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MASTER'S THESIS

DOES LIQUIDITY RISK EXPLAIN THE EXCESS RETURNS OF THE MINIMUM VOLATILITY INVESTING STRATEGY?

Ljubljana, May 2016 GORAN OBRADOVIĆ

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In the past, many researchers in asset pricing have thoroughly tested many models proposed by the traditional finance theory, with the Capital Asset Pricing Model (hereinafter: CAPM) being one of the most notorious models (see for example Sharpe (1964); Lintner (1965); Black (1972)). The CAPM could not account for the returns of some portfolios, which consistently violated the assumptions of the model and the underlying theory. This means that the market capitalization-weighted (hereinafter: MCW) portfolio, which ought to be the most efficient portfolio according to the CAPM, does not give the most efficient investing strategy with the greatest Sharpe ratio. The shortcomings of the CAPM and MCW investing were revealed in a number of research papers, showing that relatively simple investing strategies generate statistically significantly higher returns than the MCW portfolio (Blitz & van Vliet, 2007). The most recognized contribution to the field of finance was made by Fama and French (1992), who documented the outperformance of the market, in terms of risk-adjusted returns, by firms with a small market capitalization and those with a high book-to-market value. Later they found that these premiums were a compensation for additional risk factors (Fama & French, 1993). Their discovery was extended by Carhart (1997), who included a momentum risk factor which enhanced the explanation of excess returns. Since it was possible, by these simple strategies, to generate similar and greater returns to those of the market, the assumption of market efficiency started being questioned.

The increasing research of the subject led to many authors suggesting a shift to risk-based strategies. Among those strategies, one of the most successful and closely studied was the minimum variance strategy, or in other words the strategy of minimum volatility (hereinafter: MV) investing. MV investing takes advantage of the fact that securities with low volatility tend to outperform the ones with high volatility, also called the volatility effect (Blitz & van Vliet, 2007). The discovery that low-volatility stocks earn high risk-adjusted returns was first revealed by Black, Jensen and Scholes (1972) and Fama and MacBeth (1973), but gained more attention with Haugen and Baker in 1991. They found that market-matching to domestic cap-weighted stock indexes was not an optimal investing strategy when the CAPM assumptions did not hold. There exist alternatives that have the same (or greater) return and lower volatility (Haugen & Baker, 1991). Among those alternatives, the MV strategy has probably received the most attention from researchers as well as practitioners. Empirical observations put the MV portfolio above its theoretical position on the risk-return plane, while the empirical MCW portfolio falls below its theoretical position. Reviewing the relevant literature, we find that MV portfolios seem to generate greater returns at a lower level of risk than MCW portfolios. Outperformance of stocks with the lowest volatility is considered somewhat of an anomaly, since it violates the assumptions on which traditional finance theory rests. This is why it has been a target of researchers trying to make sense of it, since it gained traction in 1991. Following Haugen and Baker (1991), many have confirmed the MV outperformance and have offered possible explanations for the apparent anomaly. In this thesis I examine some of those studies and present their most significant findings (see for example Blitz and van Vliet (2007, 2011); Clarke, de Silva and Thorley (2006, 2011); Ang, Hodrick, Xing and Zhang (2006, 2009); Baker, Bradley and Wurgler (2011)). Research suggests that there exist other possible sources of systematic risk, in addition to the Fama, French and Carhart factors, which might explain the apparent anomaly of the MV effect (Arnott, Kalesnik, Moghtader, & Scholl, 2010). Some authors (see for example Scherer (2010); Frazzini and Pedersen (2010); Cowan and Wilderman (2011)) included these risk sources into their regressions of MV portfolio excess returns as separate factors, and were able to explain the anomaly, at least partly, suggesting that there may still be some other underlying risk sources. The findings, however, seem to vary among researchers and there is no consensus of the risk sources that would completely explain the anomaly.

