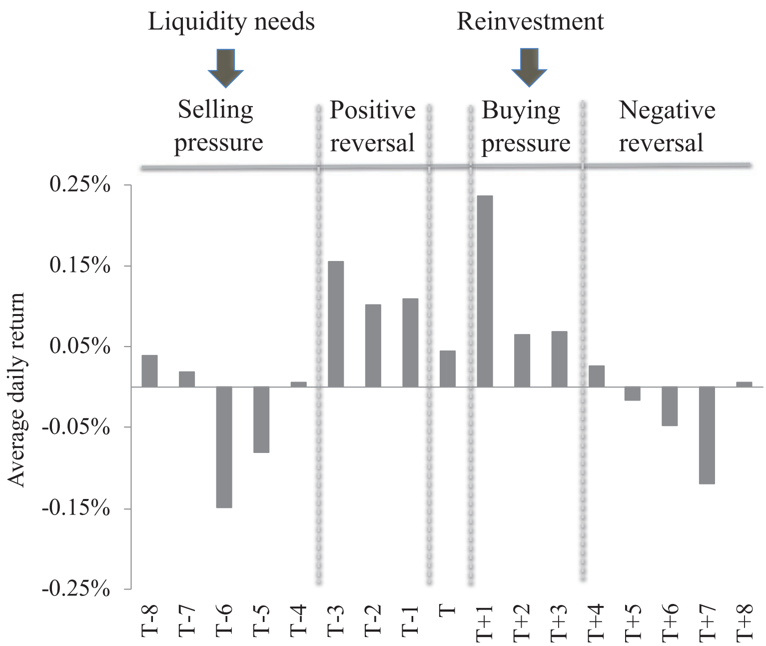

Figure 4
Average daily returns around the turn of the month
This figure shows the average daily returns of the CRSP value-weighted index around the turn of the month. Day T denotes the last trading day of the month. The sample period ranges from July 1995 (start of the 3-day settlement period in U.S. equity and corporate bond markets) to December 2013.

of the month $T+1$ to $T+3$, which we label "buying pressure" following the logic of Ogden (1990). As the buying pressure fueled by newly cleared money subsides, the cycle is completed by a "negative reversal" from $T+4$ to $T+8$. The return patterns at the beginning of the month are already documented in the literature, so we focus on the end of the month, with a particular emphasis on the positive return reversal that follows the month-end selling pressure, generating a negative correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns.

A cumulative version of Figure 4 is displayed in Figure 5, which illustrates the accrual of the turn of the month returns over time and highlights the economic importance of these patterns. Note also that the patterns seem to have become more pronounced over time. Consider, for example, that over the last decade of our sample (2003–2013), the cumulative excess return during the positive reversal periods was 103%, accounting for 73% of the total U.S. equity market's excess return, while the cumulative excess return during the selling pressure periods was -31%. Importantly, the correlation between $T-3$ to $T-1$ returns (positive reversal) and $T-8$ to $T-4$ returns (selling pressure) was -0.54. Indeed, in this paper we show that the large month-end returns can be explained to a significant extent by reversals from preceding days' price

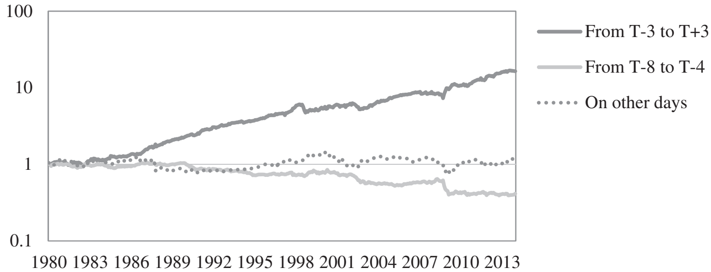

Figure 5
Cumulative stock returns around the turn of the month
This figure shows the cumulative returns in excess of the risk-free rate from investing in the CRSP value-weighted index only on days $T-3$ to $T+3$ around the turn of the month. Day T refers to the last trading day of the month. It also shows the excess returns from investing in the same index only on days $T-8$ to $T-4$, and only on days outside $T-8$ to $T+3$. The sample period ranges from January 1980 to December 2013. Note the logarithmic scale.

pressures. We document also similar return patterns and reversals in bonds and in international equities: all 23 equity markets that we survey provide some evidence of return reversals prior to month end and in 20 of them the reversals are statistically significant.[5,6]

We verify the causality of the observed link between settlement conventions and month-end reversals utilizing our international sample and a quasi-experimental design around a major settlement rule change in Europe. This analysis strongly supports our conjecture. We also find causality between payment flows and month-end reversals by studying predictable variation in month-end payment volume: when the last business day of the month is a Friday, the monthly cycle for pensions and the weekly payment cycle for salaries coincide, creating abnormally large payment volumes at the month end. Consistent with our hypothesis, we find that the month-end reversals in equity and bond markets are two to three times larger whenever the last trading day of the month is a Friday.[7]

Having documented the systematic nature of price pressures and subsequent reversals at the end of the month, we present both direct and indirect evidence

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5 Notably, the three countries (Finland, New Zealand, and Sweden) where reversals are statistically insignificant are small and feature pension systems that make a significant portion of payments outside the turn of the month period. These cross-country findings lend further support to our argument that the return patterns are related to month-end liquidity-related selling as driven by the monthly payment cycle. See the Internet Appendix for further details.

6 McConnell and Xu (2008) also document high returns for the last 4 days of the month in recent samples of U.S. and international equity market data. More commonly, academic literature has focused on the high returns on the last day of the month and the first 3 days of the month (e.g., Lakonishok and Smidt 1988; Cadsby and Ratner 1992; Dzhabarov and Ziemba 2010). Our contribution to this literature is to show large return reversals around $T-4$ and $T+3$ and to link them to the monthly payment cycle.

7 According to the Bureau of Labor Statistics, 69% of private businesses pay their employees either weekly or biweekly (Burgess 2014). This proportion increases in firm size and out of the largest firms 91% pay their employees either weekly or biweekly. These wages and salaries are commonly paid at the end of the workweek, making Friday the most common payday (e.g., Farrell and Greig 2016).

that links these patterns to institutional flows. Our direct evidence leverages a data set that contains trade-level observations for hundreds of institutional investors (mutual funds, hedge funds, pension funds, and other asset managers). This ANcerno data set (obtained from Abel Noser Solutions) is considered a highly representative sample of institutional investors' trading in the U.S. stock market (e.g., Puckett and Yan 2011). Our analysis reveals significant seasonalities in the relative tendency of institutions to buy and sell stocks. Consistent with our hypothesis and the clustering of institutional payments on T and $T+1$, we find that institutions are on average net sellers in the stock market on $T-4$ (guaranteed liquidity for payments due on T), and on $T-3$ (guaranteed liquidity for payments due on $T+1$), and that they are net buyers on the last day of the month and the first couple of days of the month. The highest selling pressure occurs on $T-4$, which coincides with the peak in the stock market dividend yield in Figure 3.[8]

When we divide the institutions into groups based on their past year's trading behavior, we find that a subset of institutions systematically engages in month-end selling year after year – some of them selling regularly up to $T-4$, some of them up to $T-3$. Moreover, we document using regression analysis that greater aggregate institutional net selling on days $T-8$ to $T-4$ (normalized by stock market capitalization) is associated with higher subsequent stock market returns on days $T-3$ to $T-1$. These findings lend direct support to our hypothesis that institutional trading affects stock return patterns at the end of the month.

Combining this direct evidence on institutional investors' month-end trading patterns with the associated patterns in market returns leads us to conclude that institutions may incur significant costs from their liquidity-driven trading. Indeed, we estimate the annual average costs to institutions at approximately 30.6 billion U.S. dollars during our ANcerno sample period (1999–2013). Moreover, our evidence suggests that this suboptimal behavior can be attributed to agency problems that stem from reputational risks. The associated costs are eventually borne by the clients of the institutions.[9]

8 That the direction of the institutional trading changes during the day $T-3$ helps explain the high returns observed on that day. Figure A5 in the Internet Appendix shows that institutional buy ratios in excess of their hourly sample average are highly negative on the morning of $T-3$, but become indistinguishable from zero by the afternoon.

9 Conditional on the observed return patterns at the month end, it would be optimal for return-maximizing fund managers (agents) to conduct their liquidity-motivated selling as early as $T-9$. However, if their principals punish them for potentially missed market returns or for higher tracking error, it may be optimal for managers to keep their equity exposure until the last possible selling day ($T-4$). The Internet Appendix studies agency-related explanations. First, we examine an idea that agents might be less willing to sell at $T-9$ (optimal from an expected return standpoint) due to reputational concerns whenever the $T-8$ to $T-4$ returns in the recent past were positive (such that those who followed the optimal practice and sold at $T-9$ underperformed those that delayed their selling until $T-4$). Consistent with this, we find the month-end return patterns to be significantly more pronounced if recent $T-8$ to $T-4$ returns were positive. In addition, the ANcerno data provides direct evidence that in this case institutions' month-end selling occurs closer to $T-4$. The second reason institutions might be unwilling to sell at $T-9$ is the risk of increased tracking error to the market, which increases in volatile markets. Consistent with this idea, we find that volatility significantly amplifies the month-end return patterns and delays institutions' selling closer to $T-4$, which is the last day that guarantees liquidity on T (see Tables A3–A5 in the Internet Appendix).

We find additional, albeit indirect, evidence for a link between institutional trading and turn of the month return patterns by studying mutual fund flows, mutual fund holdings, and the cross-section of stock returns. We begin by linking mutual fund industry outflows (another measure of market wide selling pressure) to the intensity of month-end reversals. During the sample period for which we have weekly mutual fund flow data, we find that flow-related mutual fund selling pressure helps predict more than 40% of the time-series variation in $T-3$ to $T-1$ market returns. Month-end return reversals also can be linked to mutual fund holdings at the stock level. Our findings indicate that stocks held in greater proportions by mutual funds exhibit more pronounced turn of the month patterns: more negative returns from $T-8$ to $T-4$ and more positive returns from $T-3$ to $T-1$.[10] In addition, such stocks exhibit greater return reversals around $T-4$.

We then calculate a stock specific measure of expected flow-related price pressure along the lines of Lou (2012) and find that month-end patterns are more pronounced for stocks that face selling pressure due to mutual fund outflows. We moreover find evidence that the statistical significance of the turn of the month return patterns depends on stock-level liquidity. In particular, month-end reversals are significant only for large and liquid stocks, which is consistent with the notion that the patterns are driven by investors' liquidity needs, and that investors respond to month-end outflows and cash needs conscious of transaction costs. In our international sample, we show that month-end market return reversals are stronger in countries with larger mutual fund sectors and demonstrate that the strength of the return reversals in the U.S. stock market has varied over time with the proportion of the market held by the mutual fund industry.[11]

To complete our evidence related to mutual funds, we show that mutual funds' turn of the month trading patterns predict their alpha. For instance, we find that the Carhart (1997) four-factor alpha is significantly larger for the decile of funds whose past returns revert the least around $T-4$ compared to the decile of funds experiencing the most negative return reversals around $T-4$. We interpret this as supplementary evidence (to that obtained from ANcerno's institutional trading data) that most institutions suffer significantly from their month-end trading practices.

We find mixed evidence on the efforts of hedge funds to capitalize on the turn of the month return patterns. Akin to mutual funds, we find that hedge funds' stock market betas are on average *smaller* before the month end than

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10 According to Investment Company Institute, approximately one-half of U.S. long-term mutual fund assets excluding money market funds are delegated by pension funds (http://www.ici.org/research/stats/retirement).

11 That the price pressure is closely tied to mutual fund holdings and flows suggests that investors commonly use mutual fund vehicles as parking spots for month-end liquidity. One reason for this could be that the trading costs of a mutual fund are shared with *all* of the investors in the fund. This socialization of transaction costs might provide an explanation for why investors do not pay sufficient attention to the costs that arise from month-end liquidity related trading.

at the beginning of the month.[12] By implication, our results suggest that the aggregate hedge fund industry has not mitigated but rather *contributed to* the turn of the month return patterns on average during our sample period. One possible explanation is that hedge fund vehicles are often ill-designed to provide month-end liquidity, as their redemption dates commonly fall exactly on the last day of the month. Agency reasons may provide additional deterrents for risk taking near the month end.

