EXAMINING THE EXISTENCE OF THE CHARACTERISTIC LIQUIDITY PREMIUM

A STUDY OF THE U.S. STOCK MARKET

JOEL EJDESJÖ

MAXIME KARL MARCEL RUNDSTRÖM

Master Thesis

Stockholm School of Economics

2022

Examining the Existence of the Characteristic Liquidity Premium: A Study of the U.S. Stock Market

Abstract:

This paper examines the existence of a characteristic liquidity premium among U.S. stock returns between January 1964 and December 2021 after adjusting for transaction costs. Liquidity is estimated using four different measures in order to capture different dimensions of liquidity (price impact, trading cost, trading speed, and trading quantity). When constructing long-short portfolios double-sorted on size and liquidity we find evidence of a liquidity premium among small stocks, with average gross alphas in the range of 0.85%-1.13% for NYSE depending on the specific liquidity measure used. For small stocks, the liquidity premium is found to be persistent across all subperiods considered. This holds true for all proxied dimensions of liquidity, except for trading cost for which long-short portfolios are generally found to generate negative alphas. We find adjusting for transaction costs to have limited impact on the magnitude or significance of the portfolio alphas. Standard transaction cost mitigation strategies are generally found to be inefficient in taking advantage of the liquidity premium as the reduction in transaction cost is outweighed by a reduction of the exposure to the underlying liquidity signal.

Keywords:

Characteristic liquidity premium, liquidity dimension, low-frequency effective spread, transaction cost mitigation, net returns alpha

Authors:

Joel Ejdesjö (24218)
Maxime Karl Marcel Rundström (24111)

Tutors:

Tobias Sichert, Assistant Professor, Department of Finance*

Examiner:

Paolo Sodini, Professor, Department of Finance

Master Thesis
Master Program in Finance
Stockholm School of Economics

* **Acknowledgements**: We would particularly like to thank our supervisor Assistant Professor Tobias Sichert for his helpful comments and valuable suggestions.

Contents

1. Introduction

Despite being one of the most well-recognized and studied concepts in the finance literature, the nature and the importance of a liquidity premium is greatly debated. Originating from the research of Amihud & Mendelson (1986), the concept that liquidity has a significant effect on asset prices is broadly accepted and influences conclusions regarding valuation, market efficiency and corporate finance. It is standard practice for illiquid assets (for example private equity) to be priced by benchmarking these assets to comparable liquid assets (for example public equity) and then applying a liquidity discount. Concerning public equity, there is great debate regarding the magnitude of a *characteristic* liquidity premium, that is the premium associated with the cost of trading a security, as defined by Ben-Rephael et al. (2015). Liquidity premium is often estimated as the alpha generated from a trading strategy taking a long position in illiquid stocks and short position in liquid stocks. Several papers have found evidence of the existence of a characteristic liquidity premium, albeit of different magnitudes (Amihud & Mendelson (1986), Constantinides (1986), Vayanos (1998), Pastor & Stambaugh (2003), Ben-Rephael et al. (2015) and Chen & Zimmermann (2020)). However, these papers are limited to examining gross alpha, and thus only present an upper bound on the profitability of such trading strategies, which may not provide a full picture of the development of the liquidity premium over time. Little research has been conducted examining the returns of liquidity strategies post transaction costs, and often only briefly as part of papers examining dozens of other anomalies (Chen & Velikov (2021)). Furthermore, recent research has shown that when taking transaction costs into account, the majority of previously thought to be positive alpha strategies have failed to generate alphas on a net return basis (Novy-Marx & Velikov (2016), Chen & Velikov (2021)).

Our paper contributes to the debate by examining if prior conclusions regarding the liquidity premium hold after taking transaction costs into account. That is, we try to answer the question "*Is there a characteristic liquidity premium on the U.S. stock market and does it persist after taking transaction cost into account?*" To do this, we examine the size of alphas generated by long-short liquidity portfolios over time. Intuitively, transaction costs should be substantial for illiquid stocks, and should thus be considered when examining alpha of liquidity-based strategies. We also consider the possibility for investors to employ transaction cost mitigation strategies, and how this affects the size of alpha. Finally, by evaluating a more recent sample of stocks and making use of the Fama & French (2015) five-factor asset pricing model, which has remained largely untested in a liquidity setting, our paper adds additional robustness to the prior literature.

We perform an empirical analysis based on a dataset of listed stocks on the main US stock exchanges (NYSE, NASDAQ and AMEX) between January 1964 and December 2021. In order to capture different dimensions of liquidity we calculate four different market-based proxies, based on the methodology in the original papers: IMPACT (Amihud (2002)), COST (average of four different measures; (Hasbrouck (2009), Corwin and Schultz (2012), Abdi & Ranaldo (2017), and Kyle and Obizhaeva (2016)), SPEED (Liu (2006)) and QUANTITY (Datar et al. (1998). Each month, we sort stocks based on their liquidity into five quintile portfolios, separately for each stock exchange. This is repeated for each liquidity measure. Following this, we characterize the liquidity premium using a long-short trading strategy where we take a long position in the least liquid stocks and short the most liquid stocks. In doing this, we follow an approach similar to Ben-Rephael et al. (2015) and other papers before them (Brennan et al. (1998), Chordia et al. (2001) and Liu (2006)). We risk-adjust our portfolio returns with the Fama-French four-factor model that includes a momentum factor proposed by

Carhart (1997) as well as the Fama & French (2015) five-factor model. Net returns are determined by adjusting gross returns using an effective spread transaction cost proxy derived from daily trading data, as per the approach used in Chen & Velikov (2021). Following this, and similar to Novy-Marx & Velikov (2016), we consider three different cost mitigation strategies: (1) limiting the sample of stocks each month to the lowest cost tercile, (2) staggered partial rebalancing, and (3) a buy/hold spread of 20%/40%.

We find that our IMPACT, COST and SPEED long-short portfolios do not generate any significant positive alphas when considering the entire sample as a whole, indicating there is no characteristic liquidity premium applicable to all stocks. When we double sort our portfolios on size and liquidity, we do however observe positive and significant gross average alphas for smaller stocks on NYSE and small and medium stocks on NASDAQ. This is in line with the prior literature (e.g. Ben-Rephael et al. (2015), Liu (2006)). Adjusting for transaction costs, we find that these only have a limited impact on the magnitude and significance level of alphas. Hence, we fail to find a risk-based explanation and our results suggest the presence of a liquidity premium that is persistent even when taking transaction costs into account. In contrast, for our COST long-short portfolios we consistently obtain negative alphas across all size groups, which indicates that the dimension of liquidity this measure proxies is priced differently. Generally, the alphas for NASDAQ are on average 1-2 percentage points larger. This indicates the presence of a liquidity premium on NASDAQ of a larger magnitude than on NYSE, in line with the findings of Ben-Rephael et al. (2015).

When analyzing our portfolios over time, we split our sample period in five for NYSE/AMEX stocks and in three for NASDAQ. We find that for small stocks, the IMPACT, SPEED and QUANTITY based portfolios generate significant and positive alphas for all subperiods. As such, we find no evidence of a diminishing liquidity premium. Our results are in line with those of Liu (2006), while contrasting the results of Ben-Rephael et al. (2015) which find a diminishing liquidity premium. However, the paper of Ben-Rephael et al. (2015) does not include the most recent 2012-2021 data.

Generally, the implementation of cost mitigation strategies is found to severely reduce the exposure of the portfolio to the underlying signal. This indicates standard cost mitigation strategies are not suitable when forming long-short liquidity portfolios. The exception to this is the low-cost strategy for NASDAQ stocks, as the reduction in transaction costs outweighs the loss of signal exposure. As such, when implemented, the strategy ameliorates the profitability of the long-short portfolios.

The remainder of the paper is organized as follows: In section two, we describe the closest literature related to our topic and discuss the current findings. We also consider the different measures available to proxy liquidity and explain our contribution to the literature. In section three, we present our data sources, variable construction, and methodology. In section four, we analyze and report the results of the empirical analysis performed. In section 5, we conclude and discuss the implications of our findings.

2. Literature review

The definition of liquidity itself is commonly defined in the literature as *"the ability to trade large size quickly, at low cost, when you want to trade"* (Ben-Rephael et al. (2015)). Several studies have examined the relationship between asset returns and liquidity. Generally, illiquid

assets have been found to have higher returns than what can be expected from standard asset pricing models. This asset pricing phenomenon has become famous as the liquidity premium.

When considering public equity, the debate in the literature regarding the nature and magnitude of the liquidity premium is still ongoing. Amihud & Mendelson (1986) assume that "the liquidity premium is proportional to the present value of transaction costs multiplied by an exogenous trading frequency." They conclude that the liquidity premium is of significantly greater importance than the magnitude of any transaction costs. Employing a different method, Constantinides (1986) and Vayanos (1998) make use of models where the trading frequency is endogenized and find that the liquidity premium is "second order" and thus difficult to identify empirically. Adding to the debate, a number of more recent studies argue that certain stocks are more susceptible to market liquidity shocks, and that this sensitivity is priced (Pastor & Stambaugh (2003), Acharya & Pedersen (2005), Charoenrook and Conrad (2008), Sadka (2006), Korajczyk & Sadka (2008), Abdi & Ranaldo (2017)). As a result, we make use of the definitions of Ben-Rephael (2015) and differentiate between two kinds of liquidity premiums: (1) a characteristic liquidity premium associated with the transaction cost of trading in the security, and (2) a systematic liquidity premium, associated with the sensitivity of the stock returns to shocks in market liquidity.

Given the different dimensions of liquidity, a multitude of measures have been proposed when examining the characteristic liquidity premium (e.g Amihud & Mendelson (1986), Datar et al. (1998), Chordia et al. (2001), Amihud (2002), Liu (2006), Goyenko et al. (2009), Hasbrouck (2009) and Abdi & Ranaldo (2017)). Given this, Liu (2006) defined four types of measures each proxying for a separate dimension of liquidity: price impact (sensitivity of returns to traded volume), trading cost (costs incurred when purchasing or selling securities), trading speed (the continuity of trading) and trading quantity (volume of shares traded). Several other papers have published papers comparing measures and detailing their usefulness in proxying different aspects of liquidity (e.g. Goyenko et al. (2009) and Hasbrouck (2009)). Still, little consensus has been reached on what measures to use.

Given the multitude of liquidity measures in play, a significant characteristic liquidity premium has been identified among U.S. stocks using a wide array of different measures (e.g. Eleswarapu (1997), Brennan et al. (1998), Amihud (2002) and Chordia et al. (2009)). Datar et al. (1998) find that stock returns are strongly negatively related to their turnover rates. Amihud (2002) shows that expected market illiquidity as proxied by a price impact measure (absolute return in relation to traded volume) positively affects ex ante stock excess return. Liu (2006) proposes a liquidity measure based on zero trading days and finds a robust and significant liquidity premium over his sample period 1963-2003. His measure captures the trading speed dimension of liquidity, in contrast to previous literature which have focused on trading cost, trading quantity and price impact. Ben-Rephael et al. (2015) form long-short portfolios rebalanced yearly based on three different liquidity measures and find that the characteristic liquidity premium has decreased since the 1980s and is largely non-existent in the most recent period examined (2000-2011) except for the smallest stocks on NASDAQ.

The study of the liquidity premium based on liquidity-based trading strategies is often limited to gross alphas. The size of these gross alphas can only be viewed as an upper bound for the profitability of such strategies. Additionally, recent research indicates that alphas may substantially decrease when considering transaction costs. Novy-Marx & Velikov (2016) study the performance of 23 pricing anomalies after taking trading costs into consideration and find as a result that five of them yield negative net alphas, while the significance level of the other

positive alphas is greatly reduced. For several anomalies, this can however be limited by employing standard cost mitigation strategies aimed at reducing portfolio turnover.
In this paper, our goal is to make progress on verifying the existence and magnitude of the characteristic liquidity premium after taking transaction costs into account. When it comes to portfolio formation and determining gross alpha, we follow a similar methodology as Ben-Rephael et al. (2015). When adjusting gross alphas to get net alphas we follow the methodology in Novy-Marx & Velikov (2016). We follow the conventional approach of benchmarking against the Fama-French four-factor model but differentiate our study by also including the more recent Fama & French (2015) five-factor model. Largely untested in the liquidity premium literature, this newer model may offer some further insights. Additionally, we examine the liquidity premium in the most recent subperiod possible, 2012-2021, in order to confirm if the trend is still a decreasing one. Given the variety of different liquidity measures, we make use of four different ones to capture different dimensions of liquidity.

3. Data, variable construction, and methodology

3.1. Raw data and filtering

We collect data from the Center for Research in Security Prices (CRSP). This includes daily data for stock returns, trading volume, opening prices, and closing prices. In terms of monthly data, we collect number of shares outstanding and stock return. The variables are selected in order to be able to calculate our chosen liquidity measures and value-weighted portfolio returns. We limit our dataset to the main US stock exchanges: New York Stock Exchange (NYSE), American Stock Exchange (AMEX) and NASDAQ. We limit our sample to the period January 1964 to December 2021 for NYSE and AMEX in order to allow for comparison across these two exchanges, since data is only available from 1964 for AMEX. For NASDAQ the sample period is January 1986 to December 2021. Our initial sample comprises approximately 32,988 unique stocks and 4,204,131 stock-month observations. Monthly asset pricing data for the Fama-French four- and five-factor model are sourced from Kenneth R. French´s Data Library.

To ensure reliability and to minimize the impact of noise in our estimations we apply a number of filters to our initial sample. We only consider common stocks which are also the primary traded security of their respective company. Following Abdi & Ranaldo (2017), we discard stock-month observations if a change of the primary stock exchange occurs. Observations are also excluded if there is a larger stock split, dividend or share repurchase, as determined by a change of 20% or more in the cumulative price adjustment factor from CRSP (CFACRP). Furthermore, we follow the method of Ben-Rephael et al. (2015) and only keep stocks that satisfy the following three requirements: (1) The stock has return data for at least 60 trading days during the year, (2) the stock is listed at the end of the year, and (3) the stock has a year-end price that is higher than $2. The reason to exclude stocks below a certain price level is because the minimum tick of $1/8 affects the returns of these stocks in a disproportionate manner than market forces otherwise would.[1] In addition to this, we follow Liu (2006) and require stocks to have values for daily price and traded volume for a period of 12 months in a row before being included.

[1] The addition of noise to the estimation due to the effect of a minimum tick is discussed in Harris (1994). As a result, applying filters to discard stocks below a certain price level is commonly used, see for example Amihud (2002), Acharya and Pedersen (2005), Kamara et al. (2008), and Ben-Rephael et al. (2015). When implementing A stricter minimum price filter, such as those in Amihud (2002), the observed liquidity premium decreases in magnitude. This is a result of excluding a higher number of small and illiquid stocks, which often have a lower stock price.

Our final sample consist of 23,820 unique stocks and 2,780,544 stock-month observations. To get a sense of the significance of our sample for each stock exchange, we calculate the total end of year market cap of the companies in our final sample and divide this value with the total market cap of the stock exchange. Table 1 provides details of our sample for each year. The number of stocks on NYSE ranges between 1,145-1,846 while being fairly constant over time. In contrast, the number of AMEX and NASDAQ stocks in the sample is decreasing over time, which is in line with the reduction of listed stocks on these exchanges during the same time period. The share of total market cap is on average 80% and never drops below 72% for NYSE. The corresponding numbers are 82% and 62% for AMEX, and 62% and 37% for NASDAQ. We conclude that the restrictions applied do not drastically reduce the universe of stocks considered and that our sample reflect a fair portion of the overall market during the sample period considered.

Table 1.

Number of Stocks and Share of Total Market Capitalization by Year

This table lists the total number of unique stocks in our final sample as well as the share of total market cap for each year and per stock exchange (NYSE, AMEX, and NASDAQ). The share of total market is computed as the end-of-year total market capitalization of the stocks in our sample divided by the total market capitalization of firms listed on that stock exchange. All calculations are based on the number of common stocks outstanding. The sample period is 1964-2021 for NYSE & AMEX and 1986-2021 for NASDAQ.

	NYSE		AMEX		NASDAQ	
Year	Number of stocks	Share of total market cap	Number of stocks	Share of total market cap	Number of stocks	Share of total market cap
1964	1,145	72%	813	84%		
1965	1,176	72%	830	87%		
1966	1,204	77%	848	88%		
1967	1,212	76%	851	87%		
1968	1,182	77%	858	85%		
1969	1,196	76%	877	83%		
1970	1,246	76%	953	82%		
1971	1,266	77%	992	85%		
1972	1,323	77%	1,042	83%		
1973	1,374	74%	1,088	86%		
1974	1,406	79%	1,083	89%		
1975	1,402	79%	1,029	91%		
1976	1,413	78%	985	89%		
1977	1,432	78%	951	90%		
1978	1,425	79%	884	94%		
1979	1,416	81%	826	88%		
1980	1,413	80%	779	85%		
1981	1,407	81%	756	80%		
1982	1,403	83%	747	77%		
1983	1,371	83%	721	87%		
1984	1,379	81%	707	87%		
1985	1,362	83%	679	86%		
1986	1,332	84%	659	82%	3,500	87%
1987	1,326	84%	642	82%	3,785	86%
1988	1,347	84%	679	84%	4,027	87%
1989	1,291	84%	663	87%	3,840	87%
1990	1,288	85%	630	90%	3,699	84%
1991	1,319	85%	619	90%	3,571	81%
1992	1,391	83%	620	85%	3,611	79%
1993	1,484	83%	612	88%	3,636	74%
1994	1,572	85%	604	88%	4,083	74%
1995	1,632	82%	563	76%	4,322	68%
1996	1,700	82%	544	77%	4,477	65%
1997	1,818	85%	542	78%	4,826	61%
1998	1,846	80%	562	79%	4,750	55%
1999	1,807	76%	549	85%	4,317	37%
2000	1,705	77%	532	78%	4,096	44%
2001	1,565	75%	530	74%	3,950	52%

Table 1. (continued)

Number of Stocks and Share of Total Market Capitalization by Year

Year	NYSE		AMEX		NASDAQ	
	Number of stocks	Share of total market cap	Number of stocks	Share of total market cap	Number of stocks	Share of total market cap
2002	1,489	75%	494	72%	3,438	51%
2003	1,473	76%	464	72%	3,066	53%
2004	1,456	78%	441	62%	2,858	55%
2005	1,444	77%	445	73%	2,799	56%
2006	1,423	79%	439	86%	2,745	59%
2007	1,402	77%	430	77%	2,712	57%
2008	1,367	79%	409	81%	2,672	54%
2009	1,304	77%	340	90%	2,540	55%
2010	1,301	79%	269	89%	2,389	57%
2011	1,298	82%	252	85%	2,278	56%
2012	1,279	80%	234	95%	2,158	54%
2013	1,282	82%	208	63%	2,080	58%
2014	1,303	83%	194	63%	2,081	58%
2015	1,330	82%	205	68%	2,142	57%
2016	1,296	83%	193	76%	2,133	54%
2017	1,263	85%	176	74%	2,080	52%
2018	1,234	85%	175	93%	2,078	51%
2019	1,227	85%	160	95%	2,110	51%
2020	1,209	84%	150	67%	2,163	45%
2021	1,228	84%	144	65%	2,308	44%

3.2. Measuring liquidity

In order to capture different dimensions of liquidity we calculate four different market-based proxies, based on the methodology in the original papers: IMPACT (Amihud (2002)), COST (Hasbrouck (2009), Corwin and Schultz (2012), Abdi & Ranaldo (2017), and Kyle and Obizhaeva (2016)), SPEED (Liu (2006)) and QUANTITY (Datar et al. (1998)). Following Liu (2006), we calculate our liquidity measures on a rolling basis. This enables us to obtain a liquidity proxy for each stock-month observation. We opt for a periodicity of 12 months, the most suitable option determined by Liu (2006), to encompass all trading data in a year. This is of significant importance for highly illiquid stocks, as their trading volume may be very low or even non-existent for larger periods of a year. Our measures are calculated using daily data instead of intraday data, which is lacking before the 1980s. Still, similarly constructed measures have been found to be highly correlated with high-frequency benchmarks using intraday data (Goyenko et al. (2009) and Hasbrouck (2009)). A summary of our chosen liquidity measures can be found in Table 2, while a more detailed description of the construction of each measure can be found in each respective sub-section below.

Table 2.

Overview of Liquidity Measures

This table presents our chosen liquidity measures IMPACT, COST, SPEED and QUANTITY. For each measure, references to the original papers used to construct the measures are included as well as a summarizing description. The last column indicates which liquidity dimension each liquidity measure relates to, based on the liquidity dimensions defined by Liu (2006).

Liquidity measure	Reference papers	Description	Primary liquidity dimension
IMPACT	Amihud (2002) Ben-Rephael et al. (2015)	Modified version of the Amihud (2002) price impact measure adjusted for inflation.	Price impact
COST	Hasbrouck (2009) Corwin and Schultz (2012) Kyle and Obizhaeva (2016) Abdi & Ranaldo (2017)	Average of four low-frequency effective bid-ask spread proxies	Trading cost
SPEED	Liu (2006)	Liquidity measure based on daily zero trading days with a turnover adjustment following Liu (2006)	Trading speed
QUANTITY	Datar (1998) Chordia et al. (2001)	Liquidity measure based on traded volume of shares as a fraction of shares outstanding	Trading quantity

3.2.1. IMPACT

Our first measure is a version of the Amihud (2002) measure that is adjusted for inflation. The measure is a proxy for the price impact of trading volume. We adjust for inflation following the method in Ben-Rephael et al. (2015), as the economic meaning of $1 has changed substantially during the last decades. This is especially important given our longer sample period. In fact, from the start of our sample period (January 1964) to the end (December 2021), the Federal Reserve Bank of St. Louis estimate the U.S. CPI to have increased by approximately 805%. Following a similar method as Amihud (2002), for each year of our sample, we discard the upper and lower 1% of the distribution of IMPACT to avoid outliers.

Formally, IMPACT for stock i in month t is denoted by $IMPACT_{i,t}$ and is given by:

$$IMPACT_{i,t} = \frac{1}{D_{iy}} \sum_{d=1}^{D_{it}} \frac{\left|R_{idy}\right|}{VOLD_{idy} \cdot INF_{dt}} \tag{1}$$

where R_{idt} is the return on stock i on the day d of the prior twelve month period y, $VOLD_{idy}$ is the respective daily dollar volume of stock i on day d of the prior twelve month period y, D_{iy} is the number of days for which trading data are available for stock i in the prior twelve month

period y and INF_{dt} is an inflation adjustment factor using end-of-2011 prices[2]. It is important to note that days with zero trading volume are not included in the calculation of the measure, while days with zero returns associated with a non-zero volume are included.

3.2.2. COST

As our second liquidity measure, we make use of an average of low frequency effective spread proxies following the methodology of Chen & Velikov (2021). As such, it is a proxy for the trading cost dimension of liquidity. Instead of choosing one single specific measure, we opt to use a simple average of four different measures[3]. The four measures we use are Hasbrouck (2009)'s Gibbs estimate, Corwin & Schultz (2012)'s high-low-spread, Abdi & Ranaldo (2017)'s close-high-low spread, and Fong et al. (2017)'s implementation of Kyle & Obizhaeva (2016)'s invariance-based volume-over-volatility measure. The reason for using a simple average is that the predictive power of a specific measure may vary across observations, and using multiple measures average out these errors. There is also a wide abundance of effective spread proxy measures to choose from, in contrast to measures of the other liquidity dimensions for which the measures and units of these measures vary. Furthermore, using a simple average method commonly performs better than single measure estimates in a wide variety of settings (Timmermann (2006)). Indeed, Chen & Velikov (2021) find that this method matches high-frequency benchmark data better than any single low-frequency proxy on their own.

Gibbs estimate

The Gibbs estimate is an implementation of the Roll (1984) estimator of the effective spread using a Gibbs sampler following the methodology in Hasbrouck (2009). The rationale behind this proxy is the "bid-ask bounce" phenomenon, in which trades initiated by buyers tend to happen at higher prices than those initiated by seller.

Formally, the effective spread for stock i on day t is denoted by $S_{i,t}$ and is given by

$$S_{i,t} = 2\sqrt{-Cov(\Delta P_{i,t}\Delta P_{i,t-1,})} \tag{2}$$

where $P_{i,t}$ is the last observed trade price and $Cov(\Delta P_{i,t}\Delta P_{i,t-1,})$ is the serial covariance of $\Delta P_{i,t}\Delta P_{i,t-1,}$.

First, $V_{i,t}$ is defined as the unobservable fundamental value of stock *i* on day *t* below

$$V_{i,t} = V_{t-1} + e_{t,} \tag{3}$$

where $e_{t,}$ denotes the mean-zero, serially uncorrelated public information shock on day *t*.

[2] End-of-2011 prices are used in order to make results directly comparable with prior literature (e.g. Ben Rephael, 2015)

[3] When data is missing for some measures, we use the average of the remaining measures. For example, data is missing för the high-low spread and close-high-spread for NASDAQ stocks prior to 1993. Transaction cost data for the low-frequency effective spread proxies are obtained from Andrew Y. Chen's personal website to complement our own calculations.