Since MV securities are often among those which are traded less frequently, I am interested whether there is a liquidity effect that goes along with the volatility effect. I would like to see whether the outperformance of MV stocks is due to their low liquidity and illiquidity, i.e. whether it is due to the stale prices they might exhibit. I am thus interested in expanding the research further by controlling for liquidity, and seeing if the outperformance is in fact a result of low liquidity and illiquidity. A possible risk source, causing MV portfolios to require a risk premium, might therefore be liquidity risk. A research question following this reasoning, would ask whether low liquidity and illiquidity play a role in explaining the outperformance of stocks with the lowest volatility, or whether their influence is insignificant. Following this research question, I test for the role of liquidity and propose a null hypothesis of liquidity not having a significant influence on MV portfolio performance, against the alternative of liquidity having a significant influence on MV portfolio performance. To control for the effects of up and down states of equity markets and for using different liquidity measures, I also apply this hypothesis to four sub-periods and to using five different liquidity measures. This results in a total of twenty-five hypotheses, addressing the same research question. Since there has, to my knowledge, not yet been a study relating liquidity risk to MV portfolio performance, I am hoping to add another piece of the puzzle to explaining the MV anomaly.

The relevance of this kind of study is quite significant, since MV investing strategies have been gaining in importance in recent years due to worldwide unstable market conditions. The global financial crisis increased risk aversion among investors, and led to stricter regulations in the financial sector. These changing market circumstances have only contributed to the increase of interest for risk based investing strategies such as MV investing. Another reason why MV strategies are becoming more attractive, is because of their widely recognized risk-adjusted outperformance of their MCW benchmarks. As noted, this violates the assumptions on which traditional finance is based, so it is important to test whether this anomaly is due to unobserved risk sources. Recognizing whether underlying risk sources are the cause of the anomaly is vital in the wake of increased acknowledgement for risk. Numerous researchers have proposed possible explanations and alternative risk factors. Since one of the biggest influences on financial markets is liquidity, I follow in their footsteps by looking at the problem through the perspective of liquidity risk.

In Section 1 I present the theoretical framework on which this study builds, and previous research that has explored the issues of MV investing and liquidity risk. I provide the traditional finance theory with the risk factors for portfolio performance evaluation. I then follow with an overview of literature on MV investing and the volatility effect. Other risk sources that might explain the MV anomaly are reviewed next, followed by liquidity risk. Section 2, titled Data, covers all the data that is used in the study, with the sample selection process and liquidity measures used in sorting procedures. Section 3 presents the empirical analysis, where the methodology with the sorting procedures is given first, followed by main sample and sub-period results, that are numerically and graphically supplemented by portfolio performance figures and tables. Finally, the last section concludes and provides recommendations for further research.

1 THEORETICAL FRAMEWORK AND PREVIOUS RESEARCH

In this section I present the theoretical framework and provide an overview of relevant research this thesis builds on. I first present the traditional finance theory and the related portfolio performance evaluation methods. I introduce the evolution of discoveries which are the foundation of asset pricing theory, ranging from the CAPM framework, through the Fama and French (1993) factors, up to the Carhart (1997) four-factor model. This is followed by an overview of literature on the performance of MV portfolios, their risk-return properties and the risk sources explaining their performance. I review the findings of different researchers who suggest other potential risk sources that may capture the alpha return of MV portfolios. Finally, I explore the research on liquidity risk and the use of liquidity risk factors in explaining the performance of different portfolios. Following this inquiry, I propose liquidity risk as a risk factor that might potentially explain the returns of MV investing strategies.