However, we do find some evidence of hedge funds' liquidity provision as soon as we condition for market-wide funding conditions or when we divide the aggregate hedge fund industry into sub-strategies. The literature on limits to arbitrage suggests that funding constraints may decrease the ability of hedge funds to supply liquidity in the marketplace (see, e.g., Shleifer and Vishny 1997; Brunnermeier and Pedersen 2009; Nagel 2012; Jylhä, Rinne, and Suominen 2014). Consistent with this literature, our time series evidence indicates that tighter funding conditions for hedge funds are associated with greater return reversals around $T-4$. Also, we would expect hedge funds that trade daily settled instruments (e.g., futures) to be in a better position to provide month-end liquidity. Indeed, we find that funds in managed futures and global macro categories tend to have significantly higher market betas on $T-3$, implying that they capitalize on high month-end returns by systematically increasing equity exposure either at the end of day $T-4$ or on the morning of $T-3$.[13]

The intuition that asynchronously arriving sellers and buyers to the stock market cause short-term reversals in equity returns is present already in Grossman and Miller (1988). Duffie (2010) and Greenwood, Hanson, and Liao (2018) show theoretically that similar return reversals occur even when the supply and demand shocks are anticipated. Despite this well-developed theory, there exists only limited empirical support for the idea that investors' aggregate buying and selling pressures (supply and demand shocks) would lead to short-term return reversals in the aggregate equity market. To our knowledge, only two papers provide evidence on this. First, Campbell, Grossman, and Wang (1993) show that high trading volume in the stock market (associated with buying or selling pressure from some groups of investors in their model) reduces the otherwise positive autocorrelation in stock index returns in their sample. Second, Ben-Rephael, Kandel, and Wohl (2011) provide evidence that aggregate mutual fund flows in Israel create price pressure in the aggregate stock market leading to short-term return reversals. However, neither of the two papers tie the return reversals to the turn of the month time period. As a result, our finding that investors' systematic selling and buying pressures around the turn of the month cause short-term return reversals in the aggregate equity market is new to the literature. Importantly, our findings help tie the anomalous turn

12 This is especially the case for funds with less-frequent redemption cycles.

13 Note that the end of day $T-4$ is the best time to invest in order to capitalize on abnormally large month-end returns in light of historical returns.

of the month returns to standard theories of imperfectly functioning financial markets and limits to arbitrage.[14,15]

Our finding that a systematic prescheduled event—the clearing of the monthly payment cycle—can cause significant price pressures in the world's most liquid equity and bond markets is surprising. It parallels the finding of Lou, Yan, and Zhang (2013) that prescheduled Treasury auctions also cause price pressure and subsequent return reversals in the maturities that are being auctioned. One reason the type of price pressure that we document cannot be easily arbitraged away is exactly the fact that it affects some of the largest and most liquid securities in the world. Furthermore, unlike in Lou, Yan, and Zhang (2013), the risk involved in providing liquidity against month-end flows is not security-specific but largely systematic, so hedging is not easy. For these reasons, it is hard for arbitrageurs to digest the liquidity demand without price impact.

Our results also contribute to the vast existing literature on turn of the month effects that dates back to the seminal paper of Ariel (1987). Most of these studies focus on the 4-day period from the last to the third trading day of the month where abnormally high returns are documented. We believe our study is the first to investigate market behavior around the last day of the month that guarantees cash settlement before the month end. We are also the first to link the turn of the month return patterns to institutional investors' buy-sell ratios, mutual fund holdings, mutual fund flows, stock liquidity, time variation in mutual fund and hedge fund market betas, and funding conditions.

Our results have potentially several important consequences. First, we hope that our results can help institutions alter their month-end liquidity management and payment practices to avoid raising cash when the price of short-term liquidity is high. Second, they provide regulators with additional reasons to adopt shorter settlement windows.[16] Third, central bankers can use them to motivate more aggressive liquidity provision at the month end.[17] Fourth, and finally, we hope that our findings can help investors avoid falling victim to institutional trading flows. It seems plausible that most market participants, and possibly the entire economy, would benefit from more stable financial asset prices around the turn of the month.

14 Gromb and Vayanos (2012) provide a survey of related literature. In Campbell, Grossman, and Wang (1993), return reversals are associated with large volume as investors' selling pressure in their model varies over time, whereas market-making capacity does not. Interestingly, our empirical results suggest that near the turn of the month, the selling pressure, the buying pressure, and the market making capacity are all time varying, explaining why large reversals are not necessarily associated with high volume around $T-4$.

15 Other closely related papers include Mou (2011), who presents evidence of systematic return reversals due to investor rebalancing in commodity markets, and Henderson, Pearson, and Wang (2015), who study the impact of financial investors' flows on commodity futures prices.

16 Indeed, the U.S. stock and corporate bond markets transitioned to a 2-day settlement in September 2017.

17 Some evidence suggests that the Federal Funds rate no longer rises around T in the most recent samples.

1. Data on Returns, Mutual Funds, and Hedge Funds

We source our data on country equity index returns from Datastream, except for the U.S. value-weighted index, which is obtained from CRSP. Our international sample consists of the benchmark indices of countries defined by FTSE, MSCI, and S&P as developed countries. We focus on data since 1980 and select time periods for which the settlement rule in the respective stock exchanges has been 3 days or less. Country-specific sample periods are documented in Table 1. Most of the international index returns include dividends, but in some cases we have used price indices to complete the data.[18] In the case of the United States, we report the results both since 1980 and after the adoption of the 3-day settlement rule (in June 1995).

Our cross-sectional stock data come from CRSP. Our mutual fund holdings data come from Thomson Reuters Mutual Fund Holdings database. The sample period used is from July 1995 to December 2013 to match the U.S. adoption of the 3-day settlement rule. Mutual fund performance is estimated using mutual fund returns from the CRSP Survivor-Bias-Free U.S. Mutual Fund database. MFLINKS is used to combine different mutual fund classes. Our weekly mutual fund flow data come from Investment Company Institute, and the sample period ranges from January 2007 to December 2013. Hedge fund betas are estimated using the LIPPER TASS database on individual funds' monthly returns. Fama and French factors come from Ken French's Web site. Our data on bond yields and returns are obtained from FRED and Datastream. Finally, the Treasury auction dates are downloaded from TreasuryDirect.

2. Return-Based Evidence on Turn of the Month Price Pressures

2.1 Price pressure in the equity market

In this section, we present evidence on returns and return reversals around $T-4$ that are consistent with price pressures due to month-end liquidity related selling. We also show evidence that links the reversals to (1) the 3-day settlement window in the equity market and (2) to payment volume on day T in the economy.

Let us begin by determining the relevant time periods before and after the event date, $T-4$. A pension fund manager facing cash liabilities at the month end needs to sell his stocks before the close of $T-4$ to receive cash on time for payments that must be in recipients' accounts on the morning of day T. An important part of the payments are also due on day $T+1$, so we should expect selling pressure to continue until $T-3$. In practice, however, liquidity and risk considerations are likely to deter even the institutions with $T+1$ liquidity needs from selling stocks only at the close of $T-3$, but rather encourage them to distribute their sales over the preceding hours and days.

[18] Israeli index returns are entirely based on a price index, which is the only series available in Datastream.

Given these considerations, we should expect the institutional selling pressure in the equity market to be at its highest on day $T-4$ and to subside prior to the close of day $T-3$ (Figure A3 in the Internet Appendix illustrates the timing of events, and Section 3 provides direct evidence from institutional investor trading data to support these assumptions). For these reasons, and consistent with Figure 4, we begin our analysis by considering the 5 business days from $T-8$ to $T-4$ as the primary period over which we expect negative price pressure in the stock market due to sales by institutions facing turn of the month cash liabilities.[19]

Following the month-end settlement, part of the cash distributed to salaried employees (those with monthly payment cycle) and pensioners gets reinvested in the stock market via 401k and other retirement plan contributions (often automatic) as well as self-directed investments. This effect has been studied extensively in the existing literature, which reports above-average stock returns from the last business day of the month until the 3rd business day of the month (see, e.g., Ogden 1990; McConnell and Xu 2008). We include this period as part of our study but separate it from the days before the month end and the days after $T+3$. These key events of our study are illustrated in Figure 4 along with the average daily returns of the CRSP value weighted stock index. Consistent with our hypothesis, average returns are low from $T-8$ to $T-4$ (selling pressure) and high from $T-3$ to $T-1$ (return reversal). As new money arrives in investors' accounts at the month end and shortly after the month end, returns are again high from T to $T+3$ (buying pressure) and low from $T+4$ to $T+8$ (return reversal). The differences in returns are economically meaningful: for example, the average CRSP value weighted holding period return since the 1995 adoption of the 3-day settlement rule is *negative* 17 bps for $T-8$ to $T-4$ and *positive* 77 bps for $T-3$ to $T+3$. If we look at the abnormal holding period returns (by subtracting from each day's return the average daily return during our sample period) the abnormal $T-8$ to $T-4$ returns are significantly negative at -37 bps on an average month. Conversely, abnormal returns are significantly positive from $T-3$ to $T-1$ at 25 bps, and from $T-3$ to $T+3$ at 48 bps.

We observe similar return patterns not only in the United States but also in other developed equity markets. Table 1 shows that in our international sample, consisting of 22 equity markets, returns are on average negative over the selling pressure period ($T-8$ to $T-4$) and positive and statistically significant over the reversal/buying pressure period ($T-3$ to $T+3$). Importantly, in Table 2 we establish a time series relationship between returns over the selling pressure period and returns over the positive reversal period: the correlations are negative

[19] In our sample of institutional trading, described in Section 3, we document that institutions are, on average, net sellers from $T-8$ onward, with the net selling being statistically significant on $T-5$, $T-4$, and the morning of $T-3$. Duffie (2010) and Greenwood, Hanson, and Liao (2018) theoretically examine the effects of anticipated supply shocks. In their models, speculators and market makers build short positions prior to anticipated supply shocks, to be able to absorb the shocks when they occur. Such short selling can explain the low returns in $T-8$ to $T-6$, before the end of month liquidity related selling is at its largest.