Then we define the last observed trade price P_t on day *t* as

$$P_{i,t} = P_t + \frac{1}{2} S Q_{i,t} \tag{4}$$

Where S denotes the effective spread and $Q_{i,t}$ is an indicator for the last trade for stock *i* that equals to +1 if a buy trade and –1 if a sell trade. $Q_{i,t}$ is then assumed to be serially correlated, which means it is equally likely to be +1 or –1, and independent of $e_{t,}$. Eq. (3) and Eq. (4) is then merged which gives us

$$\Delta P_{i,t} = \frac{1}{2} S \Delta Q_{i,t} + e_{t,} \tag{5}$$

where Δ denotes the change operator. Roll then demonstrates that the serial covariance is

$$Cov(\Delta P_{i,t} \Delta P_{i,t-1,}) = \frac{1}{4} S^2 \tag{6}$$

which then equals Eq. (2) after rearrangement. Finally, Hasbrouck (2009) assumes that $e_{t,}$ is normally distributed with a mean equal to zero and variance equal to σ_e^2. The half spread $\frac{1}{2}$S and variance σ_e^2 is then estimated numerically using the Gibbs sampler. The Gibbs estimates are calculated from 12-month samples of daily data.

High-low-spread

The high-low spread is an estimate of the Roll (1984) model from daily high and low prices, which we calculate following the approach in Corwin & Schultz (2012). The spread estimator is presented in Eq. (7) below:

Formally, HL for stock i in month t is denoted by $HL_{i,t}$ and is given by:

$$HL_{i,t} = \frac{2(e^{\alpha} - 1)}{1 + e^{\alpha}} \tag{7}$$

where $HL_{i,t}$ is the monthly average of the daily effective spreads for stock *i* in month *t*, *e* is the mathematical constant, α, β and γ is calculated as shown in equations (8), (9) and (10) below:

$$\alpha = \frac{\sqrt{2\beta} - \sqrt{\beta}}{3 - 2\sqrt{2}} - \sqrt{\frac{\gamma}{3 - 2\sqrt{2}}} \tag{8}$$

$$\beta = E\left\{\sum_{j=0}^{1}\left[ln\left(\frac{H_{d+j}^0}{L_{d+j}^0}\right)\right]^2\right\} \tag{9}$$

$$\gamma = E\left\{\left[ln\left(\frac{H_{d+j}^0}{L_{d+j}^0}\right)\right]^2\right\} \tag{10}$$

where H_{t+j}^0 and L_{t+j}^0 is the observed high and low stock prices on day d. Eq. (8) denotes the difference between the adjustments of a single day and two-day period, (9) represents the adjustments of the daily high and low price to the high price and (10) calculates the two-day period high and low-price adjustments.

Volume over volatility

Volume over volatility is based on the microstructure invariance hypothesis of Kyle & Obizhaeva (2016). The idea behind this measure is that markets for different assets run at different speeds ("business time") and their hypothesis is that the distribution of transaction costs is the same across assets and time periods. This leads us to the result that the bid-ask spread is proportional to the right-hand side of Eq. (11) below.

Formally, VoV for stock i in month t is denoted by $VoV_{i,t}$ and is given by:

$$VoV_{i,t} = \frac{8.0\sigma^{\frac{2}{3}}}{DVOL^{\frac{1}{3}}} \tag{11}$$

where $VoV_{i,t}$is Fong et al's (2017) implementation of the volume over volatility proxy for the effective spread for stock *i* in month *t*, σ is the standard deviation of daily returns, and *DVOL* is the mean real daily dollar volume (nominal dollar volume is converted using to real dollar volume using CPI). The coefficient of 8.0 is chosen by Fong et al. (2017) to fit the average TAQ effective spread in their U.S. Sample. The exponents $\frac{2}{3}$ and $\frac{1}{3}$ are predictions of the invariance hypothesis of Kyle & Obizhaeva (2016).

Close-high-low spread

Next measure is Abdi and Ranaldo's (2017) Close-High-Low. This is a newer method that estimates the effective bid-ask spread jointly on daily close, high, and low prices. Comparing this measure to other low frequency effective spread estimates, Abdi & Ranaldo (2017) show that this measure generally provides the highest cross-sectional and average time-series correlations with the TAQ effective spread benchmark. What is of special note for our analysis is that it is shown to deliver the most accurate estimates for the less liquid stocks.

Formally, CHL for stock i in month t is denoted by $CHL_{i,t}$ and is given by:

$$CHL_{i,t} = \frac{1}{D_{iy}} \sum_{d=1}^{D_{iy}} \hat{s}_d, \qquad \hat{s}_d = \sqrt{max\{4(c_d - \eta_d)(c_d - \eta_{d+1}), 0\}} \tag{12}$$

where D_{iy} is the number of days for which trading data are available for stock *i* in the prior twelve month period y and $\hat{s}_d$ refers to the two-day estimates. The two-day estimates themselves are calculated based on the log of daily closing prices (c_d) and the log of the mid-range, defined as the average of daily high and low prices ($\eta_d = (l_d + h_d)/2$).

We use the so called two-day corrected version of the measure, which was determined to have higher correlation with the high-frequency benchmark Abdi & Ranaldo (2017). This means that when calculating CHL, we follow three steps. As a first step, we calculate estimates of squared spreads over two-day periods. Negative estimates are set to zero. Next, we calculate the square roots of the estimates. Finally, we average this measure over the prior rolling twelve-month period.

3.2.3. SPEED

Our third measure is Liu's (2006) measure calculated over the prior twelve months. It is a liquidity measure based on the number of zero trading days. Although this measure captures multiple dimensions of liquidity, such as trading quantity and trading cost, it particularly captures trading speed. This is because this measure provides an estimate of "the continuity of trading and the potential delay or difficulty in executing an order".

Formally, SPEED for stock i in month t is denoted by $SPEED_{i,t}$ and is given by:

$$SPEED_{i,t} = \left[x + \frac{1/(12\text{-}month\ turnover)}{Deflator}\right] \cdot \frac{21 * 12}{NoTD} \quad (13)$$

where x is the number of zero daily volumes in the prior 12 months, $12\text{-}month\ turnover$ is calculated as the sum of daily turnover over the prior 12 months, and $NoTD$ is the total number of trading days in the market over the prior 12 months. A deflator is chosen such that:

$$0 < \frac{1/(12\text{-}month\ turnover)}{Deflator} < 1$$

for stocks in our sample over the entire sample period. When constructing our measure, we use a deflator of 50,000. The purpose of the second term in the brackets of Eq. (13) is to act as a tie breaker for stocks with the same number of zero daily volumes. Stocks with a higher turnover are thus deemed more liquid.

3.2.4. QUANTITY

Our fourth and last measure is the standard turnover measure, calculated based on the methodology in Datar et al. (1998). This is a purely volume rated measure, and as such captures the trading quantity dimension of liquidity. In order to avoid outliers, we discard the lowest 1% and highest 1% observations of the turnover rate, following the methodology of Datar et al. (1998).

Formally, QUANTITY for stock i in month t is denoted by $QUANTITY_{i,t}$ and is given by:

$$QUANTITY_{i,t} = \frac{Number\ of\ shares\ traded\ in\ the\ prior\ 12\ months}{Average\ number\ of\ shares\ outstanding\ during\ the\ prior\ 12\ months} \quad (14)$$

3.2.5. Overview of liquidity measures

In Table 3, we report the summary statistics for the stocks in our sample for each stock liquidity measure, sorted by stock exchange. The median market cap of stocks listed on the NYSE stock exchange for our sample is USD 2,082 million, compared to just 56 million on AMEX and 225 million on NASDAQ. We find that that stocks on the NYSE stock exchange are considerably more liquid compared to the other two stock markets. For example, we find that the mean and median COST measure is 0.411 and 0.396 respectively for NYSE, which is approximately three times smaller than the corresponding measures for the AMEX and NASDAQ stock markets. This makes intuitive sense, as larger stocks are expected to be more liquid. These results support that an analysis of the effect of liquidity should differentiate between the different stock exchanges.

Table 3.

Summary Statistics by Stock Exchange

This table lists the monthly cross-sectional statistics for all stocks in our sample. Results are presented separately for the NYSE, AMEX and NASDAQ stock exchanges. The sample period for the reported variables is 1964-2021 for NYSE and AMEX and 1986-2021 for NASDAQ. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST (in %) is the average of the Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)) measures. SPEED is Liu's (2006) Zero-Trading-Days measure. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for stock following the methodology used by Datar et al. (1998). SDRET (%) is the standard deviation of monthly returns. MKTCAP is the market capitalization at the end of the year (in millions of dollars). STOCKS is the number of firms in the sample at the end of the year. MIN & MAX STOCKS is the minimum and maximum number of firms in the sample at the end of the year.

	NYSE			AMEX			NASDAQ		
Variables	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
IMPACT	0.104	0.072	0.140	3.864	2.452	4.251	3.366	2.674	3.194
COST	0.411	0.396	0.120	1.171	1.094	0.391	1.259	1.252	0.510
SPEED	1.784	1.532	1.526	31.233	31.613	13.637	21.838	18.386	17.175
QUANTITY	0.093	0.059	0.074	0.041	0.032	0.060	0.098	0.108	0.056
SDRET (%)	10.374	9.523	3.537	15.375	14.094	6.306	18.104	16.646	5.699
MKTCAP	3,728	2,082	3,855	71	56	54	586	225	856
STOCKS	1,320	1,301	144	653	666	222	2,798	2,659	751
MIN STOCKS	1,145			144			2,078		
MAX STOCKS	1,846			1,088			4,826		

Table 4 reports the monthly average Spearman Rank correlations among the four liquidity measures, standard deviation of returns and logarithm market capitalization during the period 1964-2021 for NYSE/AMEX and 1986-2021 for NASDAQ. The correlation between our liquidity measures ranges from -0.14 to 0.85 for NYSE stocks, from 0.16 to 0.75 for AMEX stocks and from 0.34 to 0.86 for NASDAQ stocks. Generally, the SPEED and QUANTITY measures have the highest correlation ranging from 0.66 to 0.86. This makes intuitive sense as they are both volume-based measures. The COST and QUANTITY measures have the lowest correlation, ranging from -0.14 to 0.34. These results are broadly in line with prior studies (e.g. Ben-Rephael et al. (2015) and Chen & Velikov (2021)). As each measure proxies a different dimension of liquidity it makes sense for them to not be perfectly correlated. As such, each measure provides a distinct contribution to our analysis. The positive correlation with the standard deviation of returns for the IMPACT and COST liquidity measures indicates that these liquidity proxies are correlated with volatility. Furthermore, we can see that the size of the underlying company to which each stock pertains to is negatively correlated to illiquidity. This confirms the intuitive idea that small stocks are in general less liquid than large stocks.

Table 4.

Spearman Rank Correlations Between Liquidity Measures

This table presents the time-series average of the monthly cross-sectional Spearman rank correlations for the main variables used in the study between Jan. 1964 and Dec 2021 for NYSE and AMEX stocks and Jan. 1986 and Dec. 2021 for NASDAQ stocks. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY (inv) is the inverse, i.e. 1/QUANTITY, defined as the average number of shares outstanding divided by the number of shares traded for the stock following the methodology used by Datar et al. (1998). By using an inverse, the measure becomes a proxy for illiquidity rather than liquidity. SDRET is the standard deviation of monthly returns. LNMKTCAP is the natural logarithm of the end-of-year market capitalization (in millions of dollars).

Variables	COST	SPEED	QUANTITY (inv)	SDRET	LNMKTCAP
PANEL A: NYSE					
IMPACT	0.61	0.44	0.25	0.40	-0.93
COST		-0.04	-0.14	0.53	-0.66
SPEED			0.85	-0.25	-0.22
QUANTITY (inv)				-0.38	0.00
SDRET					-0.50
PANEL B: AMEX					
IMPACT	0.75	0.61	0.42	0.26	-0.82
COST		0.24	0.16	0.44	-0.69
SPEED			0.66	-0.24	-0.48
QUANTITY (inv)				-0.29	-0.09
SDRET					-0.31
PANEL C: NASDAQ					
IMPACT	0.75	0.79	0.66	0.11	-0.88
COST		0.44	0.34	0.36	-0.77
SPEED			0.86	-0.26	-0.60
QUANTITY (inv)				-0.32	-0.42
SDRET					-0.26

We present summary statistics for our four liquidity measures by subperiods in Table 5. It is important to note the general decline in both mean and median illiquidity on all three stock exchanges when comparing the values for the most recent period, that is 2012-2021, to the prior periods. For example, the median value for IMPACT on the NYSE is 0.074 between 1964-1975 compared to a much lower 0.011 in 2012-2011. This holds across all four liquidity measures, with the exception of COST for the AMEX stock exchange.

In Figure 1 we present the monthly average transaction cost over our sample period, defined as half of the effective bid-ask spread, for NYSE, AMEX and NASDAQ. The graph indicates that in historical terms the transaction costs have been quite volatile and higher during period of crisis, for example during the 1970s oil crisis, Black Monday (1987), Dot-com bubble (2000), Financial crisis (2007-2009) and the Covid-19 pandemic (2020). NYSE consistently has the lowest transaction costs over time.

For each year and by stock exchange we calculate the median of the liquidity measures across all stocks available in our final sample. Figure 2 depicts the development over time of our four liquidity measures (*IMPACT*, *COST*, *SPEED* and *QUANTITY*) on NYSE and NASDAQ. The

Table 5.

Liquidity Measures Summary Statistics by Stock Exchange and Subperiod

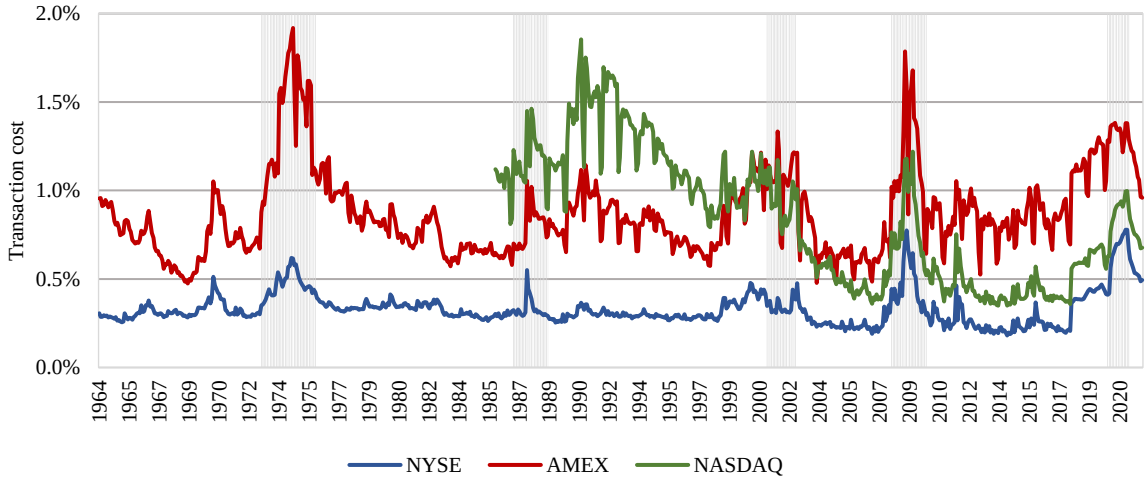
This table lists the monthly cross-sectional statistics, sorted by subperiod, for stocks in our sample listed on NYSE, AMEX and NASDAQ stock exchanges. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST (in %) is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for stock following the methodology used by Datar et al. (1998). Panel A presents the results for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011 and 2012-2021 for NYSE, Panel B reports the results for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011 and 2012-2021 for AMEX and panel C shows the results for each of the three subperiods 1986-1999, 2000-2011 and 2012-2021 for NASDAQ.

	IMPACT			COST			SPEED			QUANTITY		
Variables	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
PANEL A: NYSE												
Five Subperiods												
1964-1975	0.125	0.074	0.125	0.419	0.358	0.119	3.921	3.881	1.763	0.025	0.024	0.004
1976-1987	0.112	0.096	0.046	0.407	0.404	0.039	1.796	1.711	0.686	0.040	0.037	0.012
1988-1999	0.203	0.125	0.223	0.440	0.421	0.079	1.998	1.827	0.706	0.060	0.057	0.009
2000-2011	0.038	0.021	0.033	0.380	0.356	0.133	0.642	0.334	0.592	0.160	0.137	0.065
2012-2021	0.012	0.011	0.005	0.408	0.297	0.190	0.450	0.456	0.235	0.199	0.196	0.015
PANEL B: AMEX												
Five Subperiods												
1964-1975	2.213	1.077	2.763	1.126	0.953	0.494	30.914	28.374	16.629	0.035	0.035	0.017
1976-1987	2.818	2.361	1.472	1.075	1.032	0.204	33.438	31.613	10.259	0.027	0.028	0.007
1988-1999	5.785	4.582	4.136	1.325	1.282	0.308	37.468	36.920	6.862	0.032	0.032	0.005
2000-2011	7.561	3.918	7.267	1.222	1.143	0.436	26.760	23.246	11.208	0.048	0.048	0.017
2012-2021	2.309	1.751	1.545	1.214	1.069	0.361	8.668	7.512	3.371	0.163	0.093	0.226
PANEL C: NASDAQ												
Three Subperiods												
1986-1999	4.921	4.159	2.809	1.689	1.593	0.404	35.295	32.852	13.709	0.084	0.084	0.026
2000-2011	3.423	2.133	3.885	0.946	0.872	0.357	11.494	9.633	5.644	0.141	0.146	0.020
2012-2021	2.709	2.217	1.789	0.743	0.629	0.263	2.389	1.989	1.745	0.162	0.154	0.033

Figure 1.

Transaction Cost Over Time by Stock Exchange

The graph plots the monthly average transaction cost for NYSE, AMEX and NASDAQ over time. Transaction costs are measured as half of the effective spread, which we calculate as the average of four low-frequency proxies: Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). The sample period is 1964-2021 for NYSE/AMEX and 1986-2021 for NASDAQ. The shaded areas depict recession periods as defined by NBER.



general trend is that the measures for illiquidity (IMPACT, COST and SPEED) decrease over time while the measure for liquidity (QUANTITY) increase. Thus, the general trend is that liquidity appears to increase over time. This is especially true starting in the 1990s and continuing in the 2000s. This coincides with several technological advancements (e.g. electronic trading) as well as several regulatory market reforms (e.g. decimalization). The proliferation of digital trading may have especially contributed to this trend in the years post 2000, which can be seen when looking at QUANTITY, which has increased substantially, from approximately 10% to 20% for NYSE stock.

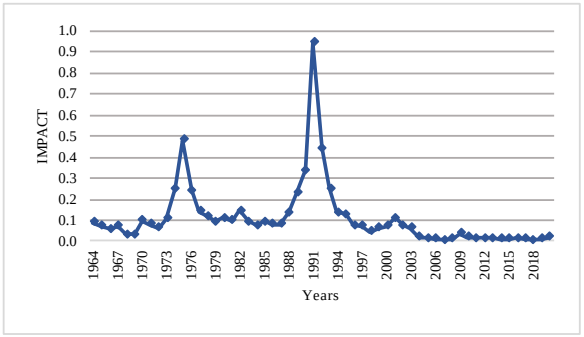
Figure 2.

Median Liquidity Measures Over Time

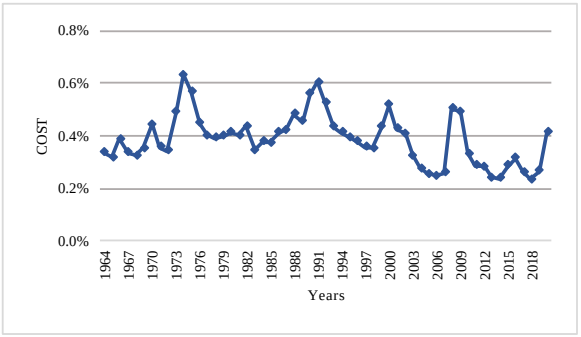
The graphs in figure 2 plot annual medians of IMPACT, COST, SPEED and QUANTITY calculated across all stocks in the sample. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST (in %) is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for stock following the methodology used by Datar et al. (1998). Graphs A1-A4 depict results for NYSE and Graph B1-B4 depict results for NASDAQ. The sample period is 1964-2021 for NYSE/AMEX and 1986-2021 for NASDAQ.

Graph A. NYSE

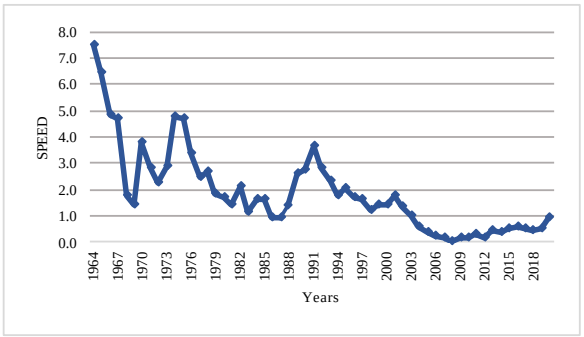
A1. IMPACT



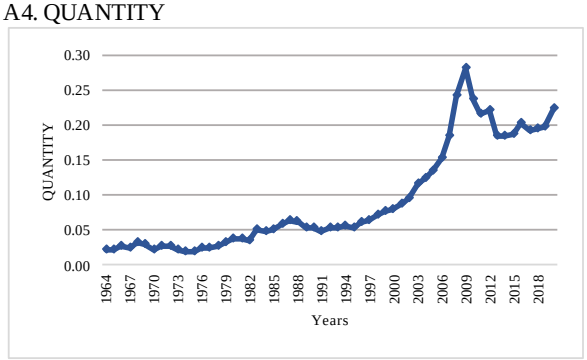
A2. COST



A3. SPEED

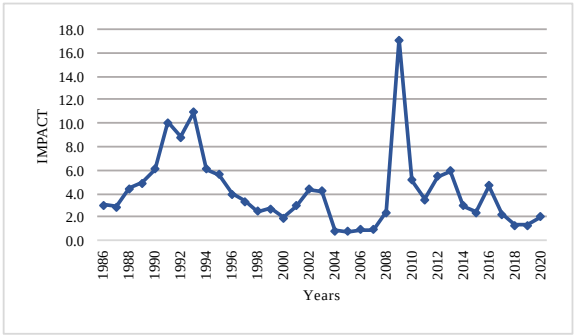


A4. QUANTITY

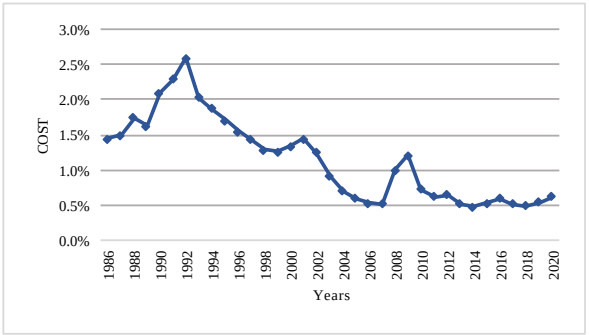


Graph B. NASDAQ

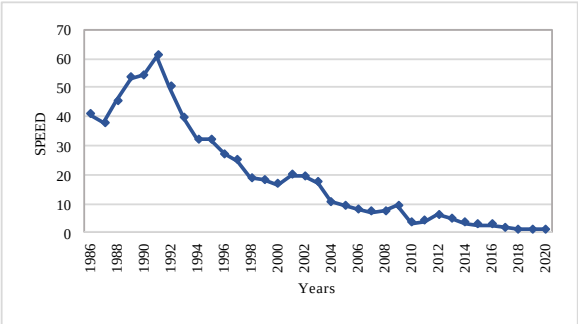
B1. IMPACT



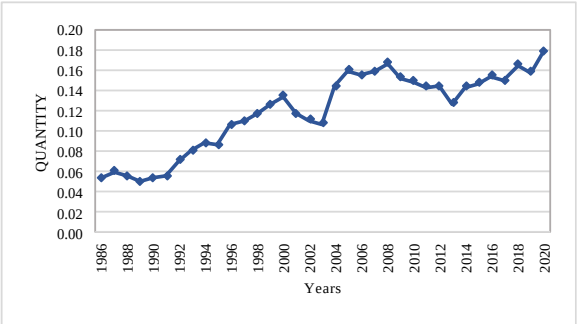
B2. COST



B3. SPEED



B4. QUANTITY



3.3. Portfolio formation

3.3.1. Portfolios with no cost mitigation

We create portfolios following a broadly accepted standard practice, similar to prior studies that make use of long-short portfolios (e.g. Campbell et al. (2008), Gao et al. (2018)). At the end of each month t we rank all stocks in the sample period based on their individual liquidity as determined by one of our liquidity measures. Based on this rank, we use percentile cut-off points to allocate each stock to a specific portfolio, where the first quintile consists of the 20% most liquid stocks and the fifth quintile of the 20% most illiquid stocks. Following Novy-Marx (2016) we opt to construct value-weighted portfolios.[4] Following this we calculate the value-weighted return of each quintile portfolio over the month $t + 2$. We use monthly portfolio rebalancing. As an example, if stock "X" is ranked in the first quintile at the end of January, then X is used as a component of the first quintile portfolio starting at the end of February and held until the end of March at which point the portfolio is rebalanced again based on the liquidity rankings at the end of February. By timing the portfolio construction and calculating the monthly returns using this approach we minimize the effects of microstructure noise and extreme return reversal which may happen in the first month $t + 1$. This process is repeated for all four of our liquidity measures.

Our portfolios are constructed separately for each stock exchange. This is standard practice among the literature examining the liquidity premium (e.g. Hasbrouck (2009) and Ben-Rephael et al. (2015)). In doing this split, we separate the effect of the different characteristics of each stock exchange on the portfolio returns. Such characteristics include for example differences in the composition of their listed stocks in terms of market cap. Furthermore, the volume data for NASDAQ is inflated and as a result our IMPACT, SPEED and QUANTITY measures are not economically comparable across exchanges.[5] Lastly, market reforms, including decimalization, have been implemented at different times or different ways for each exchange.

Following Ben-Rephael et al. (2015) we examine the existence of a liquidity premium by making use of a long-short trading strategy, forming a portfolio long in the quintile portfolio with the least liquid stocks and short in the quintile portfolio with the most liquid stocks. At

[4] When constructing equally-weighted portfolios we get similar results regarding the existence of a liquidity premium, but with a higher magnitude for alpha as each portfolio has a larger exposure to small stocks with significant liquidity premium.