1.1 Traditional finance theory and portfolio performance evaluation

Traditional finance theory rests on the central assumptions of investor rationality (Miller & Modigliani, 1961) and markets being viewed as informationally efficient, meaning that at any given time prices fully reflect all (publicly) available information of a given asset (Fama, 1970). According to Markowitz (1952, 1959) this suggests a risk-return tradeoff, meaning that one can only achieve a greater return by incurring greater systematic risk. Therefore, investors care about mean-variance efficiency. They wish to invest in a portfolio that is located on the mean-variance efficient frontier, thus maximizing their return for a given variance, or minimizing their variance for a desired return. Following these findings, the CAPM was developed by Sharpe (1964), Lintner (1965) and Black (1972). The model is described by the following formula:

$$R_t^i - R_t^f = \alpha^i + \beta_M^i \cdot \left(R_t^M - R_t^f\right) + \varepsilon_t^i \qquad (1)$$

where R_t^i-R_t^f is the excess return of asset *i* over the risk-free rate at time *t*, α^i is the intercept or Jensen's (1968) alpha, β_M^i is the asset's market beta, R_t^M-R_t^f is the market excess return and ε_t^i is the residual or idiosyncratic return of portfolio *i* in period *t*. The model suggests that it is the combination of the market portfolio and the risk-free asset that is mean-variance efficient. It implies that an asset's return is explained by a sole factor called the market beta, also referred to as the market risk premium. The CAPM beta captures an asset's return sensitivity to the market return, and is a measure of systematic risk. According to the theory, it also explains the return differences between different assets. Because the CAPM is based on the efficient markets assumption, it follows that other risks are non-systematic and can be diversified away by holding an efficient portfolio. According to the model, there is a linear relationship between an asset's expected return and market beta, called The Capital Market Line (CML). It suggests that assets with a greater market exposure (greater market beta) earn greater expected returns and vice versa. Agents should therefore invest in a portfolio with the highest expected excess return per unit of risk, according to their preferences regarding risk and return. This means they should position themselves on the efficient frontier where these preferences are met and the risk-return tradeoff is optimal, which can be captured by the Sharpe ratio.

Since its inception, the CAPM has been under scrutiny of many researchers, who have found it possible to form portfolios that performed better than predicted by the CAPM. These portfolios were able to produce positive alphas, and outperform the market in terms of risk-adjusted returns. Most notably, Fama and French (1992) found a size and value effect, which implied that market beta is not the only factor that is priced when trying to explain asset returns, and that some additional factors might help explain expected returns of assets. They showed that firms with a small market capitalization and those with a high book-to-market ratio on average had positive risk-adjusted returns. They therefore augmented the standard CAPM by adding two factors that capture the return difference of these firms. The size effect is captured by the small-minus-big (SMB) factor, while the book-to-market (value) effect is obtained through the high-minus-low (HML) factor (Fama & French, 1993). These findings have had a major contribution to the way finance was looked at going forward. Another piece of the puzzle was added by Jegadeesh and Titman (1993), who found a momentum effect by showing that stocks that performed relatively well over the last three to twelve months, continued their superior performance in the subsequent months, and stocks that performed poorly, continued their inferior performance. This finding later resulted in the Carhart (1997) momentum (UMD) factor, which captures the return difference by buying stocks that recently performed well and selling (shorting) the ones that recently performed poorly. Building on the foundation laid by the CAPM, and first adding the Fama and French (1993) factors, the initial model evolved into the Fama and French (1993) 3-factor model:

$$R_t^i\text{-}R_t^f=\alpha^i+\beta_M^i\cdot\left(R_t^M\text{-}R_t^f\right)+\beta_{SMB}^i\cdot SMB_t+\beta_{HML}^i\cdot HML_t+\varepsilon_t^i \tag{2}$$

and later, by including the Carhart (1997) momentum factor, into the Carhart (1997) 4-factor model:

$$R_t^i\text{-}R_t^f=\alpha^i+\beta_M^i\cdot\left(R_t^M\text{-}R_t^f\right)+\beta_{SMB}^i\cdot SMB_t+\beta_{HML}^i\cdot HML_t+\beta_{UMD}^i\cdot UMD_t+\varepsilon_t^i \tag{3}$$

where $R_t^i\text{-}R_t^f$ is the excess return of portfolio i over the risk-free rate at time t, α^i is the intercept, β_M^i is the portfolio's market beta, $R_t^M\text{-}R_t^f$ is the market excess return, SMB_t is the size factor, HML_t is the value factor, UMD_t is the momentum factor, ε_t^i is the residual and β_{SMB}^i, β_{HML}^i, and β_{UMD}^i are the sensitivities to the given factors.