Table 1
Stock market returns near the turn of the month around the world

Country	Settlement period (days)	Sample starts	From T-8 to T-4	From T-3 to T-1	On T	From T+1 to T+3	From T+4 to T+8	Average daily return
United States (S&P 500)	3	Jul. 1995	−0.04%	**0.11%**	−0.04%	**0.13%**	−0.03%	**0.04%**
United States (CRSP VW)	3	Jul. 1995	−0.03%	**0.12%**	0.04%	**0.12%**	−0.03%	**0.04%**
United States (S& P 500)	5 or 3	Jan. 1980	−0.01%	**0.11%**	0.08%	**0.13%**	−0.01%	**0.05%**
United States (CRSP VW)	5 or 3	Jan. 1980	−0.02%	**0.11%**	**0.14%**	**0.13%**	−0.01%	**0.05%**
Other developed countries								
Australia (S& P/ASX200)	3	Feb. 1999	−0.02%	**0.14%**	0.10%	0.09%	−0.02%	**0.04%**
Austria (ATX)	3	Feb. 1998	0.00%	**0.18%**	0.17%	**0.19%**	−0.07%	0.04%
Belgium (BEL20)	3	Jan. 1990	−0.05%	0.06%	**0.20%**	**0.15%**	−0.03%	**0.03%**
Canada (S& P/TSX C)	3	July 1995	0.00%	0.06%	**0.21%**	0.09%	−0.03%	**0.04%**
Denmark (OMXC20)	3	Dec. 1989	−0.06%	0.07%	**0.14%**	**0.18%**	0.00%	**0.04%**
Finland (OMXH25)	3	Jan. 1991	−0.02%	0.12%	**0.33%**	**0.16%**	−0.02%	**0.06%**
France (CAC40)	3	Oct. 2000	−0.07%	**0.18%**	0.15%	0.07%	−0.11%	0.01%
Ireland (ISEQ OVER)	3	Mar. 2001	−0.05%	0.02%	**0.35%**	**0.17%**	−0.05%	0.01%
Italy (FTSE MIB)	3	Jan. 1998	−0.06%	**0.12%**	0.09%	0.08%	−0.07%	0.02%
Japan (NIKKEI225)	3	Jan. 1980	0.01%	**0.11%**	0.11%	0.07%	−0.06%	0.02%
Netherlands (AEX)	3	Jan. 1983	0.00%	**0.07%**	**0.15%**	**0.18%**	−0.02%	**0.05%**
New Zealand (NZX50)	3	Jan. 2001	0.00%	**0.12%**	**0.25%**	**0.07%**	−0.04%	**0.03%**
Norway (OBX)	3	Jan. 1987	−0.02%	0.07%	**0.26%**	**0.17%**	−0.02%	**0.05%**
Portugal (PSI-20)	3	Dec. 1998	−0.08%	0.05%	**0.14%**	**0.12%**	−0.01%	0.00%
Singapore (STI)	3	Sep. 1999	−0.02%	0.10%	**0.17%**	**0.15%**	0.01%	0.03%
Spain (IBEX35)	3	Mar. 1997	−0.06%	0.11%	0.10%	**0.18%**	−0.07%	0.04%
Sweden (OMXS30)	3	Jan. 1986	−0.03%	**0.12%**	**0.16%**	**0.20%**	0.00%	**0.06%**
Switzerland (SMI)	3	Jul. 1988	−0.04%	**0.09%**	0.11%	**0.15%**	−0.01%	**0.04%**
the United Kingdom (FTSE100)	3	Aug. 1996	−0.04%	**0.11%**	0.04%	**0.16%**	−0.03%	**0.03%**
Countries with a settlement period less than 3 days								
Germany (DAX)	2	Jan. 1980	−0.03%	0.06%	**0.16%**	**0.21%**	−0.04%	**0.05%**
Hong Kong (HSI)	1 or 2	Jan. 1980	−0.01%	0.08%	**0.26%**	**0.15%**	0.03%	**0.07%**
Israel (TA-25)	1	Jan. 1992	0.00%	0.08%	0.17%	**0.17%**	0.04%	**0.06%**
Average of all indices excluding the United States			−0.03%	0.10%	0.17%	0.14%	−0.03%	0.04%

This table presents average daily stock market returns near the turn of the month in the United States and in other developed countries as defined by FTSE, MSCI, and S&P. T refers to the last trading day of the month. Our sample starts in January 1980 or later as the relevant data become available, and settlement rule is 3 days or less. For the United States, we show also the full sample results. The sample runs until the end of 2013. All figures statistically significant at the 5% level are displayed in bold.

Table 2
Return correlations near the turn of the month around the world

Country	Settlement period (days)	Sample starts	Correlation of T-8 to T-4 and T-3 to T-1 returns	Correlation of T to T+3 and T+4 T+8 returns	Daily return autocorrelation	Weekly return autocorrelation
United States (S& P 500)	3	Jul. 1995	**−0.38**	−0.11	**−0.07**	**−0.08**
United States (CRSP VW)	3	Jul. 1995	**−0.39**	−0.06	**−0.04**	−0.06
United States (S& P 500)	5 or 3	Jan. 1980	**−0.30**	−0.09	**−0.03**	**−0.05**
United States (CRSP VW)	5 or 3	Jan. 1980	**−0.32**	−0.03	0.01	−0.02
Other developed countries						
Australia (S& P/ASX200)	3	Feb. 1999	**−0.35**	**−0.16**	**−0.04**	−0.06
Austria (ATX)	3	Feb. 1998	**−0.41**	−0.09	**0.06**	−0.01
Belgium (BEL20)	3	Jan. 1990	**−0.26**	**−0.23**	**0.07**	−0.03
Canada (S& P/TSX C)	3	Jul. 1995	**−0.37**	0.03	0.00	**−0.09**
Denmark (OMXC20)	3	Dec. 1989	**−0.38**	−0.02	**0.06**	−0.05
Finland (OMXH25)	3	Jan. 1991	−0.01	**−0.19**	**0.04**	0.02
France (CAC40)	3	Oct. 2000	**−0.42**	**−0.18**	**−0.04**	**−0.09**
Ireland (ISEQ OVER)	3	Mar. 2001	**−0.26**	**−0.32**	**0.05**	−0.05
Italy (FTSE MIB)	3	Jan. 1998	**−0.28**	−0.04	0.00	−0.01
Japan (NIKKEI225)	3	Jan. 1980	**−0.18**	0.00	−0.02	−0.02
Netherlands (AEX)	3	Jan. 1983	**−0.18**	**−0.21**	0.00	0.03
New Zealand (NZX50)	3	Jan. 2001	−0.03	0.05	**0.05**	0.04
Norway (OBX)	3	Jan. 1987	**−0.23**	−0.10	**0.03**	0.02
Portugal (PSI-20)	3	Dec. 1998	**−0.21**	**−0.16**	**0.08**	0.01
Singapore (STI)	3	Sep. 1999	**−0.35**	−0.06	0.03	0.03
Spain (IBEX35)	3	Mar. 1997	**−0.21**	**−0.15**	0.02	−0.06
Sweden (OMXS30)	3	Jan. 1986	−0.11	**−0.11**	**0.04**	−0.02
Switzerland (SMI)	3	Jul. 1988	**−0.17**	**−0.24**	**0.03**	**−0.07**
the United Kingdom (FTSE100)	3	Aug. 1996	**−0.33**	**−0.24**	−0.03	**−0.08**
Countries with a settlement period less than 3 days						
Germany (DAX)	2	Jan. 1980	**−0.15**	**−0.15**	0.00	−0.02
Hong Kong (HSI)	1 or 2	Jan. 1980	**−0.19**	−0.04	**0.03**	**0.08**
Israel (TA-25)	1	Jan. 1992	**−0.13**	−0.08	0.02	**−0.07**
Average of all indices excluding the United States			**−0.24**	−0.12	0.02	−0.02

This table presents correlations of returns between $T-8$ to $T-4$ and $T-3$ to $T-1$, and correlations of returns between T to T+3 and T+4 to T+8. T refers to the last trading day of the month. Our sample starts in January 1980 or later as the relevant data become available, and settlement rule is 3 days or less. For the United States, we also show the full sample results. The sample runs until the end of 2013. All figures statistically significant at the 5% level are displayed in bold.

in all of the 23 markets and statistically significant in 20 of the 23 markets. This evidence implies that below-average returns over the selling pressure periods are associated with above-average subsequent return reversals. These findings are consistent with our argument that the return patterns are caused by end of month liquidity-related selling as driven by the monthly payment cycle. Similarly, the time series correlation between the returns on the buying pressure days including the last day of the month (T to T+3) and the returns on the subsequent 5 days (T+4 to T+8) is either negative and statistically significant (in 12 of the 23 markets) or statistically insignificant. These negative correlations are consistent with our hypothesis that there is first selling pressure and then buying pressure around the turn of the month.[20,21]

Next, to show that the link between settlement conventions and reversal patterns is causal, we investigate the impact of a recent concerted settlement change in several European countries on the timing of return reversals (a quasi-natural experiment). Specifically, on October 6, 2014, a group of European countries (Austria, Belgium, Denmark, Finland, France, Ireland, Italy, Netherlands, Norway, Portugal, Sweden, Switzerland, and the United Kingdom) changed their stock market settlement rule from 3 business days to 2 business days. The goal of the reform was to increase the safety and efficiency of settlements, and to harmonize settlement rules across Europe. As the motivations driving these rule changes are unrelated to the magnitude of the turn-of-the-month phenomenon, this reform allows us to execute a quasi-natural experiment using a difference-in-differences test setup. The control group in this experiment consists of the countries in our international sample that were not affected by this change (Australia, Canada, Japan, New Zealand, Singapore, Spain, and the United States) and continued to follow a 3-day settlement rule. Following the shortening of the settlement window, we expect a decrease in daily market return autocorrelation on $T-2$ as the return reversal should move closer to the month end. The results, displayed in Table 3, show that the autocorrelation on T-2 decreased in a statistically significant way in the countries affected by the change compared to the control group countries. The magnitude of the change (-0.78) is also meaningful from an economic

[20] That the results for emerging markets are mixed is evidence in favor of our hypothesis that the observed return reversals in developed markets are driven by institutional investors who are conscious of transaction costs and liquidity issues. Section 4 will discuss these considerations. The unreported results for emerging markets are available on request.

[21] The return patterns around $T-4$ documented in Tables 1 and 2 for U.S. stocks are robust to excluding from the sample the observations that coincide with year ends and quarter ends (e.g., Sias and Starks (1997) and Carhart et al. (2002) document large equity returns near year and quarter ends), observations that coincide with Fed's announcements (that have been found to significantly affect average returns by Lucca and Moench 2015), or observations overlapping with macroeconomic announcement dates (that have been found by Savor and Wilson (2013) to significantly affect average returns). The effects of quarter ends on securities prices are examined also in Du, Tepper, and Verdelhan (2018), who document failures in the covered interest rate parity around quarter ends in the currency market.

Table 3
Difference-in-differences test around a change in the settlement period

	Autocorrelation at $T-2$	
Treatment group $*$ After change	**−0.777**	**−0.777**
	(−3.66)	(−3.20)
Treatment group	0.178	
	(1.31)	
After change	0.336	0.336
	(1.80)	(1.51)
Intercept	**−0.313**	
	(−2.84)	
Country fixed effects	No	Yes
N	40	40
R^2	.397	.786

This table shows the results from a difference-in-differences test whether a change in the settlement period affects market index return autocorrelations at $T-2$ (i.e., correlation of $T-3$ and $T-2$ market returns). In October 6, 2014, most of the European countries changed their settlement period from 3 to 2 days. Our treatment group is formed from our international sample countries affected by this change (AUT, BEL, CHE, DNK, FIN, FRA, GBR, IRL, ITA, NLD, NOR, PRT, and SWE). Our control group consists of all countries in our international sample following the 3-day settlement period at the end of September 2013 and not affected by this change (AUS, CAN, ESP, JPN, NZL, SGP, and USA). In the first regression, autocorrelation at $T-2$ is regressed on treatment group dummy, after change dummy and their interaction, and in the second specification autocorrelation is regressed on after change dummy, treatment dummy (Treatment group dummy $*$ after change dummy), and country fixed effects. T refers to the last trading date of the month. Autocorrelations are calculated using 1 year of data before and after October 2014. t-statistics based on White heteroscedasticity-robust standard errors are shown below the coefficients. All figures statistically significant at the 5% level are displayed in bold.

perspective. The results of this experiment provide evidence that market-specific settlement rules, combined with investors' month-end liquidity needs, drive the observed return reversal patterns at the month end.[22]

Finally, we can link the return reversal patterns to payment volume, by considering the fact that U.S. corporations commonly pay salaries weekly, typically on Fridays (see, e.g., Farrell and Greig 2016). According to Bureau of Labor Statistics, 69% of private businesses pay their employees either weekly or biweekly, and 31% semimonthly or monthly (see Burgess 2014). Given these payment practices, we should expect the month-end return patterns to be more pronounced if the last day of the month T is a Friday because then both the monthly payment cycle and the weekly payment cycle coincide, creating larger than usual liquidity needs. This is indeed what we find. Both the month-end returns and the return reversals are considerably higher if the last day of the month, T, is a Friday: the average returns from $T-3$ to $T-1$ are 2.5 times higher and the correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns is negative and 3 times greater in magnitude compared to months when T is some other weekday. Importantly, however, the month-end average returns are positive and the reversal is statistically significantly negative also if the last day of the month is not a Friday.