[5] Atkins & Dyl (1997) provides details on how volume on NASDAQ is inflated.

first, we do this for all stocks in our sample. Next, for NYSE and NASDAQ we construct portfolios double sorted on size and liquidity. That is, we first sort stocks into size groups, based on the previous end-of-year market cap, before sorting on liquidity. Three size groups are used, each group corresponding to the bottom, middle and top tercile of the sample. By first sorting by size, we isolate liquidity effects from size effects. When examining AMEX stocks, we do not double sort on size and liquidity due to the limited number of common stocks with little variation in size.

3.3.2. Portfolios with cost mitigation

We are generally interested in the potential returns of trading strategies in the real world, after taking transaction costs into account. Following the same line of thought, it is then of interest if an investor can reduce these transaction costs through various strategies. Following Novy-Marx & Velikov (2016), we employ three different transaction cost mitigation strategies. The first of these is to limit the sample of stocks considered for our portfolios to the top tercile of stocks that we expect are the cheapest to trade. This is determined by the previous year's average transaction cost for the stock, using our transaction cost measure. Employing this strategy may however severely limit the sample of stocks which have an underlying exposure to the liquidity premium.

Our other two cost mitigation strategies are less drastic, as they only focus on reducing turnover and thereby lowering transaction costs. The purpose of this is to limit transaction cost without significantly reducing the exposure to underlying signal on which the strategy is based. The first of these is "staggered partial rebalancing" and entails only rebalancing part of the portfolio each month. We make use of four overlapping portfolios such that our long-short portfolios have the weight of 1/4 in each overlapping portfolio. Each month t, one of these overlapping portfolios is rebalanced based on new liquidity rankings, while also closing out the position initiated in month $t-4$. Following this strategy, the weights on 1/4 of the securities in the portfolio are rebalanced each month while the other weights are passed over from the prior month.

Our third cost mitigation strategy, and second turnover reduction strategy, is the usage of a "buy/hold spread." That is, we impose stricter requirements to actively trade into a position compared to maintaining said position from one month to the next. We employ a 20%/40% buy/hold spread. This means that on the long side a stock becomes part of the portfolio formation when it enters into the buy range (top 20% of illiquid stocks) but is not removed until it falls out of the hold range (top 40% of illiquid stocks). Correspondingly, on the short side a stock is shorted when it enters the top 20% of liquid stocks, and this short position is only covered when the stock falls out of the top 40% of liquid stocks.

As a result of the above variations of portfolio formation, we calculate the gross and net returns of 864 different portfolios each month.[6]

[6] This is a result of calculating the returns of quintile and long-short portfolios (5+1) based on four different liquidity measures (4), for all stocks and for three different size groups (1+3), for three different stock exchanges (3), using no cost mitigation and using three cost mitigation strategies (1+3). Mathematically, this can be expressed as $(5+1)*4*(1+3)*3*(1+3)=864$

3.4. Transaction cost and net returns

As a portfolio is rebalanced and the weights on securities changes, a transaction cost is incurred. This cost is larger for portfolios with higher turnover, that is portfolios with larger changes in weights, and for portfolios trading in stocks with a higher cost of trading. Formally, the transaction cost incurred by portfolio p in month t is denoted by $TC_{p,t}$ and is given by:

$$TC_{p,t} = \sum_{i=1}^{I_{p,t}} ES_{i,t} * \Delta W_{i,t} \quad (15)$$

where $ES_{i,t}$ is half of the effective bid-ask spread of stock i in month t, $\Delta W_{i,t}$ is the change in weight on stock i in month t, and $I_{p,t}$ is the number of stocks part of portfolio p in month t.

As an effective spread measure does not consider the price impact of large trades, the calculated transaction cost reflects those of a small investor. Still, when examining market efficiency and the possibility for arbitrage, we are interested in examining the marginal profitability of a strategy, and as such it is the most suitable measure to use. The effective spread proxy we use is the same as the liquidity measure COST as defined in section 3.2.2 above.

Net returns are calculated as gross returns after transaction costs. Formally, the net returns for portfolio p in month t is denoted by $NetR_{p,t}$ and is given by:

$$NetR_{p,t} = GrossR_{p,t} - TC_{p,t} \quad (16)$$

where $GrossR_{p,t}$ is the gross return on portfolio p in month t and $TC_{p,t}$ is the transaction cost of portfolio p in month t as defined in Eq. (15)

3.5. Calculating alpha

We are mainly interested in whether the liquidity premium is real and if it is distinct from other best-known anomalies, including well-established anomalies such as value and momentum. As such, we follow the previous literature and make use of standard asset pricing models. In our paper, we use the Fama-French four-factor model for our main analysis, while also presenting results using the Fama-French five-factor model. These models are specified in the following manner:

$$R_{pt} - RF_t = a_p + \beta_1(MKT_t - RF_t) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 UMD_t + e_{pt} \quad (17)$$

$$R_{pt} - RF_t = a_p + \beta_1(MKT_t - RF_t) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + e_{pt} \quad (18)$$

where Eq. (17) denotes the Fama-French four-factor model and Eq. (18) denotes the Fama-French five-factor model. $R_{pt} - RF_t$ denotes portfolio p´s return in excess of the 1-month US Treasury bill rate; MKT_t is the market return (value weighted CRSP portfolio); SMB_t denotes the factor mimicking portfolio for returns on small minus big stocks; HML_t denotes the factor mimicking portfolio for returns on high minus low book-to-market equity (BE/ME); UMD_t denotes the factor mimicking portfolio for returns on high prior returns (Up) minus low prior returns (Down); RMW_t denotes the factor mimicking portfolio for returns on robust minus

weak operating profitability and CMA_t denotes the factor mimicking returns on the conservative minus aggressive investment portfolios.

To evaluate the risk-adjusted performance of our portfolios, we follow the methodology of Ben-Rephael et al. (2015), Brennan et al. (1998) and Chordia et al. (2001)) and estimate out-of-sample alphas. For each month t, we regress the monthly excess returns of a portfolio on the returns of the Fama-French factors (detailed in Eq (17) and Eq. (18)) during the preceding 60 months. Doing this, we obtain an estimate of the loadings of each factor for each month. Next, we calculate the alpha for each specific month of a portfolio as the realized excess return of the portfolio minus the expected excess return calculated from the realized returns on the factors and the estimated factor loadings.

Formally, the four-factor alpha in month t of a portfolio p is denoted by $MONTHLY\_ALPHA_{p,t}$ and is given by:

$$MONTHLY_{ALPHA_{p,t}} = \left(RET_{p,t} - RF_t\right) - \beta_{MKT,p,t}(MKT_t - RF_t) - \beta_{SMB,p,t}SMB_t - \beta_{HML,p,t}HML_t - \beta_{UMD,p,t}UMD_t \quad (19)$$

where $RET_{p,t}$ is the gross return of the portfolio when estimating gross alphas, and net return when estimating net alphas. The betas for month t are estimated from the data for months $t-1$ to $t-61$. The five-factor alpha is calculated in a corresponding manner using the factors in Eq. (18). Using this methodology, we obtain a time series of 696 out-of-sample gross and net alpha estimates.

Finally, we calculate the average of these monthly alphas for each portfolio to obtain a measure of its overall performance. Formally, the alpha for a specific portfolio p is denoted $ALPHA_p$ and is given by:

$$ALPHA_p = \frac{1}{\mathrm{T}}\sum_{t=1}^{T} MONTHLY\_ALPHA_{p,t} \quad (20)$$

where T is the number of months in the period examined.

4. Empirical analysis

We perform our empirical analysis in four parts. In part 1, we analyze the returns of our quintile portfolios formed by sorting on our four liquidity measures. In part 2, we examine the returns of liquidity-sorted long-short portfolios. In part 3, we examine how size may impact portfolio return. For our long-short portfolios, results are presented both in terms of gross returns and net returns. That is, before and after transaction costs. In parts 2 and 3 we also examine the returns of our long-short portfolios during different subperiods. Finally, in part 4, we evaluate the impact of adopting cost mitigation strategies on the portfolio returns, and what the implications are for trading strategies attempting to take advantage of the liquidity premium. The results in the below sections are obtained using the Fama-French four-factor model. When using the Fama-French five-factor model results are not materially different and can be found in Appendix A.

4.1. Returns on liquidity-sorted quintile portfolios

The average gross excess return over the risk-free rate and average gross alphas of our quintile portfolios are presented in Table 6. Consider first the results for NYSE presented in Panel A1 and Panel A2. For all of our liquidity measures except COST, the average gross excess return is generally larger when going across the table from the most liquid stocks (quintile 1) to the most illiquid stocks (quintile 5). For example, looking at the *All sizes* quintile portfolios for IMPACT, the gross excess return is 0.54%, 0.69%, 0.72%, 0.76% and 0.80% for quintiles one to five respectively. An increasing trend across the quintiles can also be observed for the average gross alphas. Such a trend across quintiles is in line with results from prior studies of the liquidity premium, for example Liu (2006). In contrast to the other measures, the portfolios sorted on COST exhibit the opposite trend. Examining the difference between size groups, we generally find larger (or less negative) alphas among the *Size 3* group (large stocks) compared to *Size 2* and finally *Size 1* (small stocks). However, the difference in performance between Quintile 1 and Quintile 5 is the largest among *Size 1* (small stocks). The alphas have mixed significance levels but tend to have the highest t-statistics for the quintiles at the extremes, that is Quintiles 1 and Quintiles 5. When comparing NYSE to the results presented for NASDAQ in Panel B1 and Panel B2 we observe similar trends. However, we find that alphas are generally of a greater absolute magnitude than on NYSE. Results for AMEX are tabulated in Appendix B. The quintile portfolios for AMEX exhibit a similar trend as for NYSE and NASDAQ.

The Fama-French factor loadings on our Quintile 1 and Quintile 5 portfolios constructed suing stocks of all sizes are presented in Table 7. Consider first the results for NYSE in Panel A. In absolute magnitude, the loadings are the highest on the market factor and second highest on the small-minus-big factor, ranging from 0.81 to 1.24 and -0.10 to 0.90 respectively. The loadings are significant (t-statistic > 2) on all factors except the momentum factor, which has consistently low loadings for all both the Quintile 1 and Quintile 2 portfolios across all four liquidity measures. We find similar results for NASDAQ, presented in Panel B. For NASDAQ we generally observe slightly higher loadings on SMB compared to NYSE. These findings are in line with prior literature (e.g. Liu (2006)). The high loadings on SMB indicate the importance the size place a role in explaining the returns.

Table 6.

Returns of Liquidity-sorted Quintile Portfolios by Size Group

Each month we sort stocks into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. This is done separately by stock exchange. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of the Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)) measures. SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for the stock following Datar et al. (1998). The sample period is 1964-2021 for NYSE/AMEX and 1986-2021 for NASDAQ. Results are presented for three different size groups, formed by sorting stocks into terciles based on the previous end-of-year market cap. The table presents monthly average gross excess returns over the risk-free rate and average gross Fama-French four-factor alphas as calculated using Eq. 20 for each quintile portfolio. Absolute t-statistics adjusted for serial correlation using Newey-West (1987) are presented in parentheses. Panel A presents the results for NYSE, Panel B reports the results for NASDAQ and Panel C for AMEX.

	IMPACT					COST				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
PANEL A1: NYSE										
All sizes										
Excess return	0.54%	0.69%	0.72%	0.76%	0.80%	0.61%	0.57%	0.60%	0.62%	0.35%
	(3.13)	(3.63)	(3.62)	(3.48)	(3.50)	(4.05)	(3.13)	(2.83)	(2.66)	(1.06)
Alpha	-0.02%	0.03%	-0.01%	0.01%	0.04%	0.08%	-0.05%	-0.05%	-0.06%	-0.48%
	(1.00)	(0.72)	(0.16)	(0.28)	(0.54)	(2.45)	(1.33)	(1.14)	(1.02)	(4.47)
Size 1 (Small)										
Excess return	-0.64%	0.24%	0.46%	0.71%	0.74%	0.36%	0.33%	0.17%	0.03%	-0.50%
	(2.34)	(1.01)	(1.89)	(2.70)	(2.76)	(1.81)	(1.43)	(0.66)	(0.11)	(1.30)
Alpha	-1.33%	-0.47%	-0.26%	-0.09%	-0.07%	-0.26%	-0.37%	-0.57%	-0.81%	-1.38%
	(17.50)	(9.58)	(4.02)	(1.20)	(0.63)	(4.71)	(6.99)	(7.26)	(9.08)	(7.87)
Size 2										
Excess return	-0.11%	0.49%	0.77%	0.91%	1.00%	0.54%	0.53%	0.54%	0.56%	0.53%
	(0.48)	(2.52)	(3.98)	(4.74)	(5.37)	(3.26)	(2.82)	(2.65)	(2.68)	(2.06)
Alpha	-0.69%	-0.21%	0.06%	0.21%	0.32%	0.00%	-0.13%	-0.18%	-0.13%	-0.24%
	(11.25)	(4.05)	(1.29)	(4.01)	(5.38)	(0.06)	(2.73)	(3.50)	(2.24)	(3.09)
Size 3 (Large)										
Excess return	0.50%	0.57%	0.72%	0.85%	0.94%	0.63%	0.57%	0.56%	0.61%	0.64%
	(2.92)	(3.24)	(4.18)	(4.75)	(5.62)	(4.28)	(3.51)	(3.08)	(3.11)	(2.76)
Alpha	-0.03%	0.00%	0.06%	0.23%	0.30%	0.13%	0.00%	-0.05%	0.00%	0.03%
	(1.12)	(0.01)	(1.55)	(4.62)	(6.25)	(2.87)	(0.13)	(1.07)	(0.00)	(0.50)
PANEL B1: NASDAQ										
All sizes										
Excess return	0.60%	0.65%	0.71%	0.52%	0.41%	0.74%	0.60%	0.43%	0.20%	-0.56%
	(2.42)	(2.54)	(2.64)	(1.91)	(1.51)	(3.60)	(2.00)	(1.29)	(0.53)	(1.64)
Alpha	-0.12%	-0.11%	0.02%	-0.11%	-0.08%	0.02%	-0.05%	-0.35%	-0.59%	-1.22%
	(1.93)	(1.56)	(0.23)	(1.00)	(0.60)	(0.37)	(0.62)	(2.95)	(4.24)	(6.90)
Size 1 (Small)										
Excess return	-2.38%	-1.06%	-0.63%	-0.14%	-0.04%	-0.43%	-1.03%	-1.21%	-1.18%	-1.17%
	(7.69)	(3.65)	(2.21)	(0.53)	(0.14)	(1.80)	(3.67)	(4.06)	(3.79)	(4.10)
Alpha	-2.87%	-1.56%	-1.07%	-0.52%	-0.39%	-0.76%	-1.57%	-1.75%	-1.67%	-1.60%
	(19.62)	(10.02)	(7.00)	(3.37)	(2.19)	(6.16)	(10.62)	(12.51)	(10.11)	(9.25)
Size 2										
Excess return	-1.21%	-0.26%	0.25%	0.46%	0.53%	0.11%	0.03%	-0.13%	-0.27%	-0.47%
	(4.10)	(0.95)	(1.00)	(1.87)	(2.21)	(0.48)	(0.13)	(0.49)	(0.89)	(1.63)
Alpha	-1.76%	-0.83%	-0.34%	-0.10%	-0.01%	-0.37%	-0.51%	-0.60%	-0.94%	-1.14%
	(16.69)	(9.02)	(3.14)	(0.83)	(0.07)	(3.67)	(5.29)	(5.96)	(7.62)	(8.31)
Size 3 (Large)										
Excess return	0.65%	0.64%	0.78%	1.07%	1.11%	0.75%	0.68%	0.70%	0.64%	0.76%
	(2.64)	(2.49)	(3.10)	(4.47)	(4.89)	(3.91)	(2.92)	(2.54)	(1.93)	(2.05)
Alpha	-0.07%	-0.07%	0.12%	0.37%	0.43%	0.10%	-0.04%	0.00%	0.02%	-0.03%
	(0.97)	(1.19)	(1.63)	(5.35)	(5.07)	(1.62)	(0.55)	(0.02)	(0.23)	(0.23)
PANEL C1 : AMEX										
All sizes										
Excess return	0.17%	0.43%	0.55%	0.44%	0.61%	0.58%	0.13%	0.14%	-0.36%	-0.52%
	(0.77)	(1.77)	(2.34)	(1.75)	(1.99)	(2.82)	(0.48)	(0.53)	(1.24)	(1.44)
Alpha	-0.48%	-0.23%	-0.11%	-0.18%	-0.10%	-0.02%	-0.62%	-0.63%	-1.02%	-1.27%
	(4.50)	(2.05)	(1.06)	(1.34)	(0.54)	(0.18)	(4.35)	(4.14)	(6.57)	(5.65)

Table 6. (continued)

Returns of Liquidity-sorted Quintile Portfolios by Size Group

	SPEED					QUANTITY				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
PANEL A2: NYSE										
All sizes										
Excess return	0.42%	0.54%	0.63%	0.62%	0.68%	0.50%	0.54%	0.65%	0.60%	0.63%
	(1.56)	(2.56)	(3.60)	(3.77)	(4.06)	(1.89)	(2.50)	(3.58)	(3.71)	(4.21)
FF5 Alpha	-0.27%	-0.16%	-0.01%	-0.02%	-0.01%	-0.26%	-0.21%	-0.01%	-0.06%	-0.02%
	(3.42)	(2.99)	(0.38)	(0.39)	(0.22)	(3.35)	(3.95)	(0.18)	(1.15)	(0.27)
Size 1 (Small)										
Excess return	-0.60%	0.10%	0.36%	0.46%	0.65%	-0.44%	0.13%	0.37%	0.52%	0.54%
	(1.84)	(0.36)	(1.54)	(2.07)	(3.11)	(1.33)	(0.48)	(1.50)	(2.38)	(2.69)
FF5 Alpha	-1.56%	-0.87%	-0.55%	-0.35%	-0.08%	-1.41%	-0.79%	-0.57%	-0.35%	-0.19%
	(14.74)	(10.78)	(9.81)	(4.90)	(1.18)	(13.74)	(9.92)	(9.28)	(5.30)	(2.49)
Size 2:										
Excess return	0.25%	0.54%	0.56%	0.65%	0.70%	0.27%	0.58%	0.59%	0.71%	0.66%
	(0.99)	(2.40)	(2.98)	(3.69)	(4.13)	(1.07)	(2.65)	(2.96)	(4.08)	(3.96)
FF5 Alpha	-0.54%	-0.33%	-0.23%	-0.06%	-0.01%	-0.56%	-0.29%	-0.25%	-0.04%	-0.02%
	(6.89)	(5.51)	(4.69)	(1.06)	(0.21)	(7.11)	(5.26)	(5.21)	(0.70)	(0.47)
Size 3 (Large)										
Excess return	0.57%	0.59%	0.64%	0.62%	0.59%	0.68%	0.61%	0.62%	0.66%	0.62%
	(2.32)	(2.95)	(3.69)	(3.72)	(4.05)	(2.81)	(3.14)	(3.52)	(3.94)	(4.02)
FF5 Alpha	-0.01%	-0.07%	-0.03%	0.04%	-0.02%	0.02%	-0.08%	-0.07%	0.01%	-0.01%
	(0.16)	(1.17)	(0.94)	(1.07)	(0.34)	(0.26)	(1.40)	(1.82)	(0.32)	(0.09)
PANEL B2: NASDAQ										
All sizes										
Excess return	0.74%	0.84%	0.96%	0.86%	0.79%	0.62%	0.64%	0.90%	0.83%	0.69%
	(2.11)	(3.32)	(4.47)	(3.84)	(3.23)	(2.10)	(2.67)	(4.25)	(4.08)	(3.03)
FF5 Alpha	0.00%	0.05%	0.15%	0.19%	0.27%	-0.04%	-0.11%	0.17%	0.20%	0.21%
	(0.04)	(0.99)	(2.03)	(2.32)	(1.95)	(0.35)	(1.53)	(2.72)	(2.80)	(2.07)
Size 1 (Small)										
Excess return	-2.72%	-1.40%	-0.37%	0.10%	0.46%	-2.16%	-1.07%	-0.42%	-0.17%	-0.09%
	(6.67)	(4.02)	(1.13)	(0.38)	(2.03)	(6.13)	(3.45)	(1.40)	(0.61)	(0.40)
FF5 Alpha	-3.29%	-2.00%	-0.87%	-0.27%	0.18%	-2.62%	-1.51%	-0.76%	-0.40%	-0.23%
	(14.94)	(10.77)	(5.22)	(1.85)	(1.45)	(14.30)	(10.49)	(5.21)	(2.49)	(1.40)
Size 2										
Excess return	-1.08%	-0.14%	0.36%	0.67%	0.70%	-0.83%	-0.04%	0.31%	0.49%	0.54%
	(2.90)	(0.42)	(1.26)	(2.70)	(3.10)	(2.57)	(0.13)	(1.19)	(2.05)	(2.19)
FF5 Alpha	-1.73%	-0.81%	-0.28%	0.15%	0.31%	-1.44%	-0.67%	-0.35%	-0.06%	0.23%
	(10.15)	(7.05)	(2.56)	(1.51)	(2.69)	(10.32)	(6.67)	(3.19)	(0.58)	(1.98)
Size 3 (Large)										
Excess return	0.84%	0.86%	0.94%	0.94%	0.99%	0.70%	0.90%	0.91%	0.91%	0.85%
	(2.17)	(3.03)	(3.94)	(4.37)	(5.35)	(2.09)	(3.36)	(3.91)	(4.52)	(3.95)
FF5 Alpha	0.19%	0.15%	0.11%	0.20%	0.30%	0.02%	0.17%	0.08%	0.10%	0.26%
	(1.75)	(1.73)	(1.72)	(2.82)	(3.85)	(0.17)	(1.78)	(1.18)	(1.69)	(3.35)
PANEL C2 : AMEX										
All sizes										
Excess return	-0.21%	0.24%	0.64%	0.58%	0.69%	-0.21%	0.36%	0.45%	0.79%	0.58%
	(0.71)	(0.95)	(2.83)	(2.61)	(3.76)	(0.69)	(1.35)	(1.87)	(3.47)	(2.66)
FF5 Alpha	-0.76%	-0.37%	0.21%	0.05%	0.21%	-0.74%	-0.20%	-0.13%	0.26%	0.10%
	(3.92)	(2.84)	(2.43)	(0.57)	(1.89)	(4.21)	(1.68)	(1.25)	(2.42)	(0.74)

Table 7.

Liquidity-sorted Quintile Portfolios: Fama-French Four-factor Loadings

Each month we sort stocks into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. This is done separately by stock exchange. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of the Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)) measures. SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for the stock following Datar et al. (1998). The table reports the Fama-French four-factor loadings (MKT, SMB, HML, and UMD) and corresponding Newey-West (1987) t-statistics (in parentheses) for quintiles 1 and 5. The sample period is 1964-2021 for NYSE/AMEX and 1986-2021 for NASDAQ. Panel A reports loadings for NYSE, Panel B for NASDAQ and Panel C for AMEX.