Given that researchers were still able to construct portfolios that outperformed the Carhart (1997) 4-factor predictions, and therefore still found positive alpha, many studies have explored other possible risk sources. Propositions for the extension of the Carhart (1997) 4-factor model and the inclusion of additional risk factors have been made. A fifth factor was proposed by Frazzini and Pedersen (2010), who explored the performance of low-beta stocks. They suggested capturing the beta-weighted return difference between low-beta and high-beta stocks, by including the betting-against-beta (BAB) factor.

Following the above framework with all its initial assumptions, and perceiving the market portfolio as mean-variance efficient, the financial industry relied on MCW investing for many years (Arnott, Hsu, & Moore, 2005; Arnott et al., 2010). There is a host of reasons in favor of this confidence in MCW investing and several advantages of MCW portfolios (Arnott et al., 2005; Hsu, 2006). MCW investing is a passive investing strategy that requires little to no trading, since the portfolios are automatically rebalanced, leading to significant cost reductions. Since stocks with a large market capitalization often comprise the MCW portfolios, further cost reduction is achieved due to their greater liquidity. As noted by Arnott et al. (2010), MCW portfolios also have a low tax cost. Another advantage is the diversification across the stock market, as the large market capitalization stocks automatically have the greatest portfolio weights. In addition to the above benefits, the MCW portfolio is easily scalable, and if the CAPM assumptions hold, also automatically mean-variance efficient, given that the Sharpe ratio is maximized. All these advantages seem very attractive, yet they rely on assumptions that in practice usually do not hold. We can see this through the superior performances of portfolios of other investing strategies, among which the MV investing strategy is one of the most popular ones and the central theme of this thesis. I therefore follow with a presentation of MV portfolios, and an overview of the literature on MV investing and the volatility effect in the following section.

1.2 Minimum volatility investing and the volatility effect

This section presents the theory of MV portfolios and their construction, extends the introductory overview of MV literature and presents some of the more prominent papers that cover this issue. There has been a proliferation of such papers, especially after the Haugen and Baker (1991) paper was published.

MV portfolios are formed by minimizing portfolio volatility without having a given target return. Their position on the mean-variance efficient frontier is on the leftmost point, and represents a portfolio with the lowest possible level of variance. Historical return data of the universe of stocks, which are considered to be included in the portfolio, is used in forming a complete variance-covariance matrix (Luo, Cahan, Jussa, Chen, & Alvarez, 2011), or just for retrieving individual stock volatilities (Blitz & van Vliet, 2007). As the portfolio weights do not depend on any predictions of future stock returns, there is no danger of ending up with a MV portfolio with unbalanced portfolio weights. Clarke et al. (2006) note that strategies which are based on expected return forecasts, such as the MCW investing strategy, provide security weights that seem overly sensitive to small perturbations in the forecasted security returns. MV investing strategies on the other hand rely solely on the estimation of the variance-covariance matrix, or on using individual stock volatility, which in essence means using only the variance-covariance matrix diagonal as in Blitz and van Vliet (2007) and Blitz, Pang and van Vliet (2013). Another benefit of using these approaches, is the relative predictability and persistence of volatilities of stocks (Clarke et al., 2006).