22 A difference-in-differences test setup requires that before the reform, the dependent variable has a parallel trend, both in the treatment and in the control groups. Both visual inspection and formal regression test show that this assumption is satisfied in our test setup.

Table 4
Return reversals before the turn of the month: Evidence from Treasury yields

y = yield change from $T-3$ to $T-1$	52-week Treasury Bill	3-year Treasury Note
$T-8$ to $T-4$ yield change	**−0.189**	**−0.186**
	(−2.48)	(−2.58)
Intercept	−0.008	−0.005
	(−1.00)	(−0.69)
R^2	.081	.043

This table shows the results from a regression in which the changes in Treasury yields from $T-3$ to $T-1$ are regressed on the changes in Treasury yields from $T-8$ to $T-4$. Here, T refers to the last trading day of the month. The Treasury yields are those of 52-week Treasury bill and 3-year Treasury note. Both regressions include thirteen unreported dummy variables for Treasury auctions that occur in the same maturity during days $T-9$ to $T+3$. The dummy variables control for the Treasury auction effects documented in Lou, Yan, and Zhang (2013): significant price pressure during 4 days preceding Treasury auctions and the subsequent 6-day return reversal. The yield data come from Datastream. The sample period ranges from July 1995 to December 2013. t-statistics based on Newey and West (1987) standard errors are shown below the coefficients. All figures statistically significant at the 5% level are displayed in bold.

2.2 Price pressure in the bond market

Analyzing price pressures in the bond market is more complicated for several reasons, including changes in the underlying reference security for "constant maturity" bonds, and the fact that Treasury auctions are commonly held near the month end. Moreover, despite the shorter 1-day settlement window for Treasury bonds, asset allocation considerations are likely to have institutions conduct their month-end liquidity related Treasury sales close to their equity and corporate bond sales. Indeed, we observe less crisp patterns in the bond market than in the equity market. Nonetheless, as Figure 3 suggests, the turn of the month return patterns across different segments of the aggregate bond market are consistent with the monthly payment cycle.

In Table 4, we show that the Treasury bond market also experiences significant return reversals between $T-8$ to $T-4$ and $T-3$ to $T-1$. That the return reversals here coincide with those in the equity market suggests that selling pressure in the Treasury market is affected by settlement conventions in equity and corporate bond markets, in addition to those in the Treasury bond market themselves. Akin to the equity market, the return reversals in the bond market between $T-8$ to $T-4$ and $T-3$ to $T-1$ are larger if the last day of the month T is a Friday. Note, however, from Figure 3, panel C, that the reversal in yields in the bond market seems to be highest on $T-1$ after the selling pressure in the Treasury bond market has come to an end.

3. Direct Evidence of Price Pressures from Institutional Investors' Trades

To directly investigate the selling pressure hypothesis as an explanation for the observed turn of the month return patterns, we turn to the ANcerno data set that contains trade-level observations for hundreds of different institutions including hedge funds, mutual funds, pension funds, and other money managers. Our data cover the period 1999–2013. According to Puckett and Yan (2011), this data set includes the trades of many of the largest institutional investors such as

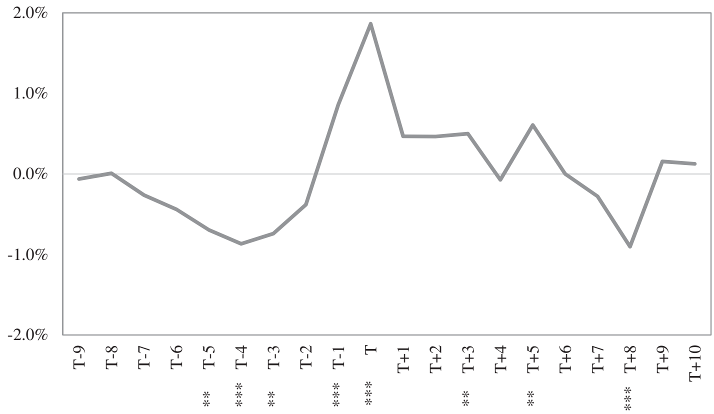

Figure 6
Institutional investors' buy ratios around the turn of the month
This figure shows institutional investors' average daily aggregate buy ratios on specific days around the turn of the month, in excess of their sample average. On any given day, the aggregate buy ratio is defined as the dollar value of institutions' buy transactions, divided by the dollar value of their buy and sell transactions. Day T denotes the last trading day of the month. The sample includes all institutions in the ANcerno database and the sample period ranges from January 1999 to December 2013. $^{*}p<.1$; $^{**}p<.05$; $^{***}p<.01$.

CalPERS, the YMCA retirement fund, Putman Investments, and Lazard Asset Management that in total account for 8% of the daily volume in CRSP.[23]

The ANcerno data reveal significant intramonth variation in institutions' buy ratios, defined as the dollar value of buy transactions divided by the dollar value of both buy and sell transactions on a given day. Consistent with our hypothesis, the institutions in the sample seem to sell more than buy in the 4 trading days leading up to $T-3$ consistent with the negative average returns on days $T-6$, $T-5$, and $T-4$. In addition, institutions execute more buys than sells in the days $T-1$ to $T+3$. On several days, such as $T-5$ to $T-3$, $T-1$ to T, and $T+3$, the buy ratios differ statistically significantly from the unconditional mean. Figure 6 displays these daily average *excess* buy ratios. As expected, institutional selling pressure is strongest on day $T-4$.[24]

One may wonder how to square the continuation of institutional selling pressure until $T-3$ with Figure 4's high average returns on the same day. Recall that $T-3$ is the last day that guarantees cash settlement for the first day of the month, which is the second largest payment day for pensions. Given this, we do expect some institutions to remain net sellers that day, particularly

[23] Unfortunately, Abel Noser Solutions no longer provides a file that allows the matching of ANcerno client codes to corresponding investor names. As a result, we are unable to disentangle different institutional investor types.

[24] To evaluate whether this institutional selling pressure captured in the ANcerno data set can affect market prices, note that the ANcerno institutions' combined signed trading volume varies between 0.15% and 0.25% of the total CRSP trading volume during the relevant days $T-8$ to $T-3$. Note furthermore that according to Puckett and Yan (2011) the ANcerno institutions represent only about 10% of all the institutional trading volume. This implies that the combined signed volume of all institutional investors on the above days can potentially comprise as much as 1.5% to 2.5% of total trading volume.

in the morning. To investigate institutions' intraday trading behavior on $T-3$, we compute *hourly* average excess buy ratios within that day and find that excess buy ratios are negative in the first trading hours of the day, but become indistinguishable from zero by the early afternoon.[25] In other words, the negative price pressure from institutional investors' liquidity-related selling diminishes rapidly following its peak at *T-4* prices, contributing to the high $T-3$ market returns observed in the data.

Another potential contributor to the positive price appreciation on $T-3$ is the increase in the supply of liquidity initiated by investors who *receive* payments on day T and can therefore start purchasing stocks on $T-3$ in anticipation of the inflows. Adding to the supply of liquidity, in Section 6 we present evidence that certain hedge fund strategies (and when funding conditions are good, the hedge fund industry on average) have abnormally high market betas on $T-3$, which suggests that liquidity supplying hedge funds arrive in the market at the end of $T-4$ or the morning of $T-3$.

Next, we investigate whether a subset of ANcerno institutions consistently demand liquidity on the days preceding the month end, when the aggregate institutional selling, on average, is abnormally large. Based on Figure 6, days $T-5$ to $T-3$ meet this requirement. We define an institution-specific variable called "signed trading volume" as the difference between the value of its stock purchases and sales and label an institution a liquidity demander if its signed trading volume from $T-5$ to $T-3$ measured over the previous year is negative.[26] Figure 7 shows the sum of signed volumes for liquidity demanders and other institutions, normalized by the CRSP market trading volume for the relevant days. It appears that some of the institutions systematically demand liquidity in the stock market at $T-3$, $T-4$, and before.[27]

As a robustness check, we split the liquidity demanding institutions in Figure 7 into two groups based on a trading pattern predicted by their payment date (recall from Figure 1A that pension payments are clustered at T and $T+1$). The first group includes institutions with negative signed trading volume from $T-5$ to $T-4$ and nonnegative signed trading volume on $T-3$ over the previous year—that is, institutions that we conjecture to have payments at T. The second group includes institutions whose signed trading volume is negative from $T-5$ to $T-4$ and also negative on $T-3$ in the previous year—these we conjecture

25 See Figure A5 in the Internet Appendix for the analysis. In addition, an unreported test using hourly returns of the S&P 500 index shows a significant intraday return reversal within the day $T-3$: the correlation between morning and afternoon returns is -0.23, and the estimate is significantly different from zero at 5% level. Here, we used 11 a.m. as the cutoff between morning and afternoon to match the selling pattern in the ANcerno data shown in Figure A5.

26 Focusing on institutions' net sales during $T-5$ to $T-3$ allows a clean identification of the liquidity demanding institutions. Results are qualitatively similar, however, if we classify liquidity demanders as net sellers during the window $T-8$ to $T-3$, as opposed to using the $T-5$ to $T-3$ window. These unreported results are available on request.

27 Consistent with institutions spreading their selling activity, we find that liquidity demanders who sell at $T-4$ during a given month, also sell statistically significantly at $T-6$, $T-5$, and $T-3$ in the same month.

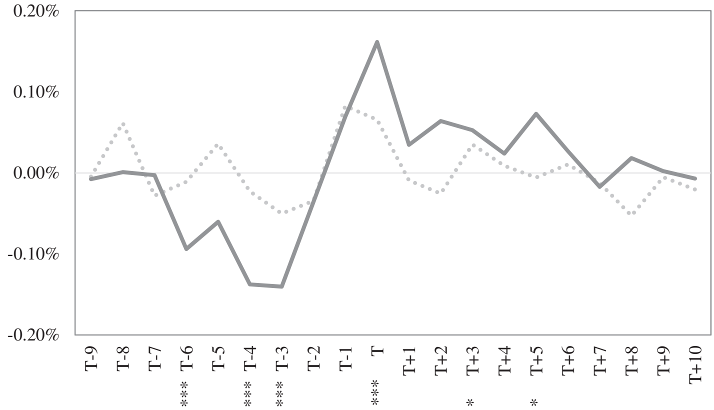

Figure 7
Systematic patterns in institutional trading around the turn of the month
This figure shows for ANcerno institutions, which we classify as either liquidity demanders (solid line) or other institutions (dotted line), their signed excess volume (relative to CRSP market volume) around the turn of the month. The signed excess volume for a given day (relative to the month end) and institution type equals the average of this type of institutions' signed volumes during the relevant days in excess of the same institutions' average daily signed volume during the entire sample. The signed volume for a given institution in a given period is the sum of its stock purchases (in dollars) minus its stock sales in that period. An institution is classified as a liquidity demander (other institution) if its signed volume during the previous year is negative (positive) on days $T-5$ to $T-3$. This time interval is selected for the identification of liquidity demanders based on Figure 6, where the institutions' month end selling is found to be significant on days $T-5$ to $T-3$. Day T denotes the last trading day of the month. The data come from ANcerno, and the sample period ranges from January 2000 to December 2010. The sample period ends at 2010, the time when Abel Noser stops providing client codes needed to track institutions. $^{*}p<.1$; $^{**}p<.05$; $^{***}p<.01$.

to be institutions with payments at $T+1$.[28] Interestingly, the selling patterns are highly persistent. The first group has highly significant negative trading volume on $T-4$, but their signed trading volume on $T-3$ is close to zero. The second group, on the other hand, has significant negative trading volume on $T-4$ and in the morning of $T-3$. These results lend further support to our hypothesis that the liquidity demanding institutions' month-end selling is linked to their turn of the month payment needs.