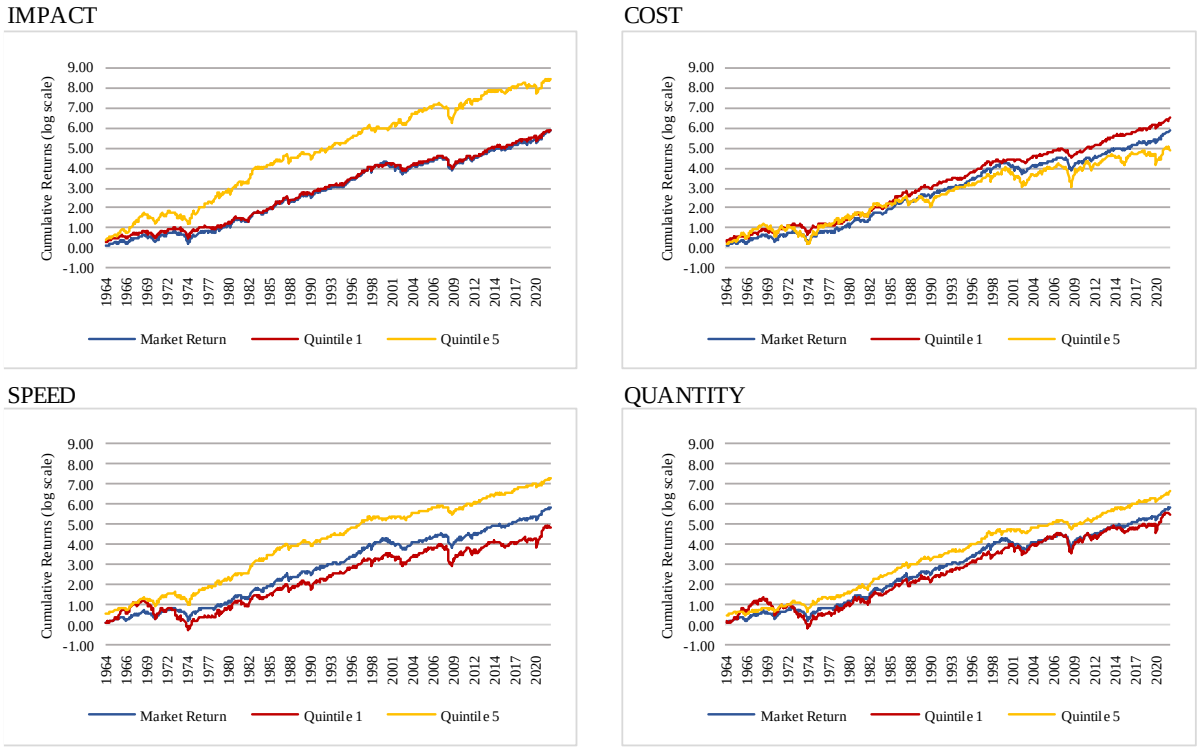
	IMPACT		COST		SPEED		QUANTITY	
	Q1	Q5	Q1	Q5	Q1	Q5	Q1	Q5
PANEL A: NYSE								
FF4 Loadings								
MKT	0.96	0.94	0.86	1.24	1.22	0.81	1.21	0.82
	(132.33)	(69.63)	(63.74)	(50.87)	(79.15)	(63.93)	(91.86)	(59.49)
SMB	-0.16	0.90	-0.16	0.81	0.40	0.21	0.40	-0.10
	(23.05)	(41.78)	(22.55)	(25.23)	(20.15)	(5.20)	(17.89)	(4.88)
HML	0.08	0.46	0.12	0.31	0.04	0.22	0.09	0.20
	(4.43)	(22.05)	(4.72)	(10.44)	(1.66)	(8.34)	(2.99)	(7.88)
UMD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.38)	(0.71)	(0.27)	(1.39)	(0.12)	(0.27)	(0.24)	(0.24)
PANEL B: NASDAQ								
FF4 Loadings								
MKT	1.00	0.67	0.92	0.81	1.19	0.51	1.12	0.60
	(41.93)	(53.20)	(51.35)	(28.32)	(50.57)	(20.86)	(37.04)	(36.35)
SMB	0.52	0.71	0.44	1.00	0.74	0.51	0.70	0.48
	(25.01)	(14.05)	(19.05)	(26.72)	(36.46)	(22.71)	(25.43)	(27.75)
HML	-0.16	0.29	-0.02	0.10	-0.40	0.34	-0.35	0.37
	(9.97)	(9.08)	(0.64)	(2.23)	(16.40)	(13.47)	(12.69)	(11.40)
UMD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.40)	(0.32)	(0.02)	(0.55)	(0.87)	(0.20)	(1.40)	(0.07)
PANEL C: AMEX								
FF4 Loadings								
MKT	0.94	0.69	0.81	0.76	1.09	0.51	1.10	0.66
	(74.97)	(25.08)	(41.18)	(23.55)	(73.20)	(21.43)	(75.54)	(20.24)
SMB	0.68	1.18	0.57	1.20	0.93	0.62	0.96	0.57
	(32.85)	(14.83)	(28.27)	(15.13)	(28.19)	(17.52)	(27.18)	(16.82)
HML	0.07	0.40	0.11	0.23	-0.03	0.28	-0.12	0.31
	(2.66)	(9.16)	(4.17)	(3.26)	(0.81)	(13.62)	(4.60)	(8.07)
UMD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.19)	(0.38)	(0.32)	(0.40)	(0.15)	(0.04)	(0.01)	(0.13)

For the sake of illustrating the performance of our quintile portfolios which form the basis of our long-short trading strategy, Figure 3 presents the cumulative return of our Quintile 1 (most liquid stocks) and Quintile 5 (most illiquid stocks) for each of our four liquidity measures. As a reference point, the value weighted cumulative market return from CRSP is also plotted. In the interest of brevity, only the results for NYSE are presented. We observe that for our liquidity measures IMPACT, SPEED and QUANTITY Quintile 5 substantially outperforms the returns of the market over time. For COST, Quintile 5 significantly underperforms compared to the market. The opposite is observed for Quintile 1 for all four liquidity measures.

Figure 3.

Cumulative Returns of Liquidity-sorted Quintile portfolios (NYSE)

Liquidity-sorted quintile portfolios are formed at the beginning of every month for each of our four liquidity measures (IMPACT, COST, SPEED and QUANTITY) based on rolling twelve-month trading data. The figures plot the cumulative excess returns over the risk-free rate for Quintile 1 (most liquid) and Quintile 5 (least liquid) as determined by each liquidity measure for NYSE. The sample period is 1964-2021. As a reference point, the value weighted cumulative market return from CRSP is also plotted in each graph.



4.2. Returns on liquidity-sorted long-short portfolios

Table 8 present the performance of our long-short portfolios by subperiod for each of our four liquidity measures, in terms of average gross and net excess returns over the risk-free rate and average gross and net four-factor alphas. To see whether there has been a significant development of the liquidity premium over time we carry out a t-test and Wilcoxon test comparing the difference between the average alphas for the first and last subperiod. Given the length of the sample period for NYSE, this process is repeated but this time comparing two longer subperiods covering the entire sample period.

Panel A of Table 8 present the results for NYSE. First, we evaluate results for the entire sample period. The mean gross and net excess return is persistently negative across all four liquidity measures. However, these are only significantly (t-statistic > 2) negative for the COST measure, with t-statistics of 2.47 and 2.85 for the gross and net excess returns respectively. Gross and net alphas are significantly negative for the IMPACT and COST long-short portfolios and non-significant for the SPEED and QUANTITY long-short portfolios. Examining results across subperiods, we see that both the average gross and net mean excess return tends to be negative for all liquidity measures across all subperiods, with the exception for the 1964-1975 subperiod for the SPEED and QUANTITY long-short portfolios. However, this negative excess return is not persistent across liquidity measures or subperiods at a significant level. Examining average alphas, we find that the COST long-short portfolio demonstrates consistently negative gross and net alphas, which are mostly significant, across the five subperiods. Similarly, IMPACT long-short portfolios generate generally negative or non-significant positive alphas across the five subperiods. However, these are of a lower magnitude compared to COST long-short portfolio. SPEED and QUANTITY long-short portfolios demonstrate a few positive alphas, but all at a non-significant level. Examining the results of our t-tests and Wilcoxon tests we find only a significant difference for the two-subperiod tests for IMPACT and COST long-short portfolios. However, these results are non-significant when comparing the first and last subperiods, indicating no major shift since the beginning of the sample period.

Panel B of Table 8 presents the results for NASDAQ. We find similar results as for NYSE. Again, there are no significantly positive average alphas. For the majority subperiods, all long-short portfolios across the four liquidity measures have either significantly negative alphas or cannot be differentiated from zero. The *first-versus-last-period* test indicate that the average net alphas are less negative (or more positive) in the most recent subperiod for the IMPACT, COST and QUANTITY long-short portfolios.

For the sake of brevity, corresponding results for AMEX are tabulated in Appendix B1. Generally, we find similar results as for NYSE. However, we do observe significant positive average alphas for the SPEED long-short portfolio for the latest subperiod (2012-2021).

Given the few positive and significant average alphas observed in our results, when we do not isolate the size effects from the liquidity effects, there is little evidence for the existence of a liquidity premium.

Table 8.

Returns on Liquidity-sorted Long-Short Portfolios by Subperiod

Each month we sort stocks on each stock exchange into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). For each liquidity measure, we then form a long-short liquidity-based self-financing portfolio. The portfolios are long in the most illiquid stocks, short in the most liquid stocks and rebalanced monthly. The sample period is 1964-2021 for NYSE & AMEX and 1986-2021 for NASDAQ. The table shows gross & net monthly mean gross excess returns, average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), for each stock exchange for various subperiods. Panel A presents the results for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. Panel B reports the results for each of the three subperiods 1986-1999, 2000-2011, and 2012-2021 for NASDAQ. t-test and Wilcoxon refer to the parametric and non-parametric tests for the differences between the coefficients of two subperiods. Two-Subperiods Test relates to the first and last halves of the sample period: 1964-1992 vs 1993-2021 for NYSE. Similarly, the First-versus Last-Period Test refers to the first and last subperiods: 1964-1975 vs 2012-2021 for NYSE, and 1986-1999 vs 2012-2021 for NASDAQ.

	IMPACT				COST				SPEED				QUANTITY			
PANEL A: NYSE	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Entire period:																
1964-2021	-0.10%	-0.31%	-0.15%	-0.36%	-0.63%	-0.94%	-0.73%	-1.03%	-0.12%	0.06%	-0.16%	0.02%	-0.23%	0.04%	-0.27%	-0.01%
	(0.65)	(3.73)	(1.01)	(4.33)	(2.47)	(7.44)	(2.85)	(8.26)	(0.70)	(0.54)	(0.97)	(0.16)	(1.29)	(0.30)	(1.51)	(0.05)
Two Subperiods																
1964-1992	-0.25%	-0.55%	-0.30%	-0.60%	-1.03%	-1.26%	-1.11%	-1.35%	-0.04%	0.00%	-0.08%	-0.04%	-0.18%	-0.02%	-0.22%	-0.07%
	(1.19)	(5.09)	(1.42)	(5.51)	(3.85)	(9.97)	(4.16)	(10.67)	(0.19)	(0.01)	(0.43)	(0.29)	(0.71)	(0.17)	(0.87)	(0.47)
1993-2021	0.05%	-0.11%	-0.01%	-0.16%	-0.28%	-0.66%	-0.38%	-0.76%	-0.17%	0.11%	-0.22%	0.07%	-0.28%	0.09%	-0.32%	0.05%
	(0.23)	(0.97)	(0.04)	(1.45)	(0.67)	(3.46)	(0.93)	(4.03)	(0.66)	(0.66)	(0.82)	(0.41)	(1.10)	(0.47)	(1.25)	(0.25)
Five Subperiods																
1964-1975	-0.39%	-0.34%	-0.44%	-0.39%	-1.16%	-0.78%	-1.24%	-0.86%	0.63%	0.42%	0.58%	0.37%	0.74%	0.34%	0.70%	0.30%
	(1.31)	(2.26)	(1.47)	(2.51)	(2.44)	(5.02)	(2.62)	(5.53)	(2.04)	(1.30)	(1.89)	(1.14)	(1.47)	(1.17)	(1.38)	(1.01)
1976-1987	0.09%	-0.61%	0.05%	-0.65%	-0.80%	-1.56%	-0.87%	-1.64%	-0.19%	0.01%	-0.23%	-0.03%	-0.61%	-0.02%	-0.65%	-0.06%
	(0.27)	(3.74)	(0.15)	(4.03)	(1.98)	(8.83)	(2.16)	(9.31)	(0.80)	(0.06)	(0.97)	(0.20)	(2.07)	(0.16)	(2.20)	(0.45)
1988-1999	-0.67%	-0.44%	-0.73%	-0.51%	-0.96%	-1.04%	-1.08%	-1.15%	-0.62%	-0.33%	-0.67%	-0.38%	-0.48%	-0.25%	-0.52%	-0.30%
	(2.65)	(3.10)	(2.89)	(3.45)	(3.23)	(5.99)	(3.63)	(6.61)	(2.97)	(1.96)	(3.18)	(2.22)	(1.69)	(1.09)	(1.86)	(1.29)
2000-2011	0.61%	0.04%	0.56%	-0.01%	-0.27%	-0.59%	-0.39%	-0.70%	0.00%	0.05%	-0.05%	0.00%	-0.44%	-0.13%	-0.48%	-0.17%
	(1.77)	(0.17)	(1.63)	(0.06)	(0.35)	(1.61)	(0.50)	(1.92)	(0.01)	(0.17)	(0.12)	(0.02)	(1.15)	(0.41)	(1.26)	(0.54)
2012-2021	-0.22%	-0.19%	-0.28%	-0.25%	-0.01%	-0.61%	-0.10%	-0.70%	-0.12%	0.34%	-0.16%	0.30%	-0.04%	0.41%	-0.07%	0.38%
	(0.73)	(1.92)	(0.94)	(2.49)	(0.01)	(2.02)	(0.13)	(2.36)	(0.25)	(1.22)	(0.31)	(1.09)	(0.09)	(1.52)	(0.15)	(1.40)
Two-Subperiods Test																
t-test		3.29		3.21		2.70		2.60		0.31		0.32		0.44		0.44
Wilcoxon		4.04		3.98		2.55		2.46		0.50		0.49		0.69		0.70
First- versus Last-Period Test																
t-test		0.00		0.18		0.67		0.61		0.74		0.72		0.06		0.05
Wilcoxon		0.21		0.40		0.44		0.39		1.00		0.99		0.16		0.14

Table 8. (continued)

Returns on Liquidity-sorted Long-Short Portfolios by Subperiod

	IMPACT				COST				SPEED				QUANTITY			
PANEL B: NASDAQ	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Entire period:																
1986-2021	-0.53%	-0.28%	-0.81%	-0.56%	-1.60%	-1.56%	-1.99%	-1.93%	-0.14%	0.18%	-0.30%	0.03%	-0.35%	0.04%	-0.52%	-0.12%
	(2.73)	(1.83)	(4.08)	(3.42)	(6.72)	(6.98)	(8.08)	(8.33)	(0.41)	(0.84)	(0.86)	(0.15)	(1.22)	(0.20)	(1.79)	(0.59)
Three Subperiods																
1986-1999	-0.63%	-0.23%	-1.05%	-0.64%	-1.79%	-1.43%	-2.32%	-1.95%	-0.67%	0.04%	-0.90%	-0.18%	-0.94%	-0.33%	-1.17%	-0.56%
	(2.25)	(0.98)	(3.82)	(2.61)	(7.43)	(5.44)	(9.26)	(6.94)	(1.20)	(0.11)	(1.61)	(0.49)	(1.74)	(1.08)	(2.17)	(1.83)
2000-2011	0.26%	-0.04%	0.09%	-0.22%	-1.24%	-1.35%	-1.52%	-1.63%	0.43%	0.17%	0.31%	0.06%	0.26%	0.09%	0.13%	-0.04%
	(0.67)	(0.13)	(0.23)	(0.70)	(2.06)	(2.74)	(2.51)	(3.24)	(0.71)	(0.45)	(0.51)	(0.15)	(0.53)	(0.21)	(0.27)	(0.09)
2012-2021	-0.90%	-0.20%	-1.10%	-0.39%	-1.13%	-1.14%	-1.39%	-1.39%	-0.38%	0.37%	-0.49%	0.26%	-0.33%	0.40%	-0.44%	0.29%
	(2.40)	(0.71)	(2.64)	(1.22)	(3.22)	(4.68)	(4.03)	(5.47)	(0.66)	(0.99)	(0.83)	(0.69)	(0.76)	(1.74)	(0.99)	(1.25)
First- versus Last-Period Test																
t-test		1.98		2.79		2.01		2.71		0.71		1.13		2.31		2.76
Wilcoxon		2.59		3.61		2.66		3.52		1.04		1.56		2.35		2.81

In Figure 4 we present the rolling twelve-month average gross alphas over time for each long-short portfolio as well as the corresponding 95% confidence interval. These graphs illustrates that the alphas for all measures are shown to have mostly been around zero or negative throughout the sample period, which agrees with findings in Table 8.

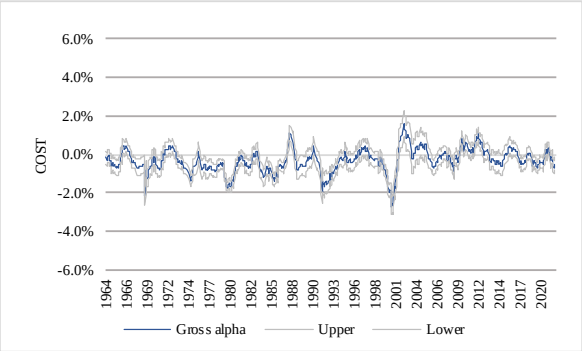
Figure 4.

Monthly Out of Sample Fama-French Four-factor Alphas Over Time

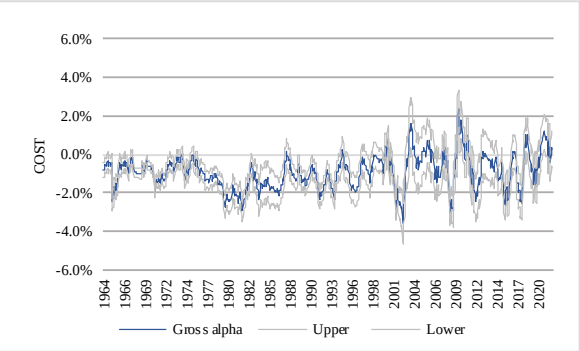
The graphs in figure 4 plots the rolling twelve-month monthly out of sample Fama-French four-factor gross alphas for the long-short portfolios formed based on the IMPACT, COST, SPEED and QUANTITY liquidity measures, as calculated using Equation 19. The corresponding upper and lower 95% confidence interval boundaries are also plotted. The sample period is 1964-2021 for NYSE & AMEX and 1986-2021 for NASDAQ.

Graph A. NYSE

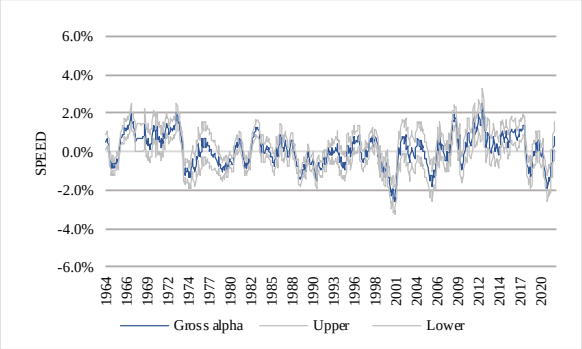
A1. IMPACT



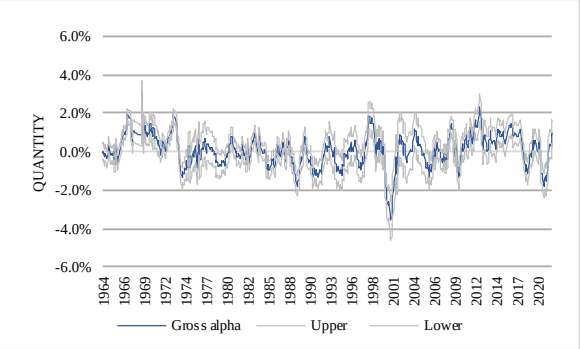
A2. COST



A3. SPEED

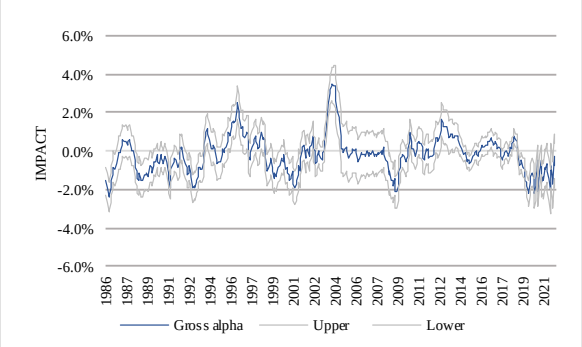


A4. QUANTITY

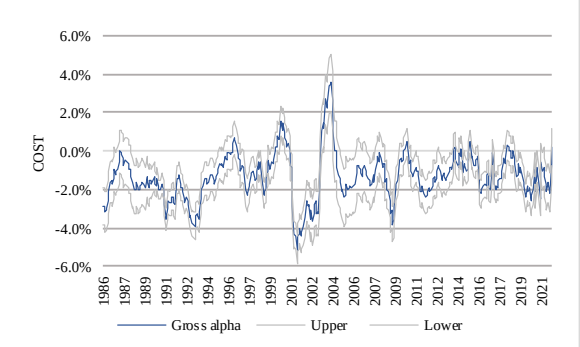


Graph B. NASDAQ

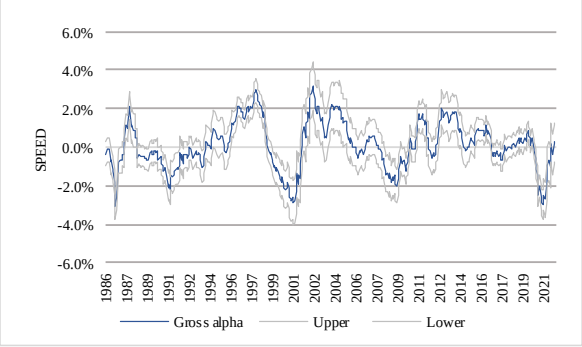
B1. IMPACT



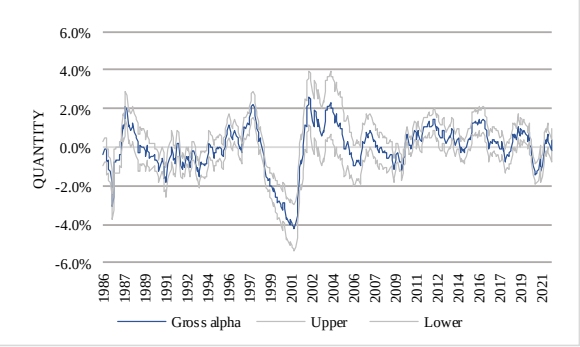
B2. COST



B3. SPEED



B4. QUANTITY



4.3. Returns on double sorted long-short portfolios

Table 9 tabulates the returns of our portfolios double sorted on size and liquidity for the entire sample period. The three size groups are based on the distribution of the previous year's end-of-year market cap, where *Size 1* indicates the tercile with the smallest stocks and *Size 3* indicates the tercile with the largest stocks. Panel A presents the results for NYSE while Panel B shows the equivalent results for NASDAQ. Due to the limited number of stocks on the AMEX stock exchange, we do not construct double-sorted portfolios for stocks listed there.

First, consider the results for NYSE in Panel A. For the smallest size tercile (*Size 1*), we observe positive average excess returns and alphas, both on a gross and net basis, for all long-short portfolios with t-statistics ranging from 3.58 to 9.89. This holds true with the exception for the COST long-short portfolio which generates negative alpha. Negative alphas for portfolios sorted on an effective spread measure is in line with previous studies (e.g. Ben-Rephael et al. (2015)). The net alphas for IMPACT, SPEED and QUANTITY long-short portfolios range from 0.75% to 1.04%. The SPEED long-short portfolio has both the highest average gross alpha (1.13%) and average net alpha (1.04%), while the IMPACT and QUANTITY long-short portfolios have respectively the second and third largest alphas. For the medium-sized stocks (*Size 2*), there is only a significant positive average net alpha for the IMPACT long-short portfolio, with a magnitude of 0.59% and a t-statistic of 6.01. The average alphas for the COST long-short portfolio are, again, negative. In contrast, the largest size tercile (*Size 3*) long-short portfolios exhibit non-significant average alphas or even significant negative alphas, both on a gross and net basis.

In Panel B a similar pattern as for NYSE can be observed for the NASDAQ long-short portfolios, but with significant (t-statistic > 2) positive alphas not only for *Size 1* stocks but also *Size 2* stocks. Overall, the average excess returns and average alphas are of considerably higher magnitudes, both on a gross and net basis. For comparison's sake, the *Size 1* average net alphas for the IMPACT, SPEED and QUANTITY long-short portfolios are ranging from 1.56% to 2.82%. Again, the SPEED long-short portfolio has the highest average alphas, followed by the IMPACT and QUANTITY long-short portfolios. The average alphas for the COST long-short portfolios are still negative. Again, alphas are the highest for *Size 1* stocks and lowest for *Size 3* stocks.

Given the size and significance level of the gross alphas presented in Table 9, this provides evidence for the existence of a liquidity premium among small stocks on NYSE and NASDAQ, and also medium-sized stocks on NASDAQ. The magnitude of alphas is substantial and, despite some differences in methodology, roughly in line with what has been observed in prior studies (e.g. Liu (2006), Ben Rephael et al. (2015)). The size of alphas is positive and significant even after taking into account transaction costs. As the alphas are monotonically decreasing when going from Size 1 to Size 3, this indicates that the liquidity premium is more prevalent among small stocks compared to large stocks.

Table 9.

Returns on Double-sorted Long-Short Portfolios

Each month we sort the stocks on each stock exchange into three size terciles, based on the previous end-of-year market cap. Size 1 refer to the smallest stocks and Size 3 to the largest stocks. Within each size group, we sort the stocks into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). For each liquidity measure, we then form a long-short liquidity-based self-financing portfolio. The portfolios are long in the most illiquid stocks, short in the most liquid stocks and rebalanced monthly. The sample period is 1964-2021 for NYSE and 1986-2021 for NASDAQ. The table shows gross & net monthly mean gross excess returns, average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size for each stock exchange. Panel A presents the results for NYSE and Panel B reports the result for NASDAQ.