ANcerno's trade-level data also allow us to estimate the costs incurred by ANcerno institutions due to the price impact of their month-end liquidity related trades. To do that, we compare the actual trading of ANcerno institutions to hypothetical trading of equal volume but with improved market timing. Concretely, we compare a scenario where the institutions execute at the closing prices of $T-9$ all of the trades that they in reality execute between $T-8$ and $T-3$. This calculation suggests that over our sample period 1999-2013, the institutions in the ANcerno database sacrificed 45.9 billion U.S. dollars due to price impact of their month-end liquidity related trades. This amount

[28] This definition guarantees that we do not have any overlap between the groups of institutions and allows us to study these two separate groups' trading behavior on T-3.

Table 5
Impact of institutional trading on the turn of the month returns

	y = market return from $T-3$ to $T-1$				
Market return ($T-8$ to $T-4$)	**−0.352**			**−0.344**	**−0.344**
	(−2.51)			(−2.71)	(−2.71)
Institutional investors' net sales ($T-8$ to $T-4$)		35.27		**40.37**	
		(1.50)		(2.14)	
Institutional investors' net sales ($T-5$ to $T-4$)			**117.25**		**111.09**
			(2.53)		(3.49)
Intercept	**0.003**	0.002	0.000	0.001	−0.001
	(2.39)	(0.98)	(−0.09)	(0.32)	(−0.52)
R^2	.184	.020	.084	.209	.259

This table shows the results from a regression in which the market index return from $T-3$ to $T-1$ is regressed on the $T-8$ to $T-4$ index return, and on institutional investors' net sales during $T-8$ to $T-4$. Here, T refers to the last trading day of the month. Institutional investors' net sales is defined as the difference between the value of all ANcerno institutions' stock sales and purchases during the days $T-8$ to *T-4,* or, alternatively, during the days $T-5$ to $T-4$, when the difference is positive, and 0 otherwise. The figures are normalized by the U.S. total stock market capitalization at the beginning of the selling pressure period. Our institutional investors' trade data come from ANcerno, and the sample period ranges from January 1999 to December 2013. The index returns are those of the CRSP value-weighted index. t-statistics based on Newey and West (1987) standard errors are shown below the coefficients. All figures statistically significant at the 5% level are displayed in bold.

corresponds to 26 bps of the ANcerno institutions' total trading volume during our sample period. Assuming, like in Puckett and Yan (2011), that the institutions in the ANcerno's database represent 10% of all institutional trading volume, the total trading cost of month-end liquidity related trading to institutions could be tenfold: 459 billion dollars during our sample period, or approximately 30.6 billion dollars per annum.[29]

To investigate whether institutional liquidity demands can explain the observed month-end return patterns in a regression setting, we use the ANcerno database to examine the market impact of the selling pressure. The results in Table 5 show that the net selling of the ANcerno institutions during $T-8$ to $T-4$, and particularly during $T-5$ to $T-4$, predict higher stock market returns from $T-3$ to $T-1$. The economic magnitude of this institutional selling pressure is meaningful: a 1-standard-deviation increase in net selling is predicted to increase $T-3$ to $T-1$ market returns by 0.32 to 0.67 percentage points, depending on the regression specification. This finding provides additional direct support to our hypothesis that institutional trading is responsible for the observed predictable variation in stock returns near the turn of the month.[30]

Finally, we utilize one more piece of information in the ANcerno data set to examine our price pressure hypothesis around the turn of the month. If the institutions that we identified as liquidity demanders are indeed "marginal investors" that move markets, their orders ought to be filled at prices that are

29 Note that our calculations cannot account for the impact of possible futures market transactions on month-end performance. Some of the ANcerno institutions might use futures to offset the temporary reduction in their market exposures before the month end.

30 To avoid the use of overlapping data, we have left out net selling on $T-3$ from these regressions.

inferior to broader market pricing on a given day. Consistent with this idea, Table A2 of the Internet Appendix shows that the sales by liquidity demanders during the selling pressure period $T-8$ to $T-4$ occur at prices well below the volume-weighted average price from order placement to completion (contrary to the sales by other institutions during this period of time). Similarly, during the buying pressure period, T to $T+3$, these liquidity demanders' purchases occur at prices that are above the volume-weighted average price.

In the next section, we present further evidence on the role of institutions in the creation of the turn of the month return patterns by linking stock returns to mutual fund holdings in the cross-section of stocks. We also investigate which types of stocks exhibit the strongest turn of the month reversals.

4. Cross-Sectional Evidence on Turn of the Month Price Pressures

4.1 Return reversals in the cross-section of stock returns

We begin our cross-sectional investigation with a straightforward extension of our aggregate stock market study. Specifically, we sort the stocks in the CRSP universe each month based on their performance over the period where we expect selling pressure, $T-8$ to $T-4$, and measure their average returns over the subsequent 3 days, where we expect reversals, $T-3$ to $T-1$, and over the 4 subsequent days, T to $T+3$, which includes the days where we expect reinvestment-driven buying pressure. The results, displayed in Table 6, demonstrate that the worst-performing stocks over the selling pressure period tend to exhibit the best average performance over the 3 and 7 subsequent days. The relationship holds monotonically across our decile portfolios, formed based on $T-8$ to $T-4$ returns for each stock. The difference in average returns between the lowest and highest decile portfolios is both statistically and economically significant: 0.7% over the 3-day period $T-3$ to $T-1$, and 0.3% over the next 4-day period T to $T+3$.

For completeness, we also conduct an analogous exercise for the period $T+4$ to $T+8$, where we expect reversal from the buying pressure at the beginning of the month. The results, displayed in panel B of Table 6, demonstrate that the $T+4$ to $T+8$ average returns across the decile portfolios sorted on T to $T+3$ returns also exhibit a large and statistically significant difference in average returns between the extreme deciles.

We conclude that the month-end return patterns we observed for aggregate market indices also hold for portfolios of individual stocks and the strength of return reversals is inversely proportional to the stocks' performance over the selling or buying pressure periods.

4.2 Mutual fund ownership, flows, and turn of the month reversals

We proposed that the return reversals in aggregate stock returns at the turn of the month are likely to be driven by sales of stocks by institutional investors with month-end cash liabilities. If this is the case, we would expect the stocks

Table 6
Cross-sectional return reversals around the turn of the month

A. Deciles based on returns from T-8 to T-4

	1	2	3	4	5	6	7	8	9	10	1-10
Returns from	**0.98%**	**0.72%**	**0.60%**	**0.58%**	**0.53%**	**0.48%**	**0.46%**	**0.44%**	**0.41%**	0.26%	**0.72%**
$T-3$ to $T-1$	(3.76)	(3.50)	(3.31)	(3.49)	(3.45)	(3.23)	(3.12)	(2.98)	(2.67)	(1.44)	(4.19)
Returns from	**0.65%**	**0.52%**	**0.52%**	**0.46%**	**0.39%**	**0.42%**	**0.43%**	**0.36%**	**0.41%**	0.31%	0.34%
T to $T+3$	(2.16)	(2.29)	(2.70)	(2.65)	(2.34)	(2.53)	(2.57)	(2.09)	(2.11)	(1.28)	(1.78)

B. Deciles based on returns from T to T+3

	1	2	3	4	5	6	7	8	9	10	1-10
Returns from	0.13%	−0.10%	−0.12%	−0.15%	−0.10%	−0.15%	−0.14%	−0.16%	−0.19%	−0.33%	**0.46%**
$T+4$ to $T+8$	(0.43)	(−0.41)	(−0.57)	(−0.73)	(−0.55)	(−0.83)	(−0.73)	(−0.83)	(−0.92)	(−1.29)	(2.66)

Panel A shows evidence of cross-sectional return reversals around the turn of the month by displaying the returns from $T-3$ to $T-1$ and from T to $T+3$ for deciles of stocks based on their $T-8$ to $T-4$ returns. Here, T refers to the last trading day of the month. In Panel B, the table shows returns from $T+4$ to $T+8$ for deciles of stocks based on their T to $T+3$ returns. Our sample includes all stocks in CRSP that have a share price above 5 USD, and a market capitalization that exceeds NYSE tenth market capitalization percentile on the tenth trading day of the corresponding month. The sample period ranges from July 1995 to December 2013. The last column shows the difference in returns between the two extreme deciles. t-statistics are shown in the parentheses. All figures statistically significant at the 5% level are displayed in bold.

owned in greater proportions by such investors to exhibit stronger return reversals. While we do not directly observe the holdings of pension funds (whose payment obligations are predominantly clustered at the month end as shown in Figure 1A), we do observe the holdings of their agents, mutual funds, which provide an easy and efficient implementation vehicle for pension funds' diversified equity investments. For this reason, we suspect that the turn of the month effects are more pronounced in the stocks that are commonly held by mutual funds.[31]

To investigate the link between mutual fund ownership and month-end return patterns, we sort stocks in each month by mutual funds' collective ownership percentage in the previous month and form decile portfolios.[32] We then compute value- and equal-weighted average returns of these portfolios. Figure 8 displays the results. Consistent with our hypothesis, the stocks that are held to a greater extent by mutual funds in a given month tend to experience monotonically lower returns over the selling pressure period, from $T-8$ to $T-4$. These same stocks also experience greater returns over the 3 subsequent days from $T-3$ to $T-1$, and again monotonically lower average returns from $T+4$ to $T+8$. Finally, the

31 Another reason mutual fund holdings might affect end of month patterns is that many mutual funds' own dividend distributions also occur at the end of the month.

32 Stocks without any mutual fund ownership are included in decile 1. Mutual fund ownership of stocks varies considerably. Ranking all CRSP stocks based on their mutual fund ownership during our sample period (July 1995 to December 2013) gives a tenth percentile of 0.3% and 90th percentile of 47.7%. So the interdecile range is as much as 47.3%.

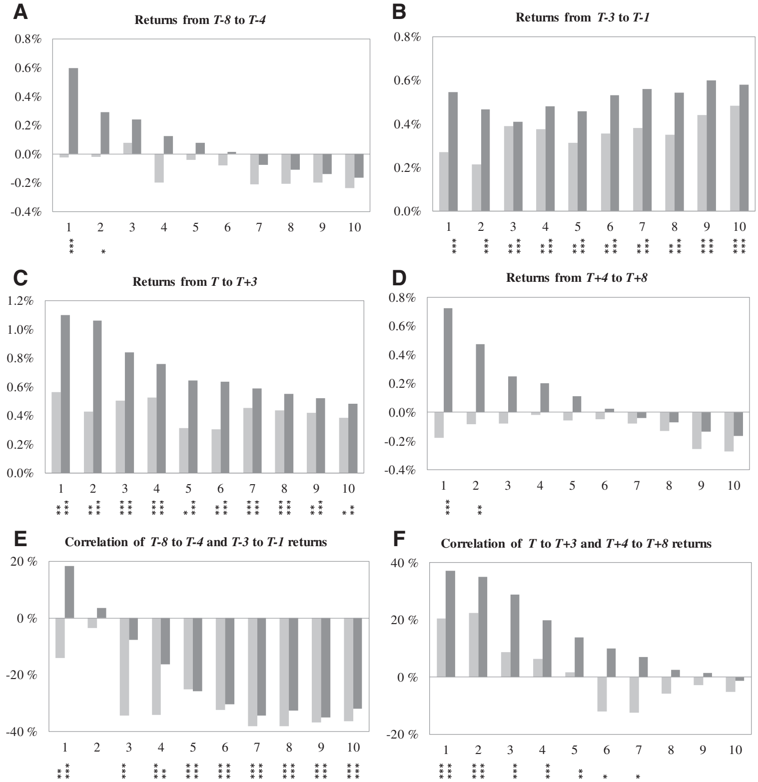

Figure 8
Impact of mutual fund holdings on turn of the month return patterns
This figure shows the value- (light gray) and equal-weighted (dark gray) average returns and selected correlations of returns around the turn of the month for deciles of stocks sorted on mutual funds' total ownership percentages in the previous month. The sample consists of all CRSP stocks from July 1995 to December 2013, and the decile portfolios are formed using the Thomson Reuters Mutual Fund Holdings database. Panel A documents the returns from $T-8$ to $T-4$, panel B the returns from $T-3$ to $T-1$, panel C the returns from T to $T+3$, and panel D the returns from $T+4$ to $T+8$. Finally, panel E shows the correlations between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns and panel F the correlations between T to $T+3$ and $T+4$ to $T+8$ returns in different mutual fund ownership deciles. 10=highest ownership decile, that is, stocks that have the highest mutual fund ownership. T refers to the last trading day of the month. $^{*}p<.1$; $^{**}p<.05$; $^{***}p<.01$.

correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns is more negative and statistically highly significant for the stocks that are more commonly held by mutual funds.[33,34]

[33] Figure A6 in the Internet Appendix shows that these patterns are even stronger if we use only institutional fund ownership percentages to form the decile portfolios. Institutional funds are defined as mutual funds with at least one share class marked as institutional.