	IMPACT		COST		SPEED		QUANTITY	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net
PANEL A: NYSE								
Size 1 (Small)								
Excess return	1.01%	0.88%	-1.23%	-1.39%	0.88%	0.79%	0.61%	0.51%
	(8.75)	(7.50)	(4.58)	(5.15)	(5.34)	(4.76)	(3.58)	(2.96)
Alpha	0.89%	0.76%	-1.49%	-1.65%	1.13%	1.04%	0.85%	0.75%
	(7.03)	(5.99)	(7.37)	(8.07)	(9.89)	(9.07)	(7.37)	(6.42)
Size 2								
Excess return	0.74%	0.69%	-0.38%	-0.45%	0.08%	0.03%	0.01%	-0.04%
	(7.92)	(7.35)	(2.36)	(2.81)	(0.58)	(0.20)	(0.10)	(0.29)
Alpha	0.64%	0.59%	-0.61%	-0.68%	0.24%	0.19%	0.20%	0.14%
	(6.56)	(6.01)	(6.16)	(6.93)	(2.40)	(1.89)	(1.86)	(1.32)
Size 3 (Large)								
Excess return	0.06%	0.04%	-0.35%	-0.41%	-0.35%	-0.38%	-0.41%	-0.45%
	(0.65)	(0.38)	(2.17)	(2.51)	(2.25)	(2.46)	(2.55)	(2.74)
Alpha	-0.04%	-0.06%	-0.47%	-0.53%	-0.21%	-0.24%	-0.22%	-0.25%
	(0.54)	(0.92)	(5.17)	(5.80)	(1.94)	(2.23)	(1.89)	(2.16)
PANEL B: NASDAQ								
Size 1 (Small)								
Excess return	2.12%	1.46%	-1.02%	-1.81%	2.97%	2.48%	1.80%	1.10%
	(9.37)	(5.73)	(6.50)	(9.82)	(9.33)	(7.85)	(6.58)	(3.69)
Alpha	2.26%	1.65%	-1.08%	-1.85%	3.28%	2.82%	2.23%	1.56%
	(10.98)	(6.93)	(6.95)	(10.05)	(15.69)	(12.99)	(13.32)	(8.18)
Size 2								
Excess return	1.49%	1.18%	-0.93%	-1.25%	1.57%	1.35%	1.05%	0.78%
	(6.98)	(5.45)	(4.83)	(6.22)	(4.99)	(4.29)	(3.75)	(2.74)
Alpha	1.51%	1.23%	-1.07%	-1.38%	1.80%	1.58%	1.41%	1.16%
	(10.36)	(8.08)	(7.69)	(9.39)	(11.11)	(9.58)	(9.26)	(7.26)
Size 3 (Large)								
Excess return	0.18%	0.07%	-0.30%	-0.45%	-0.08%	-0.17%	-0.31%	-0.41%
	(1.17)	(0.44)	(0.97)	(1.42)	(0.24)	(0.49)	(0.96)	(1.24)
Alpha	0.16%	0.06%	-0.45%	-0.58%	0.10%	0.01%	0.03%	-0.06%
	(1.47)	(0.50)	(2.26)	(2.93)	(0.53)	(0.07)	(0.19)	(0.30)

In Table 10 we present average excess return and average alphas for our long-short portfolios double-sorted on size and liquidity by different subperiods. Similar to the analysis conducted in section 4.2 we have five subperiods for NYSE and three subperiods for NASDAQ. We perform t-tests and Wilcoxon tests in order to examine if there is any statistical difference in the liquidity premium between subperiods. In the interest of brevity, only the portfolios with the smallest stocks (*Size 1*) are tabulated. Appendix C1 provide results for the other size groups, that is *Size 2* and *Size 3*.

Consider the results for NYSE in Panel A first. As can be seen, we find positive average excess returns and average alphas for all long-short portfolios, except the COST long-short portfolio, throughout all five subperiods. Gross alphas are all positive and significant for the IMPACT, SPEED and QUANTITY long-short portfolios across all five subperiods, with t-statistics ranging from 2.02 to 7.83, with the exception for QUANTITY during the subperiod 1964-1975 which has a t-statistic of 1.61. Positive net alphas are only persistent across all subperiods for the SPEED long-short portfolio. Despite this, net alphas are also positive and significant for the IMPACT and QUANTITY long-short portfolios during the two latest subperiods, that is 2000-2011 and 2012-2021. No decreasing trend in average alphas can be observed across subperiods. For *Size 2*, we also find significant positive alphas for the most recent subperiod. For Size 3, the largest stocks, we only find significant positive alphas for the IMPACT long-short portfolio, and only in the three most recent subperiods. Overall, comparing average gross alphas with average net alphas, and average gross excess returns with average net excess returns, the trends are the same and taking into account transaction costs does not change the main conclusion.

Next, consider the results for NASDAQ in Panel B. The overall picture is similar as for NYSE, although the magnitude of both gross and net alphas are higher and are all positive and significant for all subperiods. The net alphas are on average approximately 1-2 percentage points higher on NASDAQ compared to NYSE for the most recent subperiod, that is 2012-2021. For *Size 2*, significant and positive average gross and net alphas are observed across all three subperiods. In contrast, for *Size 3*, the alphas are non-significant with the exception for the IMPACT long-short portfolio during the subperiod 2012-2021 and for the QUANTITY long-short portfolio during 1986-1999. Again, the prior commentary holds true for all long-short portfolios except for the COST long-short portfolio for which average alphas are negative.

In general, when examining the results by subperiods we still find evidence for the liquidity premium, however not fully persistent across the subperiods. We still find that the liquidity premium is stronger for smaller stocks, even when taking transaction costs into account. This finding is consistent with prior research, such as Ben-Rephael et al. (2015) and Liu (2006). Finally, for *Size 1* stocks we find a strong prevalence of alpha in the two most recent subperiods, that is 2000-2011 and 2012-2021. This result is in fact contrary to Ben-Rephael et al. (2015) which concluded that the characteristic liquidity premium has been diminishing over time. However, their study does not consider the most recent subperiod, which we have found to have alphas of high magnitude on both NYSE and NASDAQ.

Table 10.

Returns on Double-sorted Long-Short Portfolios by Subperiod (Small stocks)

Each month we sort the stocks on each stock exchange into three size terciles, based on the previous end-of-year market cap. Size 1 refer to the smallest stocks and Size 3 to the largest stocks. Within each size group, we sort the stocks into five five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). For each liquidity measure, we then form a long-short liquidity-based self-financing portfolio. The portfolios are long in the most illiquid stocks, short in the most liquid stocks and rebalanced monthly. The table shows gross and net monthly average gross excess returns, average Fama-French four-factor alphas (calculated using Eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size and subperiod for each stock exchange. Panel A presents the results for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. Panel B reports the results for each of the three subperiods 1986-1999, 2000-2011, and 2012-2021 for NASDAQ. t-test and Wilcoxon refer to the parametric and non-parametric tests for the differences between the coefficients of two subperiods. Two-Subperiods Test relates to the first and last halves of the sample period: 1964-1992 vs 1993-2021 for NYSE. Similarly, the First-versus Last-Period Test refers to the first and last subperiods: 1964-1975 vs 2012-2021 for NYSE, and 1986-1999 vs 2012-2021 for NASDAQ.

	IMPACT				COST				SPEED				QUANTITY			
PANEL A: NYSE	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Size 1 (Small)																
Two Subperiods																
1964-1992	0.85%	0.48%	0.72%	0.35%	-1.80%	-2.04%	-1.96%	-2.20%	0.89%	0.99%	0.81%	0.91%	0.51%	0.63%	0.40%	0.52%
	(4.51)	(2.64)	(3.75)	(1.90)	(5.84)	(7.60)	(6.14)	(7.87)	(4.52)	(6.66)	(4.13)	(6.17)	(2.20)	(4.11)	(1.74)	(3.41)
1993-2021	1.16%	1.23%	1.04%	1.12%	-0.74%	-1.03%	-0.90%	-1.18%	0.87%	1.24%	0.78%	1.15%	0.71%	1.03%	0.61%	0.94%
	(7.92)	(8.41)	(6.93)	(7.56)	(1.81)	(3.88)	(2.22)	(4.53)	(3.36)	(7.47)	(2.95)	(6.81)	(2.82)	(6.35)	(2.40)	(5.67)
Five Subperiods																
1964-1975	1.39%	0.78%	1.28%	0.68%	-1.21%	-0.94%	-1.34%	-1.06%	1.20%	0.74%	1.12%	0.66%	0.98%	0.49%	0.88%	0.39%
	(5.10)	(2.65)	(4.80)	(2.26)	(2.96)	(3.19)	(3.33)	(3.65)	(3.60)	(2.87)	(3.34)	(2.51)	(2.30)	(1.61)	(2.05)	(1.25)
1976-1987	0.77%	0.50%	0.67%	0.40%	-1.47%	-2.05%	-1.59%	-2.17%	0.49%	0.86%	0.42%	0.79%	0.15%	0.57%	0.06%	0.49%
	(2.85)	(2.02)	(2.47)	(1.64)	(4.00)	(7.66)	(4.31)	(8.10)	(1.75)	(4.65)	(1.50)	(4.28)	(0.44)	(3.20)	(0.19)	(2.73)
1988-1999	0.75%	0.53%	0.58%	0.36%	-2.36%	-2.62%	-2.59%	-2.84%	1.17%	1.44%	1.07%	1.34%	0.78%	0.97%	0.65%	0.84%
	(3.34)	(2.07)	(2.46)	(1.37)	(5.25)	(6.83)	(5.53)	(7.03)	(5.39)	(7.83)	(4.97)	(7.41)	(3.92)	(4.93)	(3.25)	(4.30)
2000-2011	1.29%	1.36%	1.18%	1.27%	-0.57%	-0.63%	-0.73%	-0.78%	0.83%	0.98%	0.74%	0.90%	0.59%	0.80%	0.50%	0.70%
	(5.51)	(5.27)	(5.06)	(4.86)	(0.89)	(2.13)	(1.13)	(2.66)	(2.42)	(4.31)	(2.15)	(3.85)	(1.71)	(3.82)	(1.42)	(3.28)
2012-2021	1.00%	1.28%	0.86%	1.14%	-0.39%	-0.93%	-0.54%	-1.09%	0.82%	1.54%	0.71%	1.43%	0.72%	1.36%	0.62%	1.27%
	(4.10)	(6.05)	(3.31)	(5.38)	(0.48)	(1.58)	(0.68)	(1.88)	(1.37)	(4.58)	(1.17)	(4.18)	(1.27)	(3.98)	(1.08)	(3.64)
Two-Subperiods Test																
t-test		3.13		3.15		3.10		3.08		1.08		1.02		1.51		1.53
Wilcoxon		3.22		3.25		3.44		3.41		1.71		1.65		1.60		1.59
First- versus Last-Period Test																
t-test		0.49		0.29		0.15		0.29		1.49		1.38		1.06		0.98
Wilcoxon		0.44		0.26		0.15		0.30		1.69		1.62		1.32		1.25

Table 10. (continued)

Returns on Double-sorted Long-Short Portfolios by Subperiod (Small stocks)

	IMPACT				COST				SPEED				QUANTITY			
PANEL B: NASDAQ	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Size 1 (Small)																
Three Subperiods																
1986-1999	2.15%	2.15%	1.13%	1.19%	-1.09%	-1.10%	-2.35%	-2.32%	3.06%	3.21%	2.23%	2.42%	1.75%	2.26%	0.75%	1.29%
	(7.81)	(8.04)	(3.64)	(3.90)	(6.38)	(5.90)	(11.04)	(10.04)	(9.11)	(12.55)	(6.64)	(8.69)	(5.97)	(10.37)	(2.45)	(5.23)
2000-2011	2.44%	2.33%	2.01%	1.89%	-1.15%	-1.20%	-1.67%	-1.71%	2.54%	2.63%	2.21%	2.30%	1.91%	1.93%	1.48%	1.49%
	(6.17)	(9.11)	(5.19)	(7.03)	(3.64)	(3.86)	(4.71)	(4.95)	(3.38)	(7.10)	(3.00)	(6.42)	(3.30)	(7.15)	(2.67)	(5.62)
2012-2021	2.87%	3.35%	2.58%	3.07%	-0.68%	-0.72%	-1.07%	-1.10%	3.40%	4.14%	3.12%	3.88%	1.95%	2.77%	1.41%	2.27%
	(7.81)	(11.35)	(6.83)	(10.36)	(1.77)	(1.96)	(2.84)	(3.09)	(7.36)	(12.69)	(6.64)	(11.82)	(3.05)	(7.40)	(1.90)	(4.93)
First- versus Last-Period Test																
t-test		7.50		10.21		1.61		4.30		2.27		3.93		4.41		5.87
Wilcoxon		6.96		8.62		1.39		4.12		2.34		3.85		4.20		5.41

4.4. Effects of cost mitigation

We test three different cost mitigation strategies on our long-short portfolios: Low-cost, Staggered partial rebalancing and a 20%/40% Buy/Hold spread. Table 11 presents the effect of our cost mitigation strategies. For reference, the values for the standard portfolios constructed using no cost mitigation are included. We analyze the effect of each cost mitigation strategy on the turnover of the portfolio, the transaction cost, and its performance in terms of net alpha. We also calculate the information ratio of the alpha of the cost mitigation portfolio relative to the alpha of the corresponding standard portfolio. This provides a measure for the improvement or deterioration of the investment opportunity using the cost mitigation strategy.

Consider first the results for NYSE in Panel A. Beginning by analyzing the results for our standard long-short portfolios constructed using stocks of all sizes, we find that the turnover ranges from 10% to 20%. Transaction costs range from 0.04% to 0.10%. This magnitude in transaction costs is in line with similar low turnover strategies as determined by Novy-Marx (2016). When implementing our low-cost cost mitigation strategy, that is limiting the sample of stocks to the cheapest tercile to trade, we find that the turnover of the portfolios increases. Thus, the benefits of lower transaction cost for each individual trade are outweighed by a higher number of trades, resulting in little-to-no reduction in transaction cost. When implementing our staggered partial rebalancing and buy/hold spread strategies there is some reduction in turnover and as a result of transaction cost, but this effect is limited. Examining the reduction in transaction cost by size groups, we find marginally higher reductions for *Size 1*, the smallest stocks. Most strikingly is the impact of cost mitigation on the performance of each long-short portfolio. For IMPACT, SPEED and QUANTITY long-short portfolios, cost mitigation worsens the performance. This is especially true when it comes to the staggered rebalancing cost mitigation strategy. For these portfolios, the information ratio ranges from -0.43 to 0.06 when considering all size stocks, and from -0.52 to -0.15 when considering *Size 1* stocks. In other words, while reducing transaction costs we simultaneously obtain lower alphas compared to the standard portfolio. For the majority of these long-short portfolios, the performance deterioration is significant (t-statistic > 2). This indicates that when implementing cost mitigation strategies, there is a loss in exposure to the underlying liquidity premium. For the COST long-short portfolios, the average net alpha becomes less negative when implementing the low-cost and buy-hold cost mitigation strategy, and so performance improves.

Consider next the results for NASDAQ in Panel B. For staggered rebalancing and the buy-hold cost mitigation strategies the results are similar to NYSE. However, the effect of the low-cost mitigation strategy greatly differs. On NASDAQ, this strategy manages to greatly reduce transaction costs. The transaction cost reduction ranges from 0.07% to 0.26% for portfolios constructed using all size stocks, and from 0.36% to 0.62% for *Size 1* stocks. Still, by concentrating trading to the low-cost universe of stocks, the reduction in transaction cost is not large enough for it to outweigh the negative impact from lower exposure to the liquidity premium. As a result, we generally observe lower average net alphas as well as significant and negative information ratios when implementing this cost mitigation strategy.

For completion's sake, we present detailed results for our cost mitigation strategies across size groups and subperiods in Appendix D.

Table 11.

Effect of Cost Mitigation Strategies on Turnover, Transaction Cost and Net Alpha

This table presents a comparison of the performance of the long-short portfolios based on IMPACT, COST, SPEED and QUANTITY, before and after applying the Low-cost, Staggered rebalancing and Buy-hold cost mitigation strategiesdescriber in section 3.3.2. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). The table shows turnover, transaction cost, transaction cost reduction vs the standard (non-cost mitigation) strategy, Fama-French four-factor net alpha, Net alpha+ and corresponding Newey-West (1987) t-statistics (in parentheses), by size for each stock exchange. Net Alpha+ is the information ratio of the cost mitigation strategy's net alpha relative to the standard (non-cost mitigation) strategy's net alpha. Panel A presents the results for NYSE and Panel B presents results for NASDAQ.

	IMPACT				COST				SPEED				QUANTITY			
	Standard	Low-cost	Staggered	Buy-hold	Standard	Low-cost	Staggered	Buy-hold	Standard	Low-cost	Staggered	Buy-hold	Standard	Low-cost	Staggered	Buy-hold
PANEL A: NYSE																
All sizes																
Turnover	10.27%	17.37%	7.17%	10.23%	20.35%	33.57%	8.40%	16.36%	12.74%	22.20%	8.07%	12.39%	12.92%	20.54%	7.98%	11.84%
T-cost	0.05%	0.04%	0.05%	0.05%	0.10%	0.07%	0.07%	0.08%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%
T-cost reduction		-0.02%	0.00%	-0.00%		-0.03%	-0.03%	-0.02%		0.00%	-0.00%	-0.00%		-0.00%	-0.00%	-0.00%
Net alpha	-0.36%	-0.33%	-0.65%	-0.37%	-1.03%	-0.47%	-1.64%	-0.89%	0.02%	-0.37%	0.08%	0.02%	-0.01%	-0.34%	-0.01%	-0.03%
	(4.33)	(3.94)	(0.48)	(7.32)	(3.95)	(0.61)	(7.44)	(0.82)	(5.51)	(11.39)	(0.48)	(7.59)	(0.00)	(0.16)	(3.34)	(0.44)
Net alpha+		0.02	-0.43	-0.03		0.18	-0.31	0.17		-0.16	0.06	0.00		-0.15	0.00	-0.06
		(0.47)	(9.33)	(0.63)		(4.79)	(7.64)	(4.41)		(3.99)	(1.28)	(0.08)		(3.69)	(0.00)	(1.36)
Size 1 (Small)																
Turnover	16.73%	30.56%	11.48%	16.82%	20.36%	36.41%	11.53%	18.49%	14.93%	27.08%	10.03%	14.85%	17.22%	29.10%	10.29%	15.75%
T-cost	0.13%	0.06%	0.12%	0.12%	0.16%	0.08%	0.14%	0.14%	0.09%	0.06%	0.09%	0.09%	0.10%	0.06%	0.09%	0.09%
T-cost reduction		-0.06%	-0.00%	-0.00%		-0.09%	-0.02%	-0.02%		-0.03%	-0.00%	-0.00%		-0.04%	-0.01%	-0.01%
Net alpha	0.76%	-0.19%	0.04%	0.70%	-1.65%	-0.50%	-2.58%	-1.56%	1.04%	-0.22%	0.71%	0.98%	0.75%	-0.37%	0.57%	0.74%
	(5.99)	(1.25)	(0.67)	(0.33)	(6.66)	(1.08)	(7.37)	(0.69)	(5.29)	(12.14)	(0.52)	(8.45)	(0.00)	(9.07)	(1.63)	(0.55)
Net alpha+		-0.28	-0.52	-0.13		0.28	-0.45	0.10		-0.40	-0.32	-0.17		-0.34	-0.15	-0.02
		(6.79)	(13.05)	(3.55)		(5.90)	(11.21)	(2.45)		(10.05)	(7.83)	(3.93)		(8.80)	(3.71)	(0.46)
Size 2																
Turnover	13.77%	26.81%	9.44%	13.74%	17.86%	34.32%	9.07%	16.18%	13.05%	23.32%	8.86%	12.88%	14.88%	26.01%	8.77%	13.53%
T-cost	0.05%	0.05%	0.05%	0.05%	0.07%	0.07%	0.06%	0.06%	0.05%	0.05%	0.05%	0.05%	0.06%	0.05%	0.05%	0.05%
T-cost reduction		-0.00%	-0.00%	-0.00%		-0.00%	-0.01%	-0.01%		-0.00%	-0.00%	-0.00%		-0.00%	-0.01%	-0.00%
Net alpha	0.59%	0.01%	0.23%	0.53%	-0.68%	-0.47%	-1.29%	-0.63%	0.19%	-0.31%	0.13%	0.17%	0.14%	-0.38%	0.11%	0.12%
	(6.01)	(0.80)	(0.64)	(2.32)	(6.28)	(0.57)	(6.16)	(0.77)	(5.47)	(12.47)	(0.57)	(6.77)	(0.00)	(1.89)	(3.20)	(0.57)
Net alpha+		-0.23	-0.39	-0.18		0.08	-0.48	0.08		-0.20	-0.09	-0.09		-0.20	-0.02	-0.05
		(5.85)	(9.04)	(4.47)		(2.10)	(12.13)	(2.01)		(4.88)	(2.11)	(2.12)		(4.53)	(0.50)	(1.23)
Size 3 (Large)																
Turnover	9.67%	18.63%	6.72%	9.66%	20.65%	35.01%	7.83%	17.33%	11.13%	18.83%	7.61%	10.93%	12.14%	19.91%	7.38%	10.96%
T-cost	0.03%	0.04%	0.03%	0.03%	0.06%	0.07%	0.03%	0.05%	0.03%	0.04%	0.03%	0.03%	0.03%	0.04%	0.03%	0.03%
T-cost reduction		0.01%	-0.00%	0.00%		0.01%	-0.02%	-0.01%		0.01%	-0.00%	-0.00%		0.01%	-0.00%	-0.00%
Net alpha	-0.06%	-0.36%	-0.19%	-0.08%	-0.53%	-0.51%	-1.00%	-0.50%	-0.24%	-0.40%	-0.18%	-0.24%	-0.25%	-0.41%	-0.16%	-0.28%
	(0.92)	(4.14)	(0.45)	(2.69)	(0.79)	(0.39)	(5.17)	(0.63)	(5.11)	(9.52)	(0.34)	(5.68)	(0.00)	(2.23)	(3.78)	(0.37)
Net alpha+		-0.17	-0.25	-0.08		0.01	-0.31	0.04		-0.07	0.07	-0.01		-0.07	0.05	-0.03
		(3.73)	(6.49)	(2.09)		(0.21)	(7.80)	(1.21)		(1.93)	(1.52)	(0.41)		(2.00)	(1.37)	(0.68)

Table 11. (continued)

Effect of Cost Mitigation Strategies on Turnover, Transaction Cost and Net Alpha

	IMPACT				COST				SPEED				QUANTITY			
	Standard	Low-cost	Staggered	Buy-hold	Standard	Low-cost	Staggered	Buy-hold	Standard	Low-cost	Staggered	Buy-hold	Standard	Low-cost	Staggered	Buy-hold
PANEL B: NASDAQ																
All sizes:																
Turnover	17.48%	18.49%	12.29%	18.09%	24.34%	29.40%	14.46%	21.56%	16.53%	20.49%	11.21%	16.84%	21.67%	21.50%	11.27%	21.39%
T-cost	0.28%	0.09%	0.29%	0.29%	0.38%	0.13%	0.36%	0.33%	0.16%	0.09%	0.15%	0.16%	0.17%	0.09%	0.14%	0.17%
T-cost reduction		-0.19%	0.00%	0.00%		-0.26%	-0.03%	-0.05%		-0.07%	-0.00%	0.00%		-0.08%	-0.03%	-0.00%
Net alpha	-0.56%	0.02%	-0.88%	-0.54%	-1.93%	-0.16%	-3.06%	-1.75%	0.03%	-0.29%	-0.11%	-0.01%	-0.12%	-0.41%	-0.03%	-0.13%
	(3.42)	(0.99)	(0.80)	(5.17)	(1.67)	(1.59)	(6.98)	(1.34)	(1.12)	(10.33)	(0.91)	(8.12)	(0.00)	(0.15)	(1.15)	(0.46)
Net alpha+		0.19	-0.28	0.02		0.40	-0.53	0.18		-0.11	-0.13	-0.15		-0.12	0.06	0.08
		(4.38)	(4.66)	(0.45)		(8.55)	(9.18)	(3.19)		(1.88)	(2.47)	(3.02)		(2.23)	(1.05)	(1.48)
Size 1 (Small):																
Turnover	27.50%	30.57%	18.23%	28.16%	32.71%	37.71%	18.90%	30.23%	24.70%	28.99%	16.58%	24.80%	35.06%	30.60%	18.40%	35.43%
T-cost	0.66%	0.15%	0.64%	0.66%	0.80%	0.18%	0.67%	0.72%	0.49%	0.13%	0.47%	0.49%	0.70%	0.14%	0.58%	0.70%
T-cost reduction		-0.51%	-0.03%	-0.00%		-0.62%	-0.13%	-0.08%		-0.36%	-0.02%	-0.00%		-0.57%	-0.12%	-0.00%
Net alpha	1.65%	0.64%	0.89%	1.59%	-1.85%	-0.40%	-3.28%	-1.69%	2.82%	0.62%	2.60%	2.74%	1.56%	0.66%	1.55%	1.48%
	(6.93)	(6.46)	(1.22)	(3.43)	(11.37)	(4.29)	(6.95)	(3.10)	(4.17)	(11.13)	(1.72)	(9.43)	(0.00)	(12.99)	(5.80)	(1.01)
Net alpha+		-0.28	-0.40	-0.06		0.40	-0.57	0.18		-0.56	-0.18	-0.15		-0.28	0.10	-0.10
		(4.99)	(8.89)	(1.53)		(7.44)	(11.02)	(4.30)		(9.54)	(3.48)	(2.96)		(4.60)	(1.53)	(2.03)
Size 2:																
Turnover	25.13%	26.09%	16.71%	25.93%	27.86%	34.86%	15.92%	25.50%	21.64%	23.84%	14.80%	22.38%	25.16%	25.16%	14.85%	24.28%
T-cost	0.30%	0.13%	0.29%	0.30%	0.32%	0.15%	0.27%	0.29%	0.23%	0.10%	0.22%	0.23%	0.27%	0.12%	0.25%	0.26%
T-cost reduction		-0.18%	-0.01%	-0.00%		-0.17%	-0.05%	-0.03%		-0.12%	-0.00%	0.01%		-0.15%	-0.02%	-0.01%
Net alpha	1.23%	0.57%	0.55%	1.15%	-1.38%	-0.27%	-2.68%	-1.31%	1.58%	0.20%	1.24%	1.51%	1.16%	-0.01%	1.00%	1.10%
	(8.08)	(6.17)	(1.11)	(3.34)	(9.99)	(2.30)	(7.69)	(1.70)	(2.55)	(12.22)	(0.78)	(8.98)	(0.00)	(9.58)	(2.15)	(0.72)
Net alpha+		-0.24	-0.52	-0.13		0.31	-0.68	0.11		-0.41	-0.39	-0.18		-0.35	-0.09	-0.09
		(4.76)	(10.33)	(3.09)		(7.08)	(11.99)	(2.13)		(7.48)	(7.33)	(4.05)		(5.69)	(1.87)	(1.95)
Size 3 (Large):																
Turnover	15.64%	17.81%	10.96%	16.55%	22.55%	28.50%	11.44%	19.52%	15.74%	18.89%	10.71%	15.75%	17.32%	19.97%	10.29%	16.30%
T-cost	0.11%	0.08%	0.11%	0.11%	0.14%	0.11%	0.12%	0.13%	0.09%	0.07%	0.09%	0.09%	0.10%	0.08%	0.09%	0.09%
T-cost reduction		-0.03%	-0.00%	0.00%		-0.03%	-0.03%	-0.02%		-0.01%	-0.00%	0.00%		-0.02%	-0.01%	-0.01%
Net alpha	0.06%	-0.03%	-0.17%	0.04%	-0.58%	-0.19%	-1.44%	-0.50%	0.01%	-0.43%	0.01%	0.01%	-0.06%	-0.44%	0.04%	-0.02%
	(0.50)	(0.44)	(0.68)	(1.51)	(1.39)	(1.03)	(2.26)	(0.67)	(1.07)	(5.46)	(0.37)	(2.53)	(0.00)	(0.07)	(1.99)	(0.36)
Net alpha+		-0.03	-0.23	-0.04		0.11	-0.41	0.10		-0.20	0.00	-0.02		-0.19	0.10	0.07
		(0.93)	(4.56)	(1.03)		(2.39)	(7.92)	(2.24)		(4.41)	(0.03)	(0.33)		(3.32)	(1.62)	(1.47)

5. Conclusion

We characterize the characteristic liquidity premium with a long-short trading strategy of the least liquid and most liquid stocks and find evidence of a positive relationship between stock returns and illiquidity among small U.S. stocks across all subperiods examined between January 1964 – December 2021. Small stocks that are more illiquid as determined by the IMPACT, SPEED and QUANTITY measures deliver anomalously higher average returns when risk-adjusting returns for the Fama-French four-factor model and Fama-French five-factor model, outperforming the market at a significant level. We find that the overall absolute magnitude of these effects is larger for NASDAQ. In terms of magnitude, average gross alphas for small stocks when considering the entire sample period range from 0.85% to 1.13 % and 2.23% to 3.28% for NYSE and NASDAQ respectively. For NASDAQ a liquidity premium is even found among medium-sized stocks. In contrast, when forming long-short portfolios based on our COST measure, these generate negative alphas. This may indicate that the liquidity dimension transaction cost is priced differently compared to the liquidity dimensions proxied by the other three measures (price impact, trading speed and trading quantity). Generally, average alphas are larger for the portfolios with exposure to the trading speed liquidity dimension compared to those sorted on the other liquidity measures. We find little-to-no evidence of a liquidity premium when considering the entire sample of stocks. Indeed, when doing so, the average alphas of our long-short portfolios are generally significantly negative or non-different from zero. Generally, the results for AMEX are in line with those for NYSE. These overarching results are largely consistent with previous studies, both in terms of magnitude of alphas and the central conclusions regarding the existence of a characteristic liquidity premium (e.g. Ben Rephael et al. (2015), Liu (2006), Amihud (2002), Datar et al (1998)).

We find the liquidity premium among small stocks to be persistent across all subperiods examined from 1964 to 2021 for NYSE and January 1986 to December 2021 for NASDAQ. This indicates that the existence of the liquidity premium is not due to any particular subperiod. This is in line with the findings of Liu (2006) but contrasts the conclusion of Ben Rephael (2015) that the characteristic liquidity premium is diminishing. Nevertheless, this difference can be partially explained by our most recent sample subperiod which was not studied by Ben Rephael (2015), that is 2012-2021, having significant and positive average alphas.

When adjusting the gross alphas of our long-short portfolios for transaction costs we find there is only limited impact on their magnitude or significance level. As such, transaction costs fail to provide an explanation for the liquidity premium. The impact from transaction costs on alpha is in line with those for other low and medium-turnover anomalies as examined by Novy-Marx (2016). As such, we determine that the prior conclusions regarding the liquidity premium hold true even when taking these transactions costs into account.

When implementing cost mitigation strategies on our NYSE portfolios, these result in a limited reduction in transaction costs. This is in line with results for other strategies with similarly low levels of portfolio turnover, see for example Novy-Marx (2016). However, the cost mitigation strategies severely impact the portfolios' exposure to the underlying signal resulting in lower average net alphas across the board. Similar results are observed for NASDAQ, despite larger reduction in transaction costs. As such, implementing standard cost mitigation strategies are not viable when trying to take advantage of the characteristic liquidity premium. An investor would be best off trading the no cost mitigation strategy portfolio formed using only small stocks if the goal is to maximize alpha.

6. References

Abdi, F. and Ranaldo, A., 2017. A Simple Estimation of Bid-Ask Spreads from Daily Close, High, and Low Prices. *The Review of financial studies,* **30**(12), pp. 4437-4480.

Acharya, V.V. and Pedersen, L.H., 2005. Asset pricing with liquidity risk. *Journal of Financial Economics,* **77**(2), pp. 375-410.

Amihud, Y., 2002. Illiquidity and stock returns: cross-section and time-series effects. *Journal of financial markets (Amsterdam, Netherlands),* **5**(1), pp. 31-56.

Amihud, Y. and Mendelson, H., 1986. Asset pricing and the bid-ask spread. *Journal of Financial Economics,* **17**(2), pp. 223-249.

Atkins, A.B. and Dyl, E.A., 1997. Stock price volatility, transactions costs and securities transactions taxes. *Managerial and Decision Economics; Manage.Decis.Econ,* **18**(7-8), pp. 709-718.

Ben-Rephael, A., Kadan, O. and Wohl, A., 2015. The Diminishing Liquidity Premium. *Journal of financial and quantitative analysis; J.Financ.Quant.Anal,* **50**(1-2), pp. 197-229.

Brennan, M.J., Chordia, T. and Subrahmanyam, A., 1998. Alternative factor specifications, security characteristics, and the cross-section of expected stock returns. *Journal of Financial Economics,* **49**(3), pp. 345-373.

Campbell, J.Y., Hilscher, J. and Szilagyi, J., 2008. In Search of Distress Risk. *The Journal of finance (New York),* **63**(6), pp. 2899-2939.

Carhart, M.M., 1997. On Persistence in Mutual Fund Performance. *The Journal of finance (New York),* **52**(1), pp. 57-82.

Chen, A.Y. and Zimmermann, T., 2020. Publication Bias and the Cross-Section of Stock Returns. *Review of asset pricing studies,* **10**(2), pp. 249-289.

Chen, A.Y. and Velikov, M., 2021. Zeroing in on the Expected Returns of Anomalies. *Journal of Financial and Quantitative Analysis, Forthcoming,* .

Chordia, T., Huh, S. and Subrahmanyam, A., 2009. Theory-Based Illiquidity and Asset Pricing. *The Review of financial studies,* **22**(9), pp. 3629-3668.

Chordia, T., Subrahmanyam, A. and Anshuman, V.R., 2001. Trading activity and expected stock returns. *Journal of Financial Economics,* **59**(1), pp. 3-32.

Constantinides, G.M., 1986. Capital Market Equilibrium with Transaction Costs. *The Journal of political economy,* **94**(4), pp. 842-862.

Corwin, S.A. and Schultz, P., 2012. A Simple Way to Estimate Bid-Ask Spreads from Daily High and Low Prices. *The Journal of finance (New York),* **67**(2), pp. 719-760.

Datar, V.T., Naik, N.,Y. and Radcliffe, R., 1998. Liquidity and stock returns: An alternative test. *Journal of financial markets (Amsterdam, Netherlands)*, **1**(2), pp. 203-219.

Eleswarapu, V.R., 1997. Cost of Transacting and Expected Returns in the Nasdaq Market. *The Journal of finance (New York)*, **52**(5), pp. 2113-2127.

Fama, E.F. and French, K.R., 2015. A five-factor asset pricing model. *Journal of Financial Economics*, **116**(1), pp. 1-22.

Fong, K.Y.L., Holden, C.W. and Trzcinka, C.A., 2017. What Are the Best Liquidity Proxies for Global Research? *Review of Finance*, **21**(4), pp. 1355-1401.

Gao, P., Parsons, C.A. and Shen, J., 2018. Global Relation between Financial Distress and Equity Returns. *The Review of financial studies*, **31**(1), pp. 239-277.

Goyenko, R.Y., Holden, C.W. and Trzcinka, C.A., 2009. Do liquidity measures measure liquidity? *Journal of Financial Economics*, **92**(2), pp. 153-181.

Harris, L.E., 1994. Minimum Price Variations, Discrete Bid--Ask Spreads, and Quotation Sizes. *The Review of financial studies*, **7**(1), pp. 149-178.

Hasbrouck, J., 2009. Trading Costs and Returns for U.S. Equities: Estimating Effective Costs from Daily Data. *The Journal of finance (New York)*, **64**(3), pp. 1445-1477.

Kamara, A., Lou, X. and Sadka, R., 2008. The divergence of liquidity commonality in the cross-section of stocks. *Journal of Financial Economics*, **89**(3), pp. 444-466.

Korajczyk, R.A. and Sadka, R., 2008. Pricing the commonality across alternative measures of liquidity. *Journal of Financial Economics*, **87**(1), pp. 45-72.

Kyle, A.S. and Obizhaeva, A.A., 2016. Market Microstructure Invariance: Empirical Hypotheses. *Econometrica*, **84**(4), pp. 1345-1404.

Liu, W., 2006. A liquidity-augmented capital asset pricing model. *Journal of Financial Economics*, **82**(3), pp. 631-671.

Novy-Marx, R. and Velikov, M., 2016. A Taxonomy of Anomalies and Their Trading Costs. *The Review of financial studies*, **29**(1), pp. 104-147.

Pastor, L. and Stambaugh, R.F., 2003. Liquidity Risk and Expected Stock Returns. *The Journal of political economy*, **111**(3), pp. 642-685.

Roll, R., 1984. A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market. *The Journal of finance (New York)*, **39**(4), pp. 1127-1139.

Sadka, R., 2006. Momentum and post-earnings-announcement drift anomalies: The role of liquidity risk. *Journal of Financial Economics*, **80**(2), pp. 309-349.

Timmermann, A., 2006. Chapter 4 Forecast Combinations. Elsevier B.V, pp. 135-196.

Vayanos, D., 1998. Transaction Costs and Asset Prices: A Dynamic Equilibrium Model. *The Review of financial studies*, **11**(1), pp. 1-58.

7.2 APPENDIX

Appendix A: Results using Fama-French Five Factor Model

Appendix A1.

Liquidity-sorted Quintile Portfolio Returns

We sort the stocks in each stock exchange into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for the stock following Datar et al. (1998). The sample period is 1964-2021 for NYSE and 1986-2021 for NASDAQ. The table shows monthly mean gross excess returns, average Fama-French five-factor alphas (eq. 20) and Newey-West (1987) t-statistics (in parentheses), sorted by size, for quintiles 1 to 5. Panel A presents the results for NYSE and Panel B reports the results for NASDAQ.

	IMPACT					COST				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
PANEL A1: NYSE										
All sizes										
Excess return	0.54%	0.69%	0.72%	0.76%	0.80%	0.61%	0.57%	0.60%	0.62%	0.35%
	(3.13)	(3.63)	(3.62)	(3.48)	(3.50)	(4.05)	(3.13)	(2.83)	(2.66)	(1.06)
Alpha	-0.07%	-0.04%	-0.09%	-0.11%	-0.10%	0.04%	-0.14%	-0.14%	-0.14%	-0.59%
	(2.55)	(1.22)	(2.23)	(2.80)	(1.59)	(0.97)	(3.67)	(3.27)	(2.39)	(5.03)
Size 1 (Small)										
Excess return	-0.64%	0.24%	0.46%	0.71%	0.74%	0.36%	0.33%	0.17%	0.03%	-0.50%
	(2.34)	(1.01)	(1.89)	(2.70)	(2.76)	(1.81)	(1.43)	(0.66)	(0.11)	(1.30)
Alpha	-1.51%	-0.61%	-0.39%	-0.24%	-0.16%	-0.36%	-0.51%	-0.77%	-1.00%	-1.59%
	(18.74)	(10.40)	(6.16)	(2.61)	(1.45)	(7.21)	(9.45)	(9.31)	(9.97)	(8.21)
Size 2										
Excess return	-0.11%	0.49%	0.77%	0.91%	1.00%	0.54%	0.53%	0.54%	0.56%	0.53%
	(0.48)	(2.52)	(3.98)	(4.74)	(5.37)	(3.26)	(2.82)	(2.65)	(2.68)	(2.06)
Alpha	-0.82%	-0.26%	-0.04%	0.07%	0.21%	-0.05%	-0.23%	-0.27%	-0.27%	-0.40%
	(11.89)	(5.01)	(0.72)	(1.52)	(4.40)	(1.02)	(5.05)	(5.55)	(4.60)	(4.58)
Size 3 (Large)										
Excess return	0.50%	0.57%	0.72%	0.85%	0.94%	0.63%	0.57%	0.56%	0.61%	0.64%
	(2.92)	(3.24)	(4.18)	(4.75)	(5.62)	(4.28)	(3.51)	(3.08)	(3.11)	(2.76)
Alpha	-0.08%	-0.04%	0.02%	0.18%	0.23%	0.08%	-0.02%	-0.12%	-0.06%	-0.02%
	(2.64)	(0.82)	(0.49)	(3.92)	(4.83)	(1.72)	(0.43)	(2.59)	(1.38)	(0.37)

	SPEED					QUANTITY				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
PANEL A2: NYSE										
All sizes:										
Excess return	0.42%	0.54%	0.63%	0.62%	0.68%	0.50%	0.54%	0.65%	0.60%	0.63%
	(1.56)	(2.56)	(3.60)	(3.77)	(4.06)	(1.89)	(2.50)	(3.58)	(3.71)	(4.21)
Alpha	-0.27%	-0.16%	-0.01%	-0.02%	-0.01%	-0.26%	-0.21%	-0.01%	-0.06%	-0.02%
	(3.42)	(2.99)	(0.38)	(0.39)	(0.22)	(3.35)	(3.95)	(0.18)	(1.15)	(0.27)
Size 1 (Small):										
Excess return	-0.60%	0.10%	0.36%	0.46%	0.65%	-0.44%	0.13%	0.37%	0.52%	0.54%
	(1.84)	(0.36)	(1.54)	(2.07)	(3.11)	(1.33)	(0.48)	(1.50)	(2.38)	(2.69)
Alpha	-1.56%	-0.87%	-0.55%	-0.35%	-0.08%	-1.41%	-0.79%	-0.57%	-0.35%	-0.19%
	(14.74)	(10.78)	(9.81)	(4.90)	(1.18)	(13.74)	(9.92)	(9.28)	(5.30)	(2.49)
Size 2:										
Excess return	0.25%	0.54%	0.56%	0.65%	0.70%	0.27%	0.58%	0.59%	0.71%	0.66%
	(0.99)	(2.40)	(2.98)	(3.69)	(4.13)	(1.07)	(2.65)	(2.96)	(4.08)	(3.96)
Alpha	-0.54%	-0.33%	-0.23%	-0.06%	-0.01%	-0.56%	-0.29%	-0.25%	-0.04%	-0.02%
	(6.89)	(5.51)	(4.69)	(1.06)	(0.21)	(7.11)	(5.26)	(5.21)	(0.70)	(0.47)
Size 3 (Large):										
Excess return	0.57%	0.59%	0.64%	0.62%	0.59%	0.68%	0.61%	0.62%	0.66%	0.62%
	(2.32)	(2.95)	(3.69)	(3.72)	(4.05)	(2.81)	(3.14)	(3.52)	(3.94)	(4.02)
Alpha	-0.01%	-0.07%	-0.03%	0.04%	-0.02%	0.02%	-0.08%	-0.07%	0.01%	-0.01%
	(0.16)	(1.17)	(0.94)	(1.07)	(0.34)	(0.26)	(1.40)	(1.82)	(0.32)	(0.09)

Appendix A1. (continued)

Liquidity-sorted Quintile Portfolio Returns

	IMPACT					COST				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
PANEL B1: NASDAQ										
All sizes										
Excess return	0.60%	0.65%	0.71%	0.52%	0.41%	0.74%	0.60%	0.43%	0.20%	-0.56%
	(2.42)	(2.54)	(2.64)	(1.91)	(1.51)	(3.60)	(2.00)	(1.29)	(0.53)	(1.64)
Alpha	-0.06%	-0.02%	0.15%	0.01%	-0.01%	0.03%	0.04%	-0.15%	-0.41%	-1.12%
	(0.95)	(0.34)	(1.93)	(0.13)	(0.08)	(0.56)	(0.54)	(1.49)	(3.31)	(6.86)
Size 1 (Small)										
Excess return	-2.38%	-1.06%	-0.63%	-0.14%	-0.04%	-0.43%	-1.03%	-1.21%	-1.18%	-1.17%
	(7.69)	(3.65)	(2.21)	(0.53)	(0.14)	(1.80)	(3.67)	(4.06)	(3.79)	(4.10)
Alpha	-2.81%	-1.51%	-1.04%	-0.52%	-0.34%	-0.74%	-1.55%	-1.64%	-1.65%	-1.58%
	(16.89)	(9.34)	(6.73)	(3.19)	(1.93)	(5.59)	(10.21)	(11.64)	(9.49)	(8.91)
Size 2										
Excess return	-1.21%	-0.26%	0.25%	0.46%	0.53%	0.11%	0.03%	-0.13%	-0.27%	-0.47%
	(4.10)	(0.95)	(1.00)	(1.87)	(2.21)	(0.48)	(0.13)	(0.49)	(0.89)	(1.63)
Alpha	-1.75%	-0.80%	-0.28%	-0.01%	0.07%	-0.31%	-0.46%	-0.50%	-0.90%	-1.11%
	(12.76)	(7.14)	(2.26)	(0.09)	(0.49)	(2.98)	(4.17)	(4.22)	(6.90)	(7.84)
Size 3 (Large)										
Excess return	0.65%	0.64%	0.78%	1.07%	1.11%	0.75%	0.68%	0.70%	0.64%	0.76%
	(2.64)	(2.49)	(3.10)	(4.47)	(4.89)	(3.91)	(2.92)	(2.54)	(1.93)	(2.05)
Alpha	0.02%	0.05%	0.13%	0.53%	0.62%	0.11%	0.00%	0.09%	0.22%	0.22%
	(0.24)	(0.87)	(1.77)	(7.49)	(6.75)	(1.73)	(0.05)	(1.08)	(2.54)	(1.66)

	SPEED					QUANTITY				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
PANEL B2: NASDAQ										
All sizes:										
Excess return	0.74%	0.84%	0.96%	0.86%	0.79%	0.62%	0.64%	0.90%	0.83%	0.69%
	(2.11)	(3.32)	(4.47)	(3.84)	(3.23)	(2.10)	(2.67)	(4.25)	(4.08)	(3.03)
Alpha	0.00%	0.05%	0.15%	0.19%	0.27%	-0.04%	-0.11%	0.17%	0.20%	0.21%
	(0.04)	(0.99)	(2.03)	(2.32)	(1.95)	(0.35)	(1.53)	(2.72)	(2.80)	(2.07)
Size 1 (Small):										
Excess return	-2.72%	-1.40%	-0.37%	0.10%	0.46%	-2.16%	-1.07%	-0.42%	-0.17%	-0.09%
	(6.67)	(4.02)	(1.13)	(0.38)	(2.03)	(6.13)	(3.45)	(1.40)	(0.61)	(0.40)
Alpha	-3.29%	-2.00%	-0.87%	-0.27%	0.18%	-2.62%	-1.51%	-0.76%	-0.40%	-0.23%
	(14.94)	(10.77)	(5.22)	(1.85)	(1.45)	(14.30)	(10.49)	(5.21)	(2.49)	(1.40)
Size 2:										
Excess return	-1.08%	-0.14%	0.36%	0.67%	0.70%	-0.83%	-0.04%	0.31%	0.49%	0.54%
	(2.90)	(0.42)	(1.26)	(2.70)	(3.10)	(2.57)	(0.13)	(1.19)	(2.05)	(2.19)
Alpha	-1.73%	-0.81%	-0.28%	0.15%	0.31%	-1.44%	-0.67%	-0.35%	-0.06%	0.23%
	(10.15)	(7.05)	(2.56)	(1.51)	(2.69)	(10.32)	(6.67)	(3.19)	(0.58)	(1.98)
Size 3 (Large):										
Excess return	0.84%	0.86%	0.94%	0.94%	0.99%	0.70%	0.90%	0.91%	0.91%	0.85%
	(2.17)	(3.03)	(3.94)	(4.37)	(5.35)	(2.09)	(3.36)	(3.91)	(4.52)	(3.95)
Alpha	0.19%	0.15%	0.11%	0.20%	0.30%	0.02%	0.17%	0.08%	0.10%	0.26%
	(1.75)	(1.73)	(1.72)	(2.82)	(3.85)	(0.17)	(1.78)	(1.18)	(1.69)	(3.35)

Appendix A2.

Liquidity-sorted Quintile Portfolios: Fama-French Five Loadings

We sort the stocks in each stock exchange into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding for the stock following Datar et al. (1998). The table report the Fama-French five factor loadings (MKT, SMB, HML, RMW and CMA) and corresponding Newey-West (1987) t-statistics (in parentheses) for quintiles 1 and 5. The sample period is 1964-2021 for NYSE and 1986-2021 for NASDAQ. Panel A reports loadings for NYSE and Panel B for NASDAQ.

	IMPACT		COST		SPEED		QUANTITY	
	Q1	Q5	Q1	Q5	Q1	Q5	Q1	Q5
PANEL A: NYSE								
FF5 Loadings								
MKT	0.98	0.98	0.88	1.25	1.19	0.83	1.20	0.85
	(204.75)	(68.57)	(79.73)	(46.75)	(72.48)	(69.76)	(78.80)	(69.88)
SMB	-0.16	0.91	-0.15	0.76	0.39	0.23	0.39	-0.08
	(18.80)	(47.37)	(15.21)	(18.90)	(17.77)	(5.91)	(16.26)	(3.49)
HML	0.06	0.28	0.05	0.33	0.10	0.13	0.13	0.16
	(3.60)	(11.43)	(2.18)	(8.14)	(2.62)	(3.79)	(2.90)	(3.98)
RMW	-0.02	0.12	0.03	-0.24	-0.09	0.08	-0.06	0.03
	(1.23)	(5.24)	(1.88)	(5.83)	(3.18)	(4.42)	(1.85)	(1.57)
CMA	0.06	0.21	0.13	0.00	-0.20	0.18	-0.17	0.14
	(4.17)	(6.42)	(7.56)	(0.07)	(4.13)	(7.56)	(3.84)	(4.69)
PANEL B: NASDAQ								
FF5 Loadings								
MKT	0.96	0.64	0.91	0.78	1.10	0.50	1.06	0.60
	(51.07)	(46.48)	(52.63)	(35.03)	(75.83)	(25.43)	(47.74)	(47.06)
SMB	0.47	0.65	0.44	0.87	0.63	0.51	0.63	0.49
	(20.48)	(12.20)	(18.69)	(20.19)	(32.02)	(18.88)	(24.83)	(27.44)
HML	-0.06	0.15	0.01	-0.03	-0.30	0.20	-0.24	0.28
	(1.84)	(4.66)	(0.22)	(0.59)	(12.76)	(9.78)	(6.64)	(8.07)
RMW	-0.15	-0.29	0.00	-0.51	-0.42	-0.07	-0.33	0.08
	(3.68)	(8.55)	(0.15)	(7.12)	(11.43)	(1.64)	(7.24)	(2.76)
CMA	-0.19	0.20	-0.12	0.27	-0.32	0.11	-0.30	0.05
	(5.16)	(5.67)	(3.65)	(4.81)	(7.97)	(3.09)	(5.67)	(1.72)

Appendix A3.

Liquidity-Sorted Long-Short Portfolio Returns: Presorted by size.

We sort the stock in each stock exchange into three size terciles, based on the previous end-of-year size. Size 1 refer to the smallest size and size 3 to the largest size. Within each size group, we sort the stocks into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). For each liquidity measure, we then form a long-short liquidity-based self-financing portfolio. The portfolios are long in the most illiquid stocks, short in the most liquid stocks and rebalanced monthly. The sample period is 1964-2021 for NYSE and 1986-2021 for NASDAQ. The table shows gross & net monthly mean gross excess returns, average Fama-French five-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size for each stock exchange. Panel A presents the results for NYSE and Panel B reports the result for NASDAQ.