[34] Taken together, our evidence suggests that mutual funds (as agents) and other institutions with month-end payment cycles are a major force behind the turn of the month phenomenon. It is therefore possible that the growth of the mutual fund industry as a proportion of total stock market capitalization may be linked to the *strengthening* of the turn of the month return patterns over time. Section 5 documents this result.

Next, we examine the impact of mutual fund flows on return reversals. More precisely, we calculate stock specific measures of expected buy and sell pressures due to flows based on the methodology of Lou (2012). First, each month we assume that the previous month's flows predict flows to all funds, and that those funds buy and sell securities in the same proportion that they own the stocks according to their latest holding data. We then aggregate the flow-induced buying and selling pressures across funds and normalize our flow pressure measures by the respective stocks' market capitalizations. Consistent with our price pressure hypothesis, we find that returns during the selling pressure period $T-8$ to $T-4$ are more than 3 times as negative for the three lowest flow pressure deciles of stocks (highest selling pressure stocks) compared to the three highest flow pressure deciles of stocks. Similarly, the correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns is nearly 50% more negative for those stocks. This evidence supports our selling pressure hypothesis for the observed month-end return patterns.

We also investigate the strength of the return reversals across countries. Figure 9 displays the correlations of $T-8$ to $T-4$ and $T-3$ to $T-1$ returns for different equity indices in our international sample against the percentage of market capitalization that is held by mutual funds within each country. It appears that the return reversals around $T-4$ are indeed larger in countries where mutual funds are more prevalent. Using regression analysis, we confirm that this negative relationship between mutual fund ownership and the degree of return reversals around $T-4$ is statistically significant at the 1% level (results are available upon request). The correlations presented in Figure 9 are negative for all country indices.[35]

4.3 Stock characteristics and turn of the month returns

If the behavior of sophisticated investors is indeed inducing patterns in turn of the month stock returns, these investors should at least be trying their best to avoid it. In other words, any month-end liquidity needs should be met with sales of liquid stocks, with minimal price impact and transaction costs. To investigate this hypothesis, we sort the stocks in the CRSP universe based on different characteristics that could be associated with transaction costs. Figure 10 shows the results.

Consistent with the notion that institutional investors seek to meet their liquidity needs with minimal transaction costs, we find that the correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns is most negative for liquid stocks and large cap stocks. The differences in correlations between extreme size and liquidity deciles are significant at 1% significance level. The return

[35] Note that the correlation is least negative in Finland. Interestingly, Finnish pension payments are not clustered at the month end. Until 2013, a significant part of pension payments was made in alphabetical order to pensioners throughout the month. See the Internet Appendix for further details.

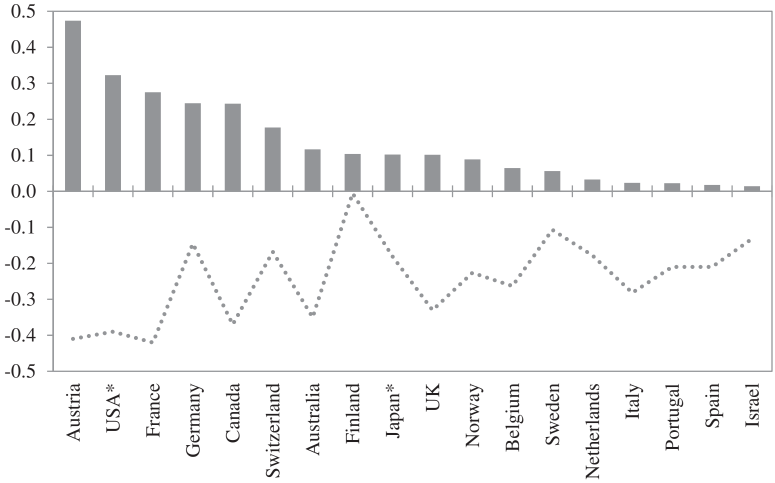

Figure 9
Mutual fund ownership and the correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns across countries
This figure shows mutual funds' domestic stock holdings as a percentage of total market capitalization (dark bar) and the correlations between $T-8$ to $T-4$ and $T-3$ to $T-1$ stock market returns for different countries (dotted line, reprinted from Table 2). Here, T refers to the last trading day of the month. The stock holdings percentage is an average of the annual observations from 2008 until 2012. Our sample includes all countries from Table 2 for which the relevant data are available from OECD's Institutional Investor Assets database. The total market capitalizations come from the World Bank. For some countries only total stock holdings (i.e., holdings including both domestic and foreign stock holdings) by mutual funds are available. Of these countries, we include the United States and Japan (denoted with stars in the figure) because of their large domestic equity markets. Denmark and Ireland, where only the mutual funds' total stock holdings are available, are excluded.

reversals of illiquid and small cap stocks are statistically insignificant.[36,37] ANcerno data also confirm that institutional investors are mainly selling liquid stocks between $T-8$ and $T-4$ (see Figure A8 in the Internet Appendix).

5. Other Evidence on Mutual Funds and Turn of the Month Price Pressures

5.1 Strength of return reversals over time

We use regression analysis to study whether there is a time-series relationship between the return reversals around $T-4$ and the size of the U.S. mutual fund industry. Our results, presented in Table 7, show that the size of the mutual fund industry normalized by stock market capitalization is indeed associated with the strength of market-wide return reversals: the interaction of the size of

[36] Furthermore, if the patterns we observe are due, in part, to mutual funds' eagerness to reduce risk near the month end, they should do so by reducing their holdings of risky but liquid stocks. Consistent with this intuition, we find that return reversals around $T-4$ are most pronounced for the most volatile, yet liquid stocks as shown in Figure A7 in the Internet Appendix.

[37] We find analogous results in the bond market where the return reversals are more pronounced for bonds of shorter maturities that typically command higher liquidity (see Table 4).

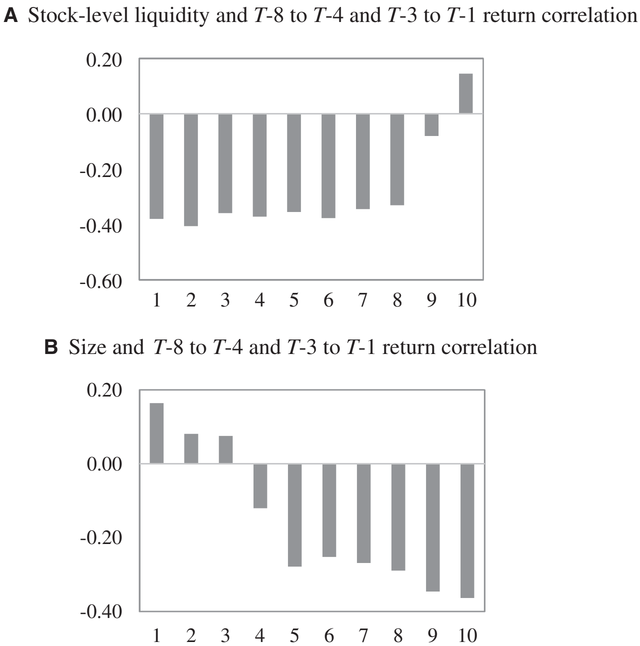

Figure 10
Stock-level liquidity, size, and turn of the month return patterns
Panel A shows the correlations between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns for stocks sorted into deciles based on their Amihud (2002) *ILLIQ* measure (the tenth being the most illiquid). Panel B shows the same correlations for stocks sorted into deciles based on their market capitalization (the tenth being the largest). Our sample, covering data from July 1995 to December 2013, includes all stocks in CRSP listed in the NYSE and the Amex (panel A), or all stocks from CRSP (panel B). The Amihud (2002) *ILLIQ* measure is calculated as a rolling 1-year average until the tenth trading day of the corresponding month. T refers to the last trading day of the month.

the mutual fund industry with $T-8$ to $T-4$ returns is negative and statistically significant (at 5% significance level) controlling for a linear time trend.

5.2 Mutual fund flow and market returns

To complement our direct evidence on the impact of institutional trading on month-end return reversals, we also investigate the impact of mutual fund outflows on stock index returns. Specifically, we regress U.S. stock market returns over the selling pressure period ($T-8$ to $T-4$) and over the reversal period ($T-3$ to $T-1$) on current month's mutual fund industry outflow up to those dates, controlling for past market returns. Mutual fund industry outflow is defined as the negative of the net flow to all mutual funds (equity, hybrid and bond funds) from the first Wednesday of the month until the last Wednesday before $T-8$ or $T-3$, when the net flow is negative, and zero otherwise (normalized by total stock market capitalization).[38] The results displayed in

[38] We use the aggregate flows to examine reversals in stock returns (and bond yields in the Internet Appendix) as they reflect, better than the flows within any single asset class, the investors' aggregate liquidity needs at month-end, which we expect to influence expected returns across all asset classes in equilibrium. The flows within one

Table 7
Impact of mutual funds' AUM on month-end return reversals

y = market returns from $T-3$ to $T-1$			
Market return ($T-8$ to $T-4$)	**−0.315**	0.627	0.627
	(−2.58)	(1.52)	(1.53)
Mutual fund industry AUM		0.043	0.048
		(1.51)	(0.32)
Interaction of mutual fund industry AUM and market return ($T-8$ to $T-4$)		−4.450	**−4.446**
		(−1.96)	(−1.98)
Linear trend			0.000
			(−0.03)
Intercept	**0.003**	0.006	0.006
	(2.55)	(−0.98)	(−0.31)
R^2	.150	.200	.200

This table shows the results from a regression of market index returns from $T-3$ to $T-1$ on $T-8$ to $T-4$ index returns, and on mutual fund industry AUM, and its interaction with the $T-8$ to $T-4$ index returns. T refers to the last trading day of the month. Mutual fund industry AUM is the sum of all domestic equity mutual funds' assets under management based on the CRSP mutual fund database, normalized by the U.S. total stock market capitalization. The index returns are those for the CRSP value-weighted index. The sample period ranges from July 1995 to December 2013. t-statistics based on Newey-West standard errors are shown below the coefficients. All figures statistically significant at the 5% level are displayed in bold.

Table 8 provide evidence that mutual fund flows significantly impact equity market returns at the turn of the month: a 1-standard-deviation increase in outflow (0.008%) predicts a 1.32 percentage point decrease in $T-8$ to $T-4$ returns and a 0.93 percentage point increase in $T-3$ to $T-1$ returns. These results lend additional support to our hypothesis that institutions' cash needs drive aggregate stock returns near the month end. Note the exceptionally high explanatory powers of these regressions, with R^2 up to 44%.

In Table A9, we also show that in the bond market the past mutual fund industry outflow significantly explains the $T-3$ to $T-1$ yield change for Treasury bonds, consistent with the price pressure hypothesis. Also here, the explanatory powers are considerable, up to 50% (40% when ignoring the effect of the dummy variables).

5.3 Mutual fund alphas and exposure to month-end return reversals

We present evidence that links the performance of equity mutual funds to their exposures to month-end return reversals. Our aim is to investigate whether funds that regularly sell equity prior to the month end (perhaps due to client-driven outflows and/or poor month-end liquidity management practices) suffer in terms of performance. Hence, the spirit of this investigation is similar to the study of the cost of institutions' month-end liquidity demand presented in Section 3.