	IMPACT		COST		SPEED		QUANTITY	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net
PANEL A: NYSE								
Size 1 (Small)								
Excess return	1.01%	0.88%	-1.23%	-1.39%	0.88%	0.79%	0.61%	0.51%
	(8.75)	(7.50)	(4.58)	(5.15)	(5.34)	(4.76)	(3.58)	(2.96)
Alpha	0.98%	0.85%	-1.61%	-1.76%	1.11%	1.02%	0.85%	0.75%
	(7.70)	(6.67)	(7.51)	(8.16)	(9.10)	(8.33)	(6.71)	(5.86)
Size 2								
Excess return	0.74%	0.69%	-0.38%	-0.45%	0.08%	0.03%	0.01%	-0.04%
	(7.92)	(7.35)	(2.36)	(2.81)	(0.58)	(0.20)	(0.10)	(0.29)
Alpha	0.66%	0.60%	-0.72%	-0.79%	0.16%	0.11%	0.17%	0.11%
	(6.57)	(6.05)	(7.11)	(7.87)	(1.43)	(0.97)	(1.46)	(0.97)
Size 3 (Large)								
Excess return	0.06%	0.04%	-0.35%	-0.41%	-0.35%	-0.38%	-0.41%	-0.45%
	(0.65)	(0.38)	(2.17)	(2.51)	(2.25)	(2.46)	(2.55)	(2.74)
Alpha	-0.07%	-0.09%	-0.48%	-0.54%	-0.38%	-0.41%	-0.40%	-0.43%
	(0.95)	(1.33)	(5.04)	(5.66)	(3.20)	(3.44)	(2.97)	(3.19)
PANEL B: NASDAQ								
Size 1 (Small)								
Excess return	2.12%	1.46%	-1.02%	-1.81%	2.97%	2.48%	1.80%	1.10%
	(9.37)	(5.73)	(6.50)	(9.82)	(9.33)	(7.85)	(6.58)	(3.69)
Alpha	2.25%	1.65%	-1.03%	-1.80%	3.23%	2.77%	2.16%	1.52%
	(10.78)	(6.90)	(7.28)	(10.30)	(15.90)	(13.29)	(12.06)	(7.54)
Size 2								
Excess return	1.49%	1.18%	-0.93%	-1.25%	1.57%	1.35%	1.05%	0.78%
	(6.98)	(5.45)	(4.83)	(6.22)	(4.99)	(4.29)	(3.75)	(2.74)
Alpha	1.58%	1.31%	-1.07%	-1.37%	1.80%	1.59%	1.41%	1.16%
	(9.78)	(7.73)	(8.99)	(10.63)	(10.58)	(9.27)	(8.72)	(6.97)
Size 3 (Large)								
Excess return	0.18%	0.07%	-0.30%	-0.45%	-0.08%	-0.17%	-0.31%	-0.41%
	(1.17)	(0.44)	(0.97)	(1.42)	(0.24)	(0.49)	(0.96)	(1.24)
Alpha	0.26%	0.15%	-0.18%	-0.31%	-0.12%	-0.21%	-0.16%	-0.25%
	(2.26)	(1.27)	(1.05)	(1.83)	(0.79)	(1.29)	(0.93)	(1.41)

Appendix B: Long-short portfolios sorted by subperiods results for AMEX

Appendix B1.

Liquidity-Sorted Long-Short Portfolio Returns: Sorted by Subperiods

We sort the stocks in each stock exchange into five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). For each liquidity measure, we then form a long-short liquidity-based self-financing portfolio. The portfolios are long in the most illiquid stocks, short in the most liquid stocks and rebalanced monthly. The sample period is 1964-2021 for NYSE & AMEX and 1986-2021 for NASDAQ. The table shows gross & net monthly mean gross excess returns, average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), for each stock exchange for various subperiods. Panel C presents the results for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. t-test and Wilcoxon refer to the parametric and non-parametric tests for the differences between the coefficients of two subperiods. Two-Subperiods Test relates to the first and last halves of the sample period: 1964-1992 vs 1993-2021 for NYSE. Similarly, the First-versus Last-Period Test refers to the first and last subperiods: 1964-1975 vs 2012-2021 for NYSE, and 1986-1999 vs 2012-2021 for NASDAQ.

	IMPACT				COST				SPEED				QUANTITY			
	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
PANEL C: AMEX																
Entire period:																
1964-2021	0.06%	-0.01%	-0.24%	-0.29%	-1.47%	-1.64%	-1.83%	-1.99%	0.53%	0.87%	0.35%	0.69%	0.27%	0.41%	0.12%	0.26%
	(0.23)	(0.02)	(0.95)	(1.19)	(4.61)	(6.26)	(5.83)	(7.67)	(1.98)	(3.20)	(1.32)	(2.62)	(0.93)	(1.71)	(0.42)	(1.10)
Two Subperiods																
1964-1992	-0.36%	-0.70%	-0.62%	-0.95%	-1.96%	-2.17%	-2.26%	-2.47%	0.12%	0.18%	-0.01%	0.05%	0.24%	0.19%	0.12%	0.07%
	(1.12)	(2.39)	(1.95)	(3.18)	(5.33)	(7.08)	(6.30)	(8.06)	(0.47)	(0.72)	(0.05)	(0.20)	(0.96)	(0.82)	(0.49)	(0.32)
1993-2021	0.43%	0.57%	0.11%	0.26%	-1.04%	-1.19%	-1.44%	-1.59%	0.87%	1.45%	0.66%	1.24%	0.28%	0.65%	0.10%	0.47%
	(1.14)	(1.67)	(0.31)	(0.77)	(2.09)	(3.08)	(2.93)	(4.14)	(2.01)	(3.41)	(1.54)	(2.99)	(0.51)	(1.53)	(0.18)	(1.10)
Five Subperiods																
1964-1975	0.44%	0.02%	0.19%	-0.19%	-1.48%	-1.24%	-1.75%	-1.48%	0.88%	0.26%	0.75%	0.13%	0.50%	-0.19%	0.40%	-0.28%
	(0.96)	(0.05)	(0.44)	(0.38)	(3.52)	(2.79)	(4.43)	(3.24)	(2.75)	(0.46)	(2.28)	(0.23)	(0.91)	(0.32)	(0.72)	(0.48)
1976-1987	-0.58%	-0.96%	-0.81%	-1.18%	-2.41%	-2.81%	-2.67%	-3.07%	-0.05%	0.32%	-0.18%	0.20%	-0.06%	0.17%	-0.18%	0.05%
	(1.25)	(2.31)	(1.72)	(2.79)	(4.53)	(7.49)	(5.06)	(8.21)	(0.13)	(1.03)	(0.45)	(0.62)	(0.20)	(0.78)	(0.59)	(0.24)
1988-1999	-0.63%	-0.19%	-0.96%	-0.51%	-1.91%	-2.18%	-2.31%	-2.58%	-0.59%	-0.04%	-0.73%	-0.18%	-0.02%	0.38%	-0.16%	0.24%
	(1.55)	(0.47)	(2.34)	(1.27)	(3.51)	(5.52)	(4.31)	(6.61)	(1.23)	(0.12)	(1.52)	(0.52)	(0.04)	(0.95)	(0.25)	(0.60)
2000-2011	-0.17%	-0.37%	-0.48%	-0.67%	-1.22%	-1.47%	-1.64%	-1.88%	0.27%	0.49%	0.11%	0.33%	0.55%	0.51%	0.38%	0.35%
	(0.29)	(0.79)	(0.86)	(1.45)	(1.13)	(1.90)	(1.54)	(2.44)	(0.54)	(1.21)	(0.22)	(0.81)	(1.38)	(1.37)	(0.98)	(0.93)
2012-2021	1.67%	1.77%	1.32%	1.43%	-0.08%	-0.08%	-0.51%	-0.50%	2.57%	3.52%	2.25%	3.21%	0.61%	1.54%	0.35%	1.28%
	(2.79)	(3.02)	(2.28)	(2.45)	(0.21)	(0.21)	(1.29)	(1.31)	(3.66)	(5.03)	(3.16)	(4.65)	(0.36)	(1.18)	(0.21)	(0.97)
Two-Subperiods Test																
t-test		1.19		1.07		0.11		0.23		1.68		1.55		1.09		0.95
Wilcoxon		1.22		1.07		0.10		0.43		1.48		1.36		1.14		0.99
First- versus Last-Period Test																
t-test		1.00		0.82		1.22		1.63		2.60		2.37		0.01		0.15
Wilcoxon		0.77		0.58		1.16		1.57		2.84		2.61		0.25		0.13

Appendix C: Long-short double sorted portfolio results by subperiods for Size

Appendix C1.

Liquidity-Sorted Long-Short Portfolio Returns: Sorted by Subperiod and Size

We sort the stock in each stock exchange into three size terciles, based on the previous end-of-year size. Size 1 refer to the smallest size and size 3 to the largest size. Within each size group, we sort the stocks into five five illiquidity quintiles, based on the rolling twelve-month IMPACT, COST, SPEED, and QUANTITY liquidity measures. IMPACT is a modified version of Amihud's (2002) liquidity measure adjusted for inflation presented in Dec. 2021 prices. COST is the average of Gibbs (Hasbrouck (2009)), HL (Corwin and Schultz (2012)), CHL (Abdi & Ranaldo (2017)) and VoV (Kyle and Obizhaeva (2016)). SPEED is Liu's (2006) Zero-Trading-Days liquidity proxy. QUANTITY is defined as the average number of shares traded divided by the average number of shares outstanding following Datar et al. (1998). For each liquidity measure, we then form a long-short liquidity-based self-financing portfolio. The portfolios are long in the most illiquid stocks, short in the most liquid stocks and rebalanced monthly. The table shows gross & net monthly mean gross excess returns, average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size and subperiod for each stock exchange. Panel A presents the results for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. Panel B reports the results for each of the three subperiods 1986-1999, 2000-2011, and 2012-2021 for NASDAQ. t-test and Wilcoxon refer to the parametric and non-parametric tests for the differences between the coefficients of two subperiods. Two-Subperiods Test relates to the first and last halves of the sample period: 1964-1992 vs 1993-2021 for NYSE. Similarly, the First-versus Last-Period Test refers to the first and last subperiods: 1964-1975 vs 2012-2021 for NYSE, and 1986-1999 vs 2012-2021 for NASDAQ.

	IMPACT				COST				SPEED				QUANTITY			
PANEL A: NYSE	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Size 2																
Two Subperiods																
1964-1992	0.43%	0.23%	0.38%	0.18%	-0.77%	-0.85%	-0.83%	-0.92%	0.00%	0.08%	-0.06%	0.03%	-0.07%	0.05%	-0.13%	-0.01%
	(3.17)	(1.71)	(2.78)	(1.32)	(5.42)	(7.20)	(5.93)	(7.82)	(0.03)	(0.58)	(0.30)	(0.21)	(0.30)	(0.35)	(0.59)	(0.04)
1993-2021	1.02%	0.99%	0.96%	0.93%	-0.05%	-0.41%	-0.12%	-0.48%	0.15%	0.38%	0.10%	0.33%	0.09%	0.32%	0.03%	0.27%
	(9.32)	(10.15)	(8.83)	(9.64)	(0.17)	(2.87)	(0.45)	(3.41)	(0.76)	(2.72)	(0.50)	(2.34)	(0.46)	(2.25)	(0.18)	(1.86)
Five Subperiods																
1964-1975	0.79%	0.51%	0.73%	0.45%	-0.81%	-0.61%	-0.89%	-0.69%	0.53%	0.29%	0.48%	0.23%	0.50%	0.10%	0.44%	0.04%
	(3.69)	(1.96)	(3.38)	(1.71)	(3.50)	(3.94)	(3.86)	(4.44)	(1.90)	(0.97)	(1.68)	(0.77)	(1.43)	(0.31)	(1.24)	(0.11)
1976-1987	0.27%	0.19%	0.23%	0.14%	-0.84%	-1.10%	-0.90%	-1.16%	-0.21%	0.10%	-0.26%	0.05%	-0.37%	0.13%	-0.43%	0.07%
	(1.47)	(1.06)	(1.21)	(0.79)	(3.53)	(5.98)	(3.80)	(6.35)	(0.85)	(0.60)	(1.04)	(0.31)	(1.15)	(0.62)	(1.34)	(0.34)
1988-1999	0.40%	0.25%	0.35%	0.20%	-0.59%	-0.69%	-0.66%	-0.75%	-0.21%	-0.05%	-0.25%	-0.10%	-0.20%	-0.06%	-0.26%	-0.12%
	(2.66)	(1.39)	(2.30)	(1.11)	(3.75)	(6.19)	(4.16)	(6.75)	(0.80)	(0.31)	(0.99)	(0.62)	(0.84)	(0.38)	(1.08)	(0.75)
2000-2011	1.20%	1.08%	1.14%	1.03%	0.26%	-0.06%	0.19%	-0.14%	0.18%	0.18%	0.13%	0.14%	0.06%	0.11%	0.01%	0.06%
	(6.81)	(7.90)	(6.61)	(7.57)	(0.67)	(0.38)	(0.48)	(0.82)	(0.61)	(0.90)	(0.44)	(0.66)	(0.21)	(0.56)	(0.04)	(0.32)
2012-2021	1.15%	1.22%	1.08%	1.16%	0.01%	-0.59%	-0.06%	-0.66%	0.28%	0.80%	0.22%	0.75%	0.30%	0.75%	0.25%	0.71%
	(7.08)	(8.35)	(6.51)	(7.99)	(0.01)	(1.90)	(0.12)	(2.17)	(0.69)	(3.13)	(0.54)	(2.88)	(0.78)	(3.02)	(0.64)	(2.78)
Two-Subperiods Test																
t-test		4.85		4.83		2.60		2.59		1.53		1.52		1.31		1.35
Wilcoxon		4.64		4.61		2.26		2.25		1.12		1.13		1.27		1.31
First- versus Last-Period Test																
t-test		2.39		2.33		0.15		0.13		1.27		1.24		1.49		1.50
Wilcoxon		2.48		2.41		0.27		0.25		1.59		1.53		1.53		1.55

Appendix C1. (continued)

Liquidity-Sorted Long-Short Portfolio Returns: Sorted by Subperiod and Size

	IMPACT				COST				SPEED				QUANTITY			
PANEL A: NYSE	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Size 3 (Large)																
Two Subperiods																
1964-1992	-0.25%	-0.32%	-0.27%	-0.35%	-0.60%	-0.66%	-0.65%	-0.72%	-0.32%	-0.27%	-0.34%	-0.30%	-0.35%	-0.31%	-0.39%	-0.34%
	(2.07)	(3.99)	(2.28)	(4.31)	(4.05)	(6.14)	(4.41)	(6.65)	(1.65)	(2.15)	(1.80)	(2.37)	(1.82)	(2.47)	(1.98)	(2.72)
1993-2021	0.35%	0.20%	0.32%	0.18%	-0.13%	-0.31%	-0.19%	-0.37%	-0.36%	-0.15%	-0.40%	-0.19%	-0.46%	-0.14%	-0.49%	-0.18%
	(2.80)	(2.35)	(2.58)	(2.02)	(0.49)	(2.30)	(0.71)	(2.75)	(1.52)	(0.93)	(1.67)	(1.13)	(1.79)	(0.76)	(1.91)	(0.93)
Five Subperiods																
1964-1975	-0.22%	-0.20%	-0.25%	-0.23%	-0.72%	-0.56%	-0.77%	-0.61%	0.25%	-0.02%	0.22%	-0.05%	0.20%	-0.07%	0.17%	-0.10%
	(1.24)	(1.59)	(1.40)	(1.81)	(2.55)	(3.06)	(2.75)	(3.37)	(0.64)	(0.07)	(0.56)	(0.17)	(0.55)	(0.23)	(0.46)	(0.33)
1976-1987	-0.19%	-0.37%	-0.22%	-0.40%	-0.59%	-0.83%	-0.64%	-0.88%	-0.64%	-0.37%	-0.67%	-0.40%	-0.74%	-0.46%	-0.77%	-0.49%
	(1.08)	(3.02)	(1.22)	(3.23)	(2.69)	(5.24)	(2.91)	(5.53)	(2.92)	(2.81)	(3.05)	(3.01)	(2.96)	(3.42)	(3.08)	(3.63)
1988-1999	-0.43%	-0.34%	-0.46%	-0.37%	-0.28%	-0.37%	-0.34%	-0.43%	-0.61%	-0.42%	-0.65%	-0.45%	-0.41%	-0.31%	-0.45%	-0.35%
	(2.75)	(3.89)	(2.91)	(4.19)	(1.67)	(2.52)	(2.08)	(2.98)	(2.51)	(2.91)	(2.64)	(3.15)	(1.29)	(1.28)	(1.42)	(1.44)
2000-2011	0.78%	0.38%	0.75%	0.35%	-0.40%	-0.47%	-0.47%	-0.54%	-0.28%	-0.23%	-0.32%	-0.27%	-0.61%	-0.23%	-0.65%	-0.27%
	(5.60)	(2.88)	(5.40)	(2.63)	(0.80)	(2.04)	(0.94)	(2.32)	(0.69)	(0.80)	(0.79)	(0.93)	(1.57)	(0.80)	(1.67)	(0.91)
2012-2021	0.39%	0.35%	0.37%	0.32%	0.21%	-0.09%	0.17%	-0.14%	-0.20%	0.14%	-0.23%	0.12%	-0.26%	0.06%	-0.29%	0.04%
	(2.91)	(3.81)	(2.77)	(3.59)	(0.45)	(0.40)	(0.36)	(0.62)	(0.52)	(0.58)	(0.59)	(0.47)	(0.68)	(0.24)	(0.74)	(0.15)
Two-Subperiods Test																
t-test		4.41		4.38		1.84		1.80		0.21		0.19		0.61		0.60
Wilcoxon		4.67		4.65		1.86		1.82		0.31		0.28		0.63		0.63
First- versus Last-Period Test																
t-test		3.21		3.21		1.79		1.79		0.47		0.46		1.17		1.17
Wilcoxon		3.17		3.17		2.12		2.12		0.61		0.59		1.05		1.04

Appendix C1. (continued)

Liquidity-Sorted Long-Short Portfolio Returns: Sorted by Subperiod and Size

	IMPACT				COST				SPEED				QUANTITY			
PANEL B: NASDAQ	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha	Gross excess return	Gross alpha	Net excess return	Net alpha
Size 2																
Three Subperiods																
1986-1999	1.72%	1.68%	1.29%	1.27%	-0.91%	-0.84%	-1.39%	-1.29%	1.57%	1.80%	1.20%	1.46%	0.88%	1.21%	0.45%	0.78%
	(6.83)	(8.54)	(5.01)	(5.91)	(5.04)	(4.95)	(7.05)	(6.80)	(3.69)	(6.70)	(2.79)	(5.04)	(2.70)	(5.43)	(1.36)	(3.31)
2000-2011	2.05%	1.90%	1.86%	1.72%	-0.90%	-0.79%	-1.12%	-1.01%	1.73%	1.67%	1.57%	1.51%	1.45%	1.42%	1.28%	1.25%
	(4.02)	(6.69)	(3.72)	(6.10)	(1.92)	(2.57)	(2.33)	(3.18)	(2.50)	(5.62)	(2.29)	(5.11)	(2.33)	(4.87)	(2.07)	(4.26)
2012-2021	1.05%	1.27%	0.87%	1.09%	-0.63%	-1.37%	-0.79%	-1.53%	1.18%	1.95%	1.05%	1.81%	1.00%	1.63%	0.87%	1.51%
	(3.86)	(7.10)	(3.00)	(5.80)	(1.58)	(6.34)	(2.02)	(6.90)	(2.60)	(7.32)	(2.23)	(6.95)	(2.19)	(6.27)	(1.88)	(5.86)
First- versus Last-Period Test																
t-test		3.37		4.84		0.83		1.88		0.37		1.26		3.46		4.66
Wilcoxon		3.16		4.59		1.27		2.41		0.21		1.12		3.61		4.62
Size 3 (Large)																
Three Subperiods																
1986-1999	-0.23%	0.03%	-0.37%	-0.10%	-0.38%	-0.33%	-0.56%	-0.50%	-0.73%	-0.03%	-0.86%	-0.16%	-1.08%	-0.51%	-1.23%	-0.66%
	(0.92)	(0.14)	(1.46)	(0.45)	(1.00)	(1.04)	(1.47)	(1.60)	(1.26)	(0.10)	(1.47)	(0.45)	(1.68)	(1.78)	(1.91)	(2.29)
2000-2011	0.74%	0.14%	0.65%	0.06%	-0.34%	-0.22%	-0.47%	-0.35%	0.64%	0.16%	0.57%	0.08%	0.18%	0.28%	0.11%	0.21%
	(2.13)	(0.95)	(1.94)	(0.40)	(0.49)	(0.71)	(0.67)	(1.11)	(1.05)	(0.55)	(0.94)	(0.28)	(0.37)	(0.99)	(0.23)	(0.73)
2012-2021	0.33%	0.55%	0.27%	0.49%	0.54%	-0.14%	0.46%	-0.22%	-0.29%	0.18%	-0.34%	0.13%	-0.03%	0.38%	-0.07%	0.34%
	(1.88)	(3.63)	(1.53)	(3.21)	(0.91)	(0.47)	(0.78)	(0.76)	(0.63)	(0.65)	(0.74)	(0.46)	(0.06)	(1.48)	(0.17)	(1.31)
First- versus Last-Period Test																
t-test		3.91		4.48		3.54		3.82		0.93		1.16		2.15		2.48
Wilcoxon		3.82		4.37		3.50		3.76		0.96		1.18		2.14		2.44

Appendix D: Performance of Cost Mitigation Strategies

Appendix D1.

Transaction cost mitigation strategies: 20%/40% Buy and Hold

This table presents the results of the liquidity-based long-short portfolios for IMPACT, COST, SPEED, and QUANTITY after applying the cost mitigation strategy using a 20%/40% buy-and-hold rule, similar to Novy-Marx & Velikov (2016), which implies that stocks are purchased when they enter the top liquidity quintile (20%) and are held until they fall out of the second top liquidity quintile (40%). The table shows transaction costs, gross & net average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size and subperiod for each stock exchange. Panel A presents the results for size 1-3 for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. Panel B reports the results for size 1-3 for each of the three subperiods 1986-1999, 2000-2011, and 2012-2021 for NASDAQ.

	IMPACT			COST			SPEED			QUANTITY		
	Gross	Tcost	Net	Gross	Tcost	Net	Gross	Tcost	Net	Gross	Tcost	Net
PANEL A: NYSE	alpha		alpha	alpha		alpha	alpha		alpha	alpha		alpha
Size 1 (Small)												
Two Subperiods												
1964-1992	0.41%	0.13%	0.28%	-1.83%	0.15%	-1.98%	0.90%	0.08%	0.81%	0.57%	0.10%	0.47%
	(2.39)		(1.62)	(7.27)		(7.52)	(6.31)		(5.77)	(4.08)		(3.38)
1993-2021	1.16%	0.12%	1.05%	-1.06%	0.14%	-1.20%	1.21%	0.09%	1.12%	1.05%	0.09%	0.96%
	(7.97)		(7.10)	(4.49)		(5.13)	(7.29)		(6.64)	(6.33)		(5.70)
Five Subperiods												
1964-1975	0.70%	0.11%	0.60%	-0.77%	0.11%	-0.88%	0.68%	0.08%	0.60%	0.50%	0.09%	0.41%
	(2.43)		(2.05)	(2.82)		(3.26)	(2.63)		(2.28)	(1.76)		(1.40)
1976-1987	0.43%	0.10%	0.34%	-1.86%	0.11%	-1.96%	0.80%	0.07%	0.72%	0.52%	0.08%	0.44%
	(1.83)		(1.43)	(7.43)		(7.85)	(4.52)		(4.12)	(2.97)		(2.51)
1988-1999	0.46%	0.17%	0.29%	-2.52%	0.21%	-2.72%	1.34%	0.10%	1.24%	0.86%	0.12%	0.74%
	(1.94)		(1.16)	(7.72)		(7.83)	(7.69)		(7.24)	(4.86)		(4.24)
2000-2011	1.34%	0.10%	1.25%	-0.64%	0.13%	-0.77%	0.96%	0.09%	0.88%	0.83%	0.09%	0.75%
	(5.01)		(4.62)	(2.39)		(2.87)	(4.19)		(3.75)	(3.85)		(3.36)
2012-2021	1.18%	0.14%	1.04%	-0.99%	0.14%	-1.13%	1.47%	0.11%	1.37%	1.41%	0.09%	1.32%
	(6.10)		(5.33)	(1.92)		(2.25)	(4.37)		(3.98)	(4.07)		(3.74)
Size 2												
Two Subperiods												
1964-1992	0.20%	0.05%	0.15%	-0.85%	0.06%	-0.91%	0.06%	0.05%	0.01%	0.00%	0.06%	-0.05%
	(1.51)		(1.12)	(7.96)		(8.56)	(0.47)		(0.09)	(0.02)		(0.35)
1993-2021	0.91%	0.06%	0.85%	-0.33%	0.06%	-0.39%	0.35%	0.05%	0.30%	0.31%	0.05%	0.26%
	(10.12)		(9.57)	(2.48)		(3.00)	(2.61)		(2.22)	(2.32)		(1.94)
Five Subperiods												
1964-1975	0.50%	0.06%	0.44%	-0.59%	0.07%	-0.66%	0.23%	0.06%	0.18%	0.13%	0.06%	0.07%
	(1.98)		(1.72)	(4.07)		(4.53)	(0.80)		(0.61)	(0.40)		(0.21)
1976-1987	0.17%	0.05%	0.13%	-1.08%	0.06%	-1.14%	0.08%	0.05%	0.03%	0.05%	0.05%	0.00%
	(1.00)		(0.73)	(6.93)		(7.32)	(0.48)		(0.19)	(0.25)		(0.01)
1988-1999	0.21%	0.05%	0.16%	-0.61%	0.06%	-0.67%	-0.06%	0.05%	-0.11%	-0.13%	0.05%	-0.18%
	(1.19)		(0.89)	(5.75)		(6.30)	(0.44)		(0.80)	(0.81)		(1.13)
2000-2011	1.00%	0.05%	0.95%	-0.01%	0.07%	-0.07%	0.17%	0.05%	0.12%	0.14%	0.05%	0.10%
	(7.57)		(7.20)	(0.07)		(0.53)	(0.87)		(0.62)	(0.74)		(0.49)
2012-2021	1.09%	0.06%	1.03%	-0.54%	0.07%	-0.60%	0.76%	0.05%	0.71%	0.73%	0.05%	0.69%
	(8.10)		(7.76)	(1.80)		(2.07)	(3.09)		(2.84)	(3.14)		(2.90)

Appendix D1. (continued)