Every month, we sort domestic equity funds by the trailing two-year correlation of their $T-8$ to $T-4$ and $T-3$ to $T-1$ returns. We find that the funds

individual asset class are influenced by existing price pressures in all the different markets as investors' selection of which long-term assets to liquidate at month end is endogenous to existing market conditions.

Table 8
Impact of mutual fund outflows on the turn of the month returns

A. Impact of outflow on T–8 to T–4 returns

	y = returns from $T-8$ to $T-4$	
Mutual fund industry outflow	**−190.00**	**−176.34**
	(−2.87)	(−2.55)
Past 20-day returns		0.052
		(0.53)
Intercept	0.001	0.000
	(0.28)	(0.10)
R^2	.189	.193

B. Impact of outflow on T–3 to T–1 returns

	y = returns from $T-3$ to $T-1$	
Mutual funds industry outflow	**212.51**	**136.43**
	(4.30)	(2.63)
$T-8$ to $T-4$ return		**−0.345**
		(−3.00)
Intercept	0.002	0.002
	(0.81)	(1.09)
R^2	.296	.437

This table shows the results from a regression in which the market index returns from $T-8$ to $T-4$ (panel A) or $T-3$ to $T-1$ (panel B) are regressed on the past market index returns, and on the mutual fund industry outflow. Here, T refers to the last trading day of the month. Mutual fund industry outflow (normalized by the U.S. total stock market capitalization) is defined as the negative of the aggregate net flow to mutual fund industry (equity, hybrid, and bond funds; see footnote 38 for motivation) from the first Wednesday of the month until the last Wednesday before $T-8$ (panel A), or until the last Wednesday before $T-3$ (panel B), when the net flow is negative, and 0 otherwise. Our weekly mutual funds' flow data come from Investment Company Institute, and the sample period ranges from January 2007 to December 2013. The index returns are those of the CRSP value-weighted index. t-statistics based on Newey and West (1987) standard errors are shown below the coefficients. All figures statistically significant at the 5% level are displayed in bold.

in the highest correlation decile have significantly higher alphas than those in the lowest correlation decile (see Table 9). In other words, funds that are less sensitive to month-end return reversals – due to better month-end liquidity management practices, fewer institutional clients, or other reasons – seem to perform better than others. Concretely, exposure to the market's return reversals *predicts* mutual fund performance.

In Table 10, we seek to better understand this relationship by investigating the characteristics of mutual funds within our correlation deciles. Consistent with our hypothesis that month-end liquidity needs drive fund behavior, we find that the funds in the highest correlation decile have the highest average cash holdings and may therefore depend less on stock sales to fulfill their month-end cash needs. These funds also have the lowest institutional ownership share, implying that they are less exposed to month-end liquidity related selling in the first place. Finally, we find that the funds in the highest correlation decile tend to generate higher returns not only during the turn of the month period but also on other days. In other words, their outperformance cannot be fully attributed to their returns at the turn of the month but they exhibit greater skill

Table 9
Mutual fund alphas and exposures to month-end return reversals

	Mutual fund deciles based on correlation of $T-8$ to $T-4$ and $T-3$ to $T-1$ returns										
	1	2	3	4	5	6	7	8	9	10	10-1
CAPM											
Alpha	−2.42%	−2.86%	−2.50%	−1.78%	−0.11%	0.67%	1.50%	3.17%	4.04%	4.84%	7.43%
	(−1.91)	(−2.93)	(−3.22)	(−2.58)	(−0.17)	(0.89)	(1.47)	(2.31)	(2.44)	(2.24)	(2.66)
$R_M - R_F$	1.07	1.13	1.10	1.09	1.06	1.02	1.01	0.99	0.95	0.84	−0.23
	(28.99)	(39.60)	(50.33)	(62.63)	(72.41)	(54.79)	(39.73)	(25.98)	(20.92)	(16.06)	(−3.38)
Fama-French 3-factor model											
Alpha	−2.48%	−2.65%	−2.56%	−2.10%	−0.90%	−0.51%	−0.11%	0.94%	1.39%	2.37%	4.96%
	(−2.16)	(−3.43)	(−3.84)	(−3.44)	(−1.77)	(−0.91)	(−0.16)	(0.96)	(1.18)	(1.41)	(2.37)
$R_M - R_F$	1.04	1.10	1.07	1.06	1.02	0.99	0.96	0.93	0.89	0.78	−0.26
	(28.24)	(52.87)	(65.45)	(79.97)	(85.45)	(69.12)	(50.45)	(35.54)	(27.10)	(16.85)	(−4.59)
SMB	0.13	0.12	0.14	0.16	0.19	0.20	0.25	0.29	0.33	0.34	0.21
	(2.59)	(3.78)	(3.71)	(5.46)	(8.84)	(8.68)	(9.87)	(8.56)	(8.88)	(5.79)	(2.93)
HML	−0.09	−0.13	−0.09	−0.06	0.01	0.07	0.11	0.20	0.24	0.20	0.29
	(−1.66)	(−3.71)	(−2.96)	(−2.11)	(0.35)	(2.03)	(2.57)	(3.36)	(3.40)	(2.26)	(2.32)
Fama-French 4-factor model											
Alpha	−2.51%	−2.63%	−2.56%	−2.13%	−0.91%	−0.58%	−0.16%	0.88%	1.28%	2.15%	4.76%
	(−2.13)	(−3.37)	(−3.79)	(−3.46)	(−1.78)	(−1.02)	(−0.22)	(0.87)	(1.05)	(1.24)	(2.18)
$R_M - R_F$	1.05	1.10	1.07	1.06	1.03	1.00	0.97	0.94	0.91	0.83	−0.22
	(26.74)	(46.11)	(51.41)	(62.28)	(66.89)	(54.65)	(43.32)	(30.11)	(23.68)	(15.86)	(−3.29)
SMB	0.13	0.12	0.14	0.16	0.19	0.20	0.25	0.29	0.33	0.34	0.21
	(2.60)	(3.74)	(3.67)	(5.44)	(8.78)	(9.13)	(10.11)	(8.81)	(9.55)	(6.17)	(2.92)
HML	−0.09	−0.13	−0.09	−0.06	0.01	0.07	0.11	0.20	0.24	0.19	0.28
	(−1.65)	(−3.71)	(−3.01)	(−2.19)	(0.34)	(2.03)	(2.56)	(3.32)	(3.38)	(2.27)	(2.30)
MOM	0.01	−0.01	0.00	0.01	0.01	0.03	0.02	0.02	0.04	0.09	0.08
	(0.26)	(−0.50)	(−0.03)	(0.62)	(0.33)	(1.49)	(1.03)	(0.81)	(1.42)	(2.97)	(1.57)

This table shows active domestic equity mutual funds' annualized alphas conditional on fund-specific trailing two-year correlations between the funds' $T-8$ to $T-4$ and $T-3$ to $T-1$ returns. More specifically, funds are divided into deciles every month based on this correlation. Alphas are calculated using the monthly returns of equal-weighted mutual fund portfolios controlling for standard risk factors with different versions of the following regression: $R_i - R_F = \alpha + \beta_M(R_M - R_F) + \beta_{SMB}R_{SMB} + \beta_{HML}R_{HML} + \beta_{MOM}R_{MOM} + \varepsilon$. Decile 10 contains the funds with the highest correlation in their $T-8$ to $T-4$ and $T-3$ to $T-1$ returns. Both daily and monthly mutual fund returns come from CRSP. The sample period ranges from September 2000 to December 2013. t-statistics are shown below the coefficients in parentheses.

also during the rest of the month. Nonetheless, their rate of outperformance is clearly higher during the last 8 trading days of the month.[39]

6. Limits to Arbitrage

6.1 Do hedge funds mitigate turn of the month return reversals?

In this section, we investigate the behavior of hedge funds near the month end, seeking for evidence on their ability to mitigate the predictable patterns

[39] We also study other fund characteristics often associated with performance (see, e.g., Cremers and Petajisto 2009) and find that the funds in our highest correlation decile are smallest by AUM, have the highest turnover and expense ratios, and the highest measured active shares (active share measures are described in Petajisto (2013) and downloaded from http://www.petajisto.net). Motivated by Frazzini, Friedman, and Pomorski (2016), we also find that the funds' exposure to month-end reversals is linked to their benchmark type: 12% of small cap funds benchmarked to Russell 2000 are in the highest correlation decile, whereas around 5% of large cap funds benchmarked to Russell 1000 or its value and growth variants are in this decile.

Table 10
Mutual fund characteristics and exposures to month-end return reversals

	Mutual fund deciles based on correlation of $T-8$ to $T-4$ and $T-3$ to $T-1$ returns										
	1	2	3	4	5	6	7	8	9	10	10-1
Trailing 2-year correlation of $T-8$ to $T-4$ and $T-3$ to $T-1$ returns											
Correlation	−0.45	−0.37	−0.34	−0.31	−0.29	−0.26	−0.23	−0.19	−0.14	−0.02	0.43
Annualized mutual fund return in excess of the risk-free rate											
$T-8$ through $T-4$	−4.51%	−5.25%	−5.01%	−4.79%	−4.44%	−4.04%	−3.87%	−3.32%	−3.09%	−1.99%	2.52%
$T-3$ through $T-1$	5.29%	5.25%	5.30%	5.62%	6.16%	6.13%	6.63%	7.06%	7.13%	6.91%	1.61%
Other days	0.87%	1.39%	1.43%	1.58%	2.30%	2.61%	2.72%	3.28%	3.76%	3.32%	2.45%
All days	1.35%	1.10%	1.38%	2.07%	3.65%	4.30%	5.07%	6.61%	7.32%	7.72%	6.37%
Mutual fund portfolio composition during the ranking month											
Cash-%	3.47%	3.03%	3.26%	3.28%	3.28%	3.19%	3.24%	3.53%	4.02%	6.57%	3.09%
Equity-%	91.77%	93.03%	93.11%	92.79%	93.42%	93.15%	93.26%	92.58%	91.77%	87.60%	−4.16%
Bond-%	0.62%	0.57%	0.54%	0.55%	0.57%	0.58%	0.65%	0.67%	0.66%	1.38%	0.76%
Other mutual fund characteristics											
Size	1,346	1,625	1,421	1,316	1,241	1,272	1,146	1,156	1,129	884	−462
Median size	251	293	275	259	252	242	239	232	212	193	−58
Active share	78.6%	74.7%	73.9%	73.9%	74.9%	76.0%	79.0%	81.2%	83.5%	87.9%	9.3%
Institutional fund	20.5%	25.3%	26.8%	27.7%	27.5%	27.2%	26.1%	24.4%	22.8%	18.3%	−2.2%
Turnover	113.7%	94.3%	92.0%	91.3%	93.3%	93.8%	93.4%	94.6%	98.2%	134.0%	20.3%
Expense ratio	1.37%	1.26%	1.24%	1.24%	1.26%	1.26%	1.29%	1.31%	1.35%	1.51%	0.14%

This table shows the active equity mutual funds' returns and characteristics conditional on fund-specific trailing two-year correlations between the funds' $T-8$ to $T-4$ and $T-3$ to $T-1$ returns. More specifically, funds are divided into deciles every month based on this correlation. *Annualized mutual fund return in excess of the risk-free rate* shows mutual funds' returns during specific days in the calendar month following the ranking month. *Mutual fund portfolio composition* shows the funds' portfolio composition (in %) at the end of ranking month using CRSP data. *Other mutual fund characteristics* shows mutual funds' size (in million USD) at the end of ranking month, funds' active share (using data downloaded from Antti Petajisto's Web page), share of funds' AUM with an institutional fund flag (CRSP), funds' turnover, and expense ratio during the ranking month. Decile 10 contains the funds with the highest correlation in their $T-8$ to $T-4$ and $T-3$ to $T-1$ returns. The daily returns and fund characteristics of active domestic equity mutual funds come from CRSP. The sample period ranges from September 2000 to December 2013.

in market returns. One would expect that speculators like hedge funds step in to trade on the significant systematic price distortions documented in Section 2. Our evidence is mixed. First, in Table 11, we show that the average market beta of hedge funds near the month end behaves similarly to the average beta of mutual funds (see Table 11; see also Table A8 in the Internet Appendix) and is smallest at $T-3$. This finding implies that hedge funds on average do not provide liquidity at $T-4$ to mutual funds that sell near the month end, contrary to what one might have expected.