Transaction cost mitigation strategies: 20%/40% Buy and Hold

	IMPACT			COST			SPEED			QUANTITY		
	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha
PANEL A: NYSE												
Size 3 (Large)												
Two Subperiods												
1964-1992	-0.33%	0.03%	-0.35%	-0.62%	0.04%	-0.67%	-0.27%	0.03%	-0.30%	-0.29%	0.03%	-0.32%
	(4.02)		(4.34)	(5.92)		(6.37)	(2.20)		(2.42)	(2.35)		(2.56)
1993-2021	0.18%	0.03%	0.15%	-0.30%	0.05%	-0.36%	-0.16%	0.03%	-0.19%	-0.22%	0.03%	-0.25%
	(2.06)		(1.73)	(2.35)		(2.74)	(0.96)		(1.16)	(1.17)		(1.32)
Five Subperiods												
1964-1975	-0.19%	0.03%	-0.22%	-0.56%	0.04%	-0.61%	-0.01%	0.03%	-0.04%	-0.06%	0.03%	-0.09%
	(1.56)		(1.78)	(3.75)		(4.08)	(0.03)		(0.13)	(0.19)		(0.29)
1976-1987	-0.36%	0.02%	-0.38%	-0.75%	0.04%	-0.80%	-0.39%	0.03%	-0.42%	-0.43%	0.03%	-0.45%
	(2.90)		(3.11)	(4.69)		(4.94)	(2.98)		(3.17)	(2.85)		(3.03)
1988-1999	-0.39%	0.03%	-0.42%	-0.35%	0.05%	-0.41%	-0.41%	0.03%	-0.44%	-0.41%	0.03%	-0.44%
	(4.12)		(4.40)	(2.42)		(2.82)	(2.77)		(3.00)	(2.11)		(2.28)
2000-2011	0.35%	0.03%	0.32%	-0.42%	0.06%	-0.48%	-0.26%	0.04%	-0.30%	-0.37%	0.04%	-0.41%
	(2.78)		(2.52)	(1.89)		(2.13)	(0.89)		(1.01)	(1.18)		(1.28)
2012-2021	0.34%	0.02%	0.31%	-0.14%	0.04%	-0.19%	0.15%	0.03%	0.12%	0.11%	0.02%	0.09%
	(3.72)		(3.50)	(0.64)		(0.83)	(0.61)		(0.50)	(0.44)		(0.35)
PANEL B: NASDAQ												
Size 1 (Small)												
Three Subperiods												
1986-1999	2.08%	1.04%	1.10%	-1.03%	1.14%	-2.12%	3.16%	0.84%	2.35%	2.29%	1.03%	1.30%
	(7.96)		(3.73)	(5.65)		(9.45)	(12.56)		(8.59)	(10.52)		(5.59)
2000-2011	2.25%	0.44%	1.81%	-1.01%	0.46%	-1.47%	2.57%	0.33%	2.25%	1.75%	0.42%	1.32%
	(9.37)		(6.98)	(3.30)		(4.38)	(7.04)		(6.38)	(6.78)		(5.11)
2012-2021	3.26%	0.29%	2.98%	-0.66%	0.35%	-1.01%	4.04%	0.26%	3.79%	2.62%	0.53%	2.13%
	(12.07)		(10.97)	(1.88)		(2.96)	(11.97)		(11.16)	(5.78)		(4.02)
Size 2												
Three Subperiods												
1986-1999	1.59%	0.43%	1.18%	-0.74%	0.44%	-1.15%	1.72%	0.38%	1.37%	1.09%	0.42%	0.68%
	(8.26)		(5.66)	(4.57)		(6.29)	(6.63)		(4.90)	(4.85)		(2.85)
2000-2011	1.86%	0.19%	1.67%	-0.79%	0.20%	-0.98%	1.63%	0.17%	1.47%	1.35%	0.17%	1.18%
	(6.88)		(6.25)	(2.54)		(3.07)	(5.63)		(5.09)	(4.87)		(4.24)
2012-2021	1.21%	0.19%	1.02%	-1.31%	0.15%	-1.46%	1.86%	0.14%	1.73%	1.63%	0.12%	1.52%
	(7.20)		(5.65)	(6.52)		(6.96)	(7.26)		(6.82)	(6.72)		(6.33)
Size 3 (Large)												
Three Subperiods												
1986-1999	-0.01%	0.14%	-0.15%	-0.27%	0.16%	-0.42%	-0.06%	0.13%	-0.19%	-0.41%	0.13%	-0.54%
	(0.03)		(0.66)	(0.83)		(1.31)	(0.19)		(0.56)	(1.45)		(1.90)
2000-2011	0.13%	0.09%	0.05%	-0.18%	0.11%	-0.29%	0.12%	0.07%	0.04%	0.25%	0.07%	0.19%
	(0.89)		(0.32)	(0.55)		(0.89)	(0.42)		(0.15)	(0.93)		(0.68)
2012-2021	0.52%	0.06%	0.46%	-0.08%	0.07%	-0.15%	0.24%	0.05%	0.19%	0.39%	0.04%	0.35%
	(3.39)		(2.96)	(0.30)		(0.55)	(0.92)		(0.72)	(1.56)		(1.40)

Appendix D2.

Transaction cost mitigation strategies: Low-cost stocks

This table presents the results of the liquidity-based long-short portfolios for IMPACT, COST, SPEED, and QUANTITY after applying the cost mitigation strategy using low-cost stocks, similar to Novy-Marx & Velikov (2016), which implies that stocks are purchased when they enter the top liquidity quintile (20%) and are held until they fall out of the second top liquidity quintile (40%). The table shows transaction costs, gross & net average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size and subperiod for each stock exchange. Panel A presents the results for size 1-3 for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. Panel B reports the results for size 1-3 for each of the three subperiods 1986-1999, 2000-2011, and 2012-2021 for NASDAQ.

	IMPACT			COST			SPEED			QUANTITY		
	Gross	Tcost	Net	Gross	Tcost	Net	Gross	Tcost	Net	Gross	Tcost	Net
PANEL A: NYSE	alpha		alpha	alpha		alpha	alpha		alpha	alpha		alpha
Size 1 (Small)												
Two Subperiods												
1964-1992	-0.29%	0.06%	-0.35%	-0.55%	0.08%	-0.62%	-0.23%	0.06%	-0.29%	-0.46%	0.06%	-0.52%
	(2.38)		(2.92)	(3.47)		(3.98)	(1.49)		(1.84)	(3.29)		(3.73)
1993-2021	0.02%	0.06%	-0.04%	-0.32%	0.07%	-0.39%	-0.11%	0.06%	-0.17%	-0.18%	0.06%	-0.24%
	(0.15)		(0.31)	(2.94)		(3.61)	(0.83)		(1.26)	(1.44)		(1.89)
Five Subperiods												
1964-1975	-0.32%	0.07%	-0.40%	-0.25%	0.08%	-0.34%	0.22%	0.06%	0.15%	-0.40%	0.07%	-0.47%
	(1.56)		(1.88)	(1.58)		(2.07)	(0.90)		(0.63)	(1.34)		(1.58)
1976-1987	-0.18%	0.06%	-0.25%	-0.70%	0.08%	-0.78%	-0.23%	0.05%	-0.28%	-0.44%	0.06%	-0.50%
	(1.10)		(1.47)	(2.56)		(2.85)	(1.14)		(1.39)	(2.54)		(2.87)
1988-1999	-0.19%	0.06%	-0.25%	-0.53%	0.07%	-0.60%	-0.53%	0.05%	-0.58%	-0.58%	0.06%	-0.64%
	(1.11)		(1.44)	(4.09)		(4.62)	(2.44)		(2.67)	(2.88)		(3.15)
2000-2011	-0.37%	0.07%	-0.44%	-0.46%	0.08%	-0.53%	-0.28%	0.06%	-0.33%	-0.15%	0.06%	-0.21%
	(1.80)		(2.12)	(2.87)		(3.28)	(1.26)		(1.53)	(0.69)		(0.97)
2012-2021	0.50%	0.06%	0.43%	-0.05%	0.08%	-0.13%	0.18%	0.06%	0.12%	0.04%	0.06%	-0.01%
	(2.11)		(1.86)	(0.24)		(0.59)	(0.97)		(0.67)	(0.26)		(0.07)
Size 2												
Two Subperiods												
1964-1992	-0.09%	0.05%	-0.15%	-0.81%	0.07%	-0.88%	-0.41%	0.05%	-0.46%	-0.51%	0.05%	-0.56%
	(0.73)		(1.12)	(7.78)		(8.43)	(3.03)		(3.37)	(3.21)		(3.54)
1993-2021	0.20%	0.06%	0.15%	-0.05%	0.07%	-0.12%	-0.14%	0.05%	-0.19%	-0.18%	0.05%	-0.23%
	(2.01)		(1.46)	(0.60)		(1.35)	(1.49)		(1.99)	(1.78)		(2.29)
Five Subperiods												
1964-1975	0.23%	0.05%	0.18%	-0.72%	0.08%	-0.79%	-0.23%	0.05%	-0.28%	-0.55%	0.06%	-0.61%
	(1.11)		(0.85)	(5.90)		(6.54)	(0.79)		(0.96)	(1.48)		(1.64)
1976-1987	-0.27%	0.05%	-0.32%	-0.84%	0.06%	-0.90%	-0.52%	0.04%	-0.56%	-0.51%	0.05%	-0.56%
	(1.42)		(1.66)	(4.68)		(5.02)	(3.93)		(4.28)	(3.61)		(3.96)
1988-1999	0.09%	0.06%	0.03%	-0.40%	0.06%	-0.46%	-0.25%	0.04%	-0.29%	-0.22%	0.05%	-0.27%
	(0.58)		(0.22)	(2.36)		(2.73)	(1.16)		(1.37)	(1.00)		(1.24)
2000-2011	0.11%	0.07%	0.04%	-0.17%	0.07%	-0.24%	-0.22%	0.05%	-0.27%	-0.34%	0.05%	-0.39%
	(0.65)		(0.27)	(1.11)		(1.59)	(1.72)		(2.13)	(2.58)		(3.01)
2012-2021	0.27%	0.05%	0.23%	0.08%	0.07%	0.01%	-0.06%	0.05%	-0.10%	-0.08%	0.05%	-0.13%
	(1.80)		(1.49)	(0.54)		(0.10)	(0.42)		(0.76)	(0.45)		(0.72)

Appendix D2. (continued)

Transaction cost mitigation strategies: Low-cost stocks

	IMPACT			COST			SPEED			QUANTITY		
	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha
PANEL A: NYSE												
Size 3 (Large)												
Two Subperiods												
1964-1992	-0.59%	0.03%	-0.63%	-0.67%	0.06%	-0.74%	-0.50%	0.03%	-0.53%	-0.47%	0.04%	-0.51%
	(5.56)		(5.87)	(3.88)		(4.26)	(3.65)		(3.89)	(3.21)		(3.45)
1993-2021	-0.11%	0.04%	-0.14%	-0.25%	0.07%	-0.31%	-0.25%	0.04%	-0.29%	-0.29%	0.04%	-0.33%
	(1.09)		(1.47)	(2.51)		(3.20)	(1.90)		(2.18)	(1.77)		(2.01)
Five Subperiods												
1964-1975	-0.23%	0.03%	-0.26%	-0.56%	0.07%	-0.63%	-0.46%	0.03%	-0.50%	-0.28%	0.04%	-0.32%
	(1.53)		(1.75)	(1.96)		(2.21)	(1.56)		(1.68)	(0.93)		(1.04)
1976-1987	-0.73%	0.03%	-0.77%	-0.83%	0.06%	-0.89%	-0.59%	0.03%	-0.63%	-0.59%	0.04%	-0.63%
	(4.71)		(4.90)	(2.94)		(3.16)	(3.21)		(3.37)	(2.87)		(3.03)
1988-1999	-0.48%	0.04%	-0.52%	-0.31%	0.06%	-0.37%	-0.36%	0.04%	-0.40%	-0.30%	0.04%	-0.34%
	(2.67)		(2.91)	(2.01)		(2.44)	(2.47)		(2.75)	(1.43)		(1.64)
2000-2011	-0.21%	0.04%	-0.26%	-0.40%	0.08%	-0.47%	-0.27%	0.04%	-0.32%	-0.40%	0.04%	-0.45%
	(1.38)		(1.66)	(2.47)		(2.90)	(1.15)		(1.32)	(1.35)		(1.48)
2012-2021	0.13%	0.03%	0.10%	-0.10%	0.06%	-0.16%	-0.13%	0.03%	-0.16%	-0.22%	0.03%	-0.25%
	(1.53)		(1.18)	(0.63)		(1.00)	(0.65)		(0.80)	(1.13)		(1.27)
PANEL B: NASDAQ												
Size 1 (Small)												
Three Subperiods												
1986-1999	0.97%	0.21%	0.77%	-0.02%	0.23%	-0.25%	1.04%	0.19%	0.86%	1.49%	0.21%	1.28%
	(3.86)		(3.03)	(0.16)		(1.59)	(4.99)		(4.02)	(3.34)		(2.92)
2000-2011	0.81%	0.12%	0.69%	-0.45%	0.15%	-0.59%	0.48%	0.12%	0.36%	0.44%	0.12%	0.32%
	(4.27)		(3.66)	(2.69)		(3.52)	(2.20)		(1.65)	(1.85)		(1.35)
2012-2021	0.72%	0.09%	0.63%	-0.10%	0.12%	-0.22%	0.76%	0.09%	0.67%	0.62%	0.08%	0.54%
	(3.75)		(3.28)	(0.60)		(1.36)	(3.85)		(3.35)	(2.85)		(2.44)
Size 2												
Three Subperiods												
1986-1999	0.88%	0.17%	0.72%	-0.09%	0.20%	-0.29%	0.63%	0.15%	0.49%	0.16%	0.18%	-0.01%
	(4.81)		(3.86)	(0.60)		(1.82)	(2.37)		(1.83)	(0.40)		(0.03)
2000-2011	0.55%	0.10%	0.45%	-0.06%	0.14%	-0.19%	0.02%	0.09%	-0.07%	-0.13%	0.09%	-0.23%
	(2.82)		(2.30)	(0.31)		(1.05)	(0.10)		(0.31)	(0.42)		(0.71)
2012-2021	0.79%	0.07%	0.72%	0.07%	0.10%	-0.03%	0.26%	0.06%	0.20%	0.32%	0.06%	0.26%
	(3.98)		(3.67)	(0.39)		(0.15)	(1.55)		(1.18)	(1.80)		(1.44)
Size 3 (Large)												
Three Subperiods												
1986-1999	0.16%	0.10%	0.07%	-0.31%	0.13%	-0.43%	-0.62%	0.09%	-0.71%	-0.94%	0.11%	-1.04%
	(0.79)		(0.32)	(1.45)		(2.04)	(2.11)		(2.42)	(2.15)		(2.38)
2000-2011	0.11%	0.07%	0.04%	0.38%	0.11%	0.28%	-0.25%	0.07%	-0.32%	-0.30%	0.07%	-0.37%
	(0.57)		(0.23)	(1.29)		(0.95)	(0.81)		(1.02)	(0.82)		(0.99)
2012-2021	0.13%	0.04%	0.09%	0.38%	0.08%	0.30%	-0.18%	0.05%	-0.22%	0.11%	0.04%	0.07%
	(0.96)		(0.65)	(1.52)		(1.24)	(0.62)		(0.78)	(0.42)		(0.27)

Appendix D3.

Transaction cost mitigation strategies: Staggered Rebalancing

This table presents the results of the liquidity-based long-short portfolios for IMPACT, COST, SPEED, and QUANTITY after applying the cost mitigation strategy using staggered rebalancing, similar to Novy-Marx & Velikov (2016), which implies that stocks are purchased when they enter the top liquidity quintile (20%) and are held until they fall out of the second top liquidity quintile (40%). The table shows transaction costs, gross & net average Fama-French four-factor alphas (eq. 20) and corresponding Newey-West (1987) t-statistics (in parentheses), by size and subperiod for each stock exchange. Panel A presents the results for size 1-3 for each of the five subperiods 1964-1975, 1976-1987, 1988-1999, 2000-2011, and 2012-2021 as well as the two subperiods 1964-1992 and 1993-2021 for NYSE. Panel B reports the results for size 1-3 for each of the three subperiods 1986-1999, 2000-2011, and 2012-2021 for NASDAQ.

	IMPACT			COST			SPEED			QUANTITY		
	Gross	Tcost	Net	Gross	Tcost	Net	Gross	Tcost	Net	Gross	Tcost	Net
PANEL A: NYSE	alpha		alpha	alpha		alpha	alpha		alpha	alpha		alpha
Size 1 (Small)												
Two Subperiods												
1964-1992	-0.27%	0.13%	-0.39%	-2.66%	0.15%	-2.81%	0.64%	0.08%	0.56%	0.30%	0.09%	0.21%
	(1.66)		(2.37)	(10.33)		(10.41)	(4.97)		(4.41)	(1.84)		(1.32)
1993-2021	0.52%	0.12%	0.41%	-2.25%	0.14%	-2.38%	0.92%	0.09%	0.83%	0.97%	0.09%	0.88%
	(3.23)		(2.48)	(7.65)		(8.16)	(5.10)		(4.54)	(5.18)		(4.67)
Five Subperiods												
1964-1975	0.10%	0.10%	0.00%	-1.60%	0.11%	-1.71%	0.48%	0.08%	0.41%	0.17%	0.08%	0.09%
	(0.40)		(0.00)	(5.08)		(5.43)	(2.48)		(2.03)	(0.55)		(0.28)
1976-1987	-0.24%	0.10%	-0.33%	-2.70%	0.11%	-2.80%	0.49%	0.07%	0.42%	0.12%	0.07%	0.05%
	(1.11)		(1.55)	(10.52)		(10.87)	(3.03)		(2.61)	(0.64)		(0.27)
1988-1999	-0.26%	0.17%	-0.42%	-3.43%	0.21%	-3.64%	1.03%	0.10%	0.93%	0.89%	0.10%	0.79%
	(1.10)		(1.71)	(10.53)		(10.51)	(5.95)		(5.49)	(4.82)		(4.34)
2000-2011	0.61%	0.10%	0.51%	-2.11%	0.13%	-2.23%	0.72%	0.09%	0.64%	0.61%	0.09%	0.53%
	(1.78)		(1.48)	(5.02)		(5.26)	(2.80)		(2.43)	(2.31)		(1.96)
2012-2021	0.66%	0.15%	0.52%	-1.97%	0.14%	-2.11%	1.21%	0.10%	1.10%	1.46%	0.10%	1.37%
	(3.78)		(2.88)	(3.15)		(3.45)	(3.19)		(2.88)	(4.02)		(3.73)
Size 2												
Two Subperiods												
1964-1992	-0.14%	0.05%	-0.19%	-1.51%	0.05%	-1.56%	-0.10%	0.05%	-0.15%	-0.13%	0.05%	-0.18%
	(1.05)		(1.43)	(13.16)		(13.64)	(0.67)		(1.00)	(0.82)		(1.13)
1993-2021	0.65%	0.06%	0.60%	-1.00%	0.06%	-1.06%	0.41%	0.05%	0.36%	0.41%	0.05%	0.36%
	(6.26)		(5.71)	(7.12)		(7.53)	(2.88)		(2.52)	(2.75)		(2.40)
Five Subperiods												
1964-1975	0.01%	0.06%	-0.05%	-1.35%	0.06%	-1.41%	0.21%	0.05%	0.15%	0.16%	0.05%	0.11%
	(0.05)		(0.16)	(8.56)		(8.98)	(0.67)		(0.48)	(0.44)		(0.29)
1976-1987	-0.12%	0.05%	-0.17%	-1.62%	0.05%	-1.67%	-0.16%	0.04%	-0.20%	-0.20%	0.05%	-0.25%
	(0.66)		(0.93)	(8.61)		(8.87)	(0.87)		(1.12)	(1.12)		(1.38)
1988-1999	-0.07%	0.05%	-0.12%	-1.30%	0.05%	-1.36%	-0.14%	0.05%	-0.19%	-0.15%	0.05%	-0.20%
	(0.39)		(0.67)	(8.86)		(9.13)	(0.87)		(1.17)	(0.92)		(1.22)
2000-2011	0.69%	0.05%	0.64%	-0.69%	0.06%	-0.74%	0.18%	0.05%	0.13%	0.19%	0.05%	0.14%
	(4.20)		(3.88)	(3.35)		(3.60)	(0.92)		(0.68)	(0.94)		(0.70)
2012-2021	0.93%	0.06%	0.87%	-1.26%	0.06%	-1.32%	0.92%	0.05%	0.87%	0.93%	0.05%	0.88%
	(5.99)		(5.44)	(4.73)		(5.01)	(3.65)		(3.41)	(3.51)		(3.30)

Appendix D3. (continued)

Transaction cost mitigation strategies: Staggered Rebalancing

	IMPACT			COST			SPEED			QUANTITY		
	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha	Gross alpha	Tcost	Net alpha
PANEL A: NYSE												
Size 3 (Large)												
Two Subperiods												
1964-1992	-0.46%	0.03%	-0.49%	-1.16%	0.03%	-1.19%	-0.29%	0.03%	-0.32%	-0.31%	0.03%	-0.34%
	(5.43)		(5.72)	(10.33)		(10.59)	(2.25)		(2.46)	(2.35)		(2.55)
1993-2021	0.08%	0.03%	0.06%	-0.79%	0.04%	-0.83%	-0.03%	0.03%	-0.06%	0.02%	0.03%	-0.01%
	(0.96)		(0.63)	(5.18)		(5.41)	(0.20)		(0.39)	(0.12)		(0.08)
Five Subperiods												
1964-1975	-0.35%	0.03%	-0.37%	-1.16%	0.03%	-1.19%	-0.04%	0.03%	-0.07%	-0.07%	0.03%	-0.10%
	(2.60)		(2.79)	(7.66)		(7.90)	(0.14)		(0.25)	(0.24)		(0.33)
1976-1987	-0.46%	0.02%	-0.49%	-1.22%	0.03%	-1.25%	-0.41%	0.03%	-0.44%	-0.44%	0.03%	-0.46%
	(3.54)		(3.73)	(6.02)		(6.16)	(2.64)		(2.81)	(2.97)		(3.14)
1988-1999	-0.51%	0.03%	-0.54%	-0.72%	0.03%	-0.76%	-0.35%	0.03%	-0.38%	-0.21%	0.03%	-0.24%
	(4.92)		(5.18)	(5.38)		(5.71)	(2.18)		(2.39)	(1.06)		(1.23)
2000-2011	0.30%	0.03%	0.27%	-1.00%	0.04%	-1.04%	-0.09%	0.04%	-0.12%	-0.13%	0.04%	-0.16%
	(2.20)		(1.97)	(3.20)		(3.33)	(0.30)		(0.42)	(0.47)		(0.60)
2012-2021	0.17%	0.02%	0.14%	-0.74%	0.03%	-0.77%	0.25%	0.03%	0.22%	0.28%	0.03%	0.25%
	(1.75)		(1.50)	(3.70)		(3.85)	(1.05)		(0.93)	(1.21)		(1.10)
PANEL B: NASDAQ												
Size 1 (Small)												
Three Subperiods												
1986-1999	1.14%	0.98%	0.23%	-2.75%	1.07%	-3.76%	2.82%	0.80%	2.05%	1.77%	0.85%	0.97%
	(4.38)		(0.75)	(12.05)		(15.50)	(10.10)		(6.68)	(7.69)		(3.73)
2000-2011	1.54%	0.42%	1.12%	-2.86%	0.45%	-3.31%	2.47%	0.33%	2.16%	1.85%	0.35%	1.50%
	(4.67)		(3.07)	(6.30)		(6.83)	(6.13)		(5.46)	(6.12)		(4.95)
2012-2021	2.81%	0.28%	2.53%	-1.64%	0.34%	-1.98%	4.02%	0.26%	3.76%	3.33%	0.38%	2.97%
	(11.13)		(9.75)	(3.70)		(4.60)	(10.78)		(9.95)	(13.45)		(10.84)
Size 2												
Three Subperiods												
1986-1999	1.00%	0.41%	0.61%	-2.30%	0.42%	-2.69%	1.52%	0.37%	1.18%	0.95%	0.38%	0.60%
	(4.34)		(2.44)	(13.53)		(14.41)	(5.02)		(3.66)	(4.14)		(2.43)
2000-2011	1.14%	0.18%	0.96%	-2.24%	0.18%	-2.42%	1.30%	0.16%	1.15%	1.20%	0.15%	1.05%
	(3.98)		(3.33)	(4.46)		(4.70)	(4.62)		(4.08)	(4.38)		(3.80)
2012-2021	0.73%	0.17%	0.56%	-2.24%	0.15%	-2.39%	1.56%	0.14%	1.42%	1.75%	0.11%	1.64%
	(3.94)		(2.75)	(7.90)		(8.31)	(6.48)		(6.08)	(6.44)		(6.16)
Size 3 (Large)												
Three Subperiods												
1986-1999	-0.23%	0.14%	-0.36%	-1.39%	0.16%	-1.54%	-0.19%	0.12%	-0.30%	-0.22%	0.11%	-0.33%
	(1.08)		(1.68)	(4.10)		(4.50)	(0.56)		(0.89)	(0.65)		(0.97)
2000-2011	-0.02%	0.09%	-0.11%	-1.29%	0.10%	-1.38%	0.23%	0.08%	0.15%	0.20%	0.07%	0.13%
	(0.13)		(0.56)	(2.64)		(2.79)	(0.89)		(0.59)	(0.54)		(0.35)
2012-2021	0.26%	0.06%	0.21%	-0.60%	0.06%	-0.66%	0.27%	0.05%	0.22%	0.47%	0.04%	0.42%
	(1.76)		(1.34)	(1.75)		(1.92)	(1.02)		(0.84)	(1.96)		(1.78)