One reason for the lack of appetite from hedge funds to systematically provide liquidity at $T-4$ may be related to the fact that their own redemption

Table 11
Hedge funds' liquidity provision around the turn of the month

	All funds	During high TED spread	During low TED spread	Global Macro	Managed Futures
$T-5$	**−0.114**	**−0.078**	**−0.044**	−0.031	**0.145**
	(−16.15)	(−8.90)	(−3.73)	(−0.75)	(4.12)
$T-4$	**−0.091**	**−0.111**	**−0.216**	−0.084	**0.082**
	(−12.71)	(−11.93)	(−19.20)	(−1.76)	(2.19)
$T-3$	**−0.025**	**−0.047**	**0.057**	**0.094**	**0.393**
	(−3.75)	(−5.66)	(4.29)	(2.05)	(9.63)
$T-2$	**−0.087**	**−0.142**	−0.004	−0.065	−0.041
	(−13.28)	(−15.16)	(−0.42)	(−1.88)	(−1.10)
$T-1$	**−0.062**	**−0.056**	**−0.071**	**0.082**	−0.048
	(−10.42)	(−8.81)	(−7.28)	(2.12)	(−1.08)
T	**−0.177**	**−0.244**	**0.054**	**−0.120**	**−0.128**
	(−21.29)	(−24.89)	(4.10)	(−2.47)	(−2.46)
$T+1$	**0.136**	**0.249**	**0.048**	0.037	**0.181**
	(20.69)	(30.66)	(5.13)	(0.96)	(4.58)
$T+2$	**0.259**	**0.381**	**0.176**	0.073	**0.249**
	(33.88)	(37.35)	(18.06)	(1.57)	(6.39)
$T+3$	**0.168**	**0.231**	−0.010	**0.112**	**0.109**
	(25.01)	(24.17)	(−1.09)	(2.47)	(2.43)
$T+4$	**0.103**	**0.069**	**0.107**	0.012	**−0.078**
	(16.30)	(8.17)	(12.25)	(0.29)	(−2.48)
$T+5$	**0.043**	**0.034**	**0.163**	0.006	−0.038
	(5.73)	(3.99)	(13.95)	(0.17)	(−0.93)
N	7,732	5,183	3,853	312	515

This table shows the hedge funds' average excess market betas around the turn of the month in selected hedge fund style categories and during low (below sample median) and high TED spread. T refers to the last trading day of the month. Hedge funds' average excess market betas are based on fund-specific regressions in which hedge fund's (monthly) return is regressed on the daily S& P 500 index returns around the turn of the month ($T-5$ to $T+5$) and the return on the S&P 500 index outside the turn of the month period. Excess market betas for any given fund are calculated as the difference of its estimated beta for any given day and its beta outside the turn of the month period. Hedge fund data come from TASS, and our sample period is from July 1995 to December 2013. t-statistics are shown below the coefficients. All figures statistically significant at the 5% level are displayed in bold.

and reporting dates are also commonly set at month ends. As a result, hedge funds are also facing liquidity needs that are concentrated near the month end, which may reduce their risk bearing capacity. Indeed, we find some support for this reasoning: the time-variation in betas near the month end seems to be more pronounced for those funds with less frequent redemption cycles (results available from authors). Therefore, it appears that the cash cycle affects the ability of hedge funds to take risk near the month end. In other words, arbitrage vehicles with month-end redemption cycles are ill-designed to provide liquidity at the month end. This result is consistent with Patton and Ramadorai (2013) who find that hedge fund risk exposures are high at the beginning of the month and low at the end of the month.[40,41]

[40] Patton and Ramadorai (2013) study day-of-the-month effects in hedge fund risk exposures by including a flexible parametric function in their regression specification.

[41] Our methodology to identify daily excess betas around the turn of the month from hedge funds' monthly returns follows the approach in Jylhä, Rinne, and Suominen (2014): we regress hedge funds' monthly returns on the

While on average the hedge fund industry does not seem to accommodate market-wide selling pressure near the month end, it is possible that a subset of hedge funds do so. Indeed, we study the behavior of different hedge fund strategies and find that Managed Futures and Global Macro funds have abnormally large positive exposures (betas) to the market on day $T-3$ (see Table 11). This implies that at least some hedge funds do provide liquidity at $T-4$, counterbalancing the selling pressure from other institutions.[42]

Furthermore, there is significant time variation in the average hedge fund's propensity to demand or supply liquidity around $T-4$. Specifically, we find that hedge funds on average supply liquidity at month ends (i.e., have a significant positive beta on $T-3$) when their funding liquidity, as measured by the TED spread, is good (below median), but significantly demand liquidity when the TED spread is high (above median). Interestingly, in times of high funding liquidity, hedge funds seem to increase their stock market betas exactly at $T-3$, implying that they purchase equity either at $T-4$ (which has historically been the best time to buy) or in the morning of $T-3$ (where our evidence indicates that the demand for month-end liquidity is still high). Only at times of poor funding liquidity does the hedge fund industry also become a demander of liquidity.

6.2 Funding constraints and turn of the month returns

Consistent with our finding that the ability of hedge funds to supply liquidity fluctuates with market-wide funding conditions, we find evidence that month-end return reversals get amplified when funding conditions are tight. Figure 11 illustrates this result by plotting $T-3$ to $T-1$ returns against $T-8$ to $T-4$ returns in a scatter plot that highlights the observations where the TED spread exceeds its 97.5th percentile. To complement this analysis, we show in the Internet Appendix that the interaction of the TED spread with $T-8$ to $T-4$ returns is a significant predictor of $T-3$ to $T-1$ returns. These findings lend support to the idea that funding constraints of institutional investors are an important contributor to return reversals around $T-4$. Note however, that the return reversals are statistically significant also if we exclude the extreme TED spread observations from our sample.[43]

Thus far, we have shown that month-end reversals are largest when there are large outflows from the mutual fund industry and the funding conditions of

daily returns on the S&P 500 index, for the days $T-5$ to $T+5$, and the return on the S&P500 index outside the turn of the month period. The funds' average excess beta on any given day around the turn of the month is the difference between the daily beta and the rest of the month beta.

42 The evidence regarding liquidity supply is especially strong for Managed Futures funds. This behavior is likely to be related to the low margin requirements (and $T+1$ settlement) of the futures and options contracts traded by these funds, which enable their managers to hold significant cash reserves at all times.

43 Similarly, the return patterns around $T-4$ documented in Tables 1 and 2 are robust to excluding from the sample the observations that coincide with NBER recessions and just the recent financial crisis (the high TED spread period). See Table A7 in the Internet Appendix.

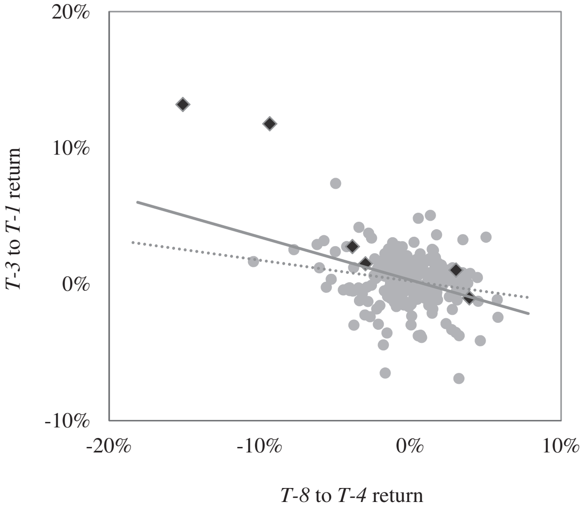

Figure 11
Correlation between $T-8$ to $T-4$ and $T-3$ to $T-1$ returns
This figure shows the scatter plot of $T-8$ to $T-4$ and $T-3$ to $T-1$ CRSP value-weighted index returns. Day T denotes the last trading day of the month. Observations from months where the TED spread (the difference between the 3-month Eurodollar and Treasury rates) exceeds its 97.5th percentile are shown in black. The solid (dashed) line represents the fitted regression line based on the full sample (sample excluding observations drawn in black). The slope of $T-8$ to $T-4$ returns is statistically significant at the 1% level in both regressions. The sample period ranges from July 1995 to December 2013.

hedge funds are tight. A perfect storm for mutual fund outflows and tightening of funding conditions occurred in October 2008, following the bankruptcy of Lehman Brothers. The entire mutual fund sector experienced vast unexpected outflows and institutions had to resort to equity markets to an unusual extent for month-end liquidity due to frozen short-term credit markets. The TED spread rose to record levels, reflecting extraordinary funding constraints for hedge funds. If our reasoning is correct, this environment should be associated with extremely poor returns during the selling pressure period $T-8$ to $T-4$ and extremely high returns during the following 3 days. In line with this expectation, following the Lehman crisis the $T-8$ to $T-4$ returns *over the following 6 months* were exceptionally poor (with cumulative returns approaching -35%) while the end of month rebound from the selling pressure was exceptionally high (cumulative returns approaching +30%). Figure A10 in the Internet Appendix demonstrates the large price pressures following the Lehman bankruptcy.

7. Conclusion

In this paper, we study the asset price implications of the monthly payment cycle. We show that the associated excess demand for cash at the month end predictably increases short-term borrowing costs and is associated with temporary decreases in equity and bond prices as institutions sell assets to raise cash. These repeated price pressures in equity and bond markets are significant from both statistical and economic perspectives.

To the best of our knowledge, we are the first to document a strong return reversal in equity and bond markets following the last day of the month that guarantees cash for month-end payments. This return reversal exists in the time series of U.S. stock and bond index returns, in the cross-section of U.S. stock returns, and in the time series of most developed stock market index returns. We verify that settlement practices *cause* the month-end reversals via a difference-in-differences test made possible by a concerted change in several countries' settlement practices in our international sample. We also link the reversal to the month-end cash cycle by demonstrating that the reversals are greater at those month ends where the monthly payment cycle coincides with the weekly payment cycle of salaries.

To shed further light on the underlying market dynamics, we present extensive evidence that associates the $T-4$ return reversals in equity markets with institutional investors' trading, and with hedge funds' limits to arbitrage. Our most direct evidence is based on ANcerno's institutional trade data, which reveal that institutions are on average net sellers up to $T-4$, but net buyers at the end of the month and on the first few days of the month. Indeed, we estimate that institutions are likely to incur significant costs from their liquidity-related trading at the month end. Moreover, using regression analysis, we demonstrate that these institutions' net sales on days $T-8$ to $T-4$ (normalized by stock market capitalization) significantly amplify the market-wide return reversals at the month end.

We also present additional, indirect evidence to support the idea that institutions' month-end liquidity needs contribute to return predictability. In particular, we show that the turn of the month return reversals are more pronounced among stocks that are more commonly held by mutual funds, and stocks that are arguably easier to use for cash management, such as large and liquid stocks. We also find that mutual fund flows up to $T-4$ significantly affect the size of the return reversals. At an aggregate level, we show that the return reversals near the turn of the month appear to have intensified as mutual funds' AUM as a proportion of the overall stock market has increased. Also in international samples, the return reversals seem to be more pronounced in countries with larger mutual fund sectors. Finally, we present evidence that mutual funds' return patterns around the turn of the month (which presumably reflect their skills to manage liquidity or other abilities) significantly predict their future alphas.

Our results contribute to the literature by tying the vast body of existing research on turn of the month return anomalies to rational models of markets with temporally segmented investors. In addition, our findings have significant practical implications for institutions that may currently mismanage their turn of the month liquidity related trading.

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