The ex ante variance-covariance matrix is the singular source from which MV portfolio weights are derived from. It is therefore crucial to estimate it accurately in order to construct an optimal portfolio (Nielsen & Aylursubramanian, 2008). The process of creating MV portfolios is in most cases associated with choosing portfolio weights in such a way as to minimize the portfolio variance. This is usually done through solving a constrained minimization problem akin to the following equation (Hoondert, 2012):

$$min_{w_t}(w_t^{'}\Sigma_t w_t) \qquad s.t.\ 1_N^{'}w_t=1 \tag{4}$$

where w_t is the vector of optimal weights, Σ_t is the variance-covariance matrix and 1_N is a vector of ones. The optimal solution is obtained through minimizing equation (4) which is subjected to the constraint that the sum of stock weights equals one. To solve this type of problem, a Lagrange multiplier is used, partial derivatives are taken and, through some mathematical manipulations, a vector of optimal weights is found. An alternative approach to constructing MV portfolios is introduced by Blitz and van Vliet (2007). They create decile portfolios that are based on a straightforward ranking of stocks on their historical volatility. In contrast to studies like Clarke et al. (2006, 2011), they effectively use only the diagonal of the historical variance-covariance matrix with their approach. Their simple method produces promising results, which are discussed later in the text, and enables a straightforward further research of MV portfolios and the volatility effect. This is one of the main reasons their method is also used in this thesis.

As observed earlier, many researchers were able to construct portfolios that outperformed the CAPM predictions of their performance. Empirical tests of Black et al. (1972), Fama and MacBeth (1973) and Haugen and Heins (1975) for the U.S. equity market clearly show higher returns of low-beta stocks than CAPM would predict. This anomaly was shown to be persistent over several decades that followed. Many have documented a flat or even a negative relation between beta and stock returns (see for example Haugen and Baker (1991, 1996); Black (1993); Falkenstein (1994)). It was also confirmed by Fama and French (1992), who documented that over the period between 1963 and 1990, the relation between U.S. stock returns and beta was approximately flat. Even though the evidence for the presence of a beta effect was quickly expanding and accumulating in the world of equity markets research, this did not make the anomaly disappear. In fact, it appeared that the effect was growing stronger with time.

A similar effect can be observed by using volatility as a risk measure, since it is closely related to beta. It is called the volatility effect, and confirms the observed flat risk-return relation. It manifests itself in the superior risk-adjusted performance of MV portfolios and was discovered by many who have explored the issue. In their 2006 paper Clarke et al. find that MV portfolios which are constructed out of 1000 largest U.S. stocks over the period between 1968 and 2005, reduce volatility by approximately 25%, while producing comparable, or even higher average returns than the market benchmark portfolio. In a later paper Clarke et al. (2011) document that the relation between volatility and expected stock returns is flat over a much longer period. Ang et al. (2006) report that high volatility U.S. stocks earn abnormally low returns over the 1963-2000 period, and provide evidence for a flat or negative relation between risk and return. These results are then also confirmed for international markets in their later paper (Ang et al., 2009). The volatility effect has proven to be an even bigger anomaly than the accompanying beta effect, which was shown by both Blitz and van Vliet (2007) and Baker et al. (2011). Blitz and van Vliet (2007) find that portfolios consisting of stocks with the lowest historical volatility produce Sharpe ratio improvements and statistically significant positive alphas. They also confirm the negative risk-return relation for international equity markets by presenting evidence for European and Japanese markets. Their simple and straightforward ranking methodology is also used in the study by Blitz et al. (2013) which investigates the volatility effect in emerging markets and produces similar results. Blitz et al. (2013) find that in emerging equity markets the empirical relation between risk and return is flat, or possibly negative, especially for portfolios whose stocks are sorted on past volatility. Another study by Blitz and van Vliet (2011) compares passive MCW investing to investing in a MV index and finds better performance of the latter strategy, while Arnott et al. (2010) find that MV portfolios outperform MCW portfolios even when adjusted for the Carhart (1997) factors.

The volatility effect anomaly has received its fair share of criticism as well. One of the more notable critics of MV investing strategies has been Scherer (2010), who claims that most of the variation of MV portfolio excess returns can be attributed to the Fama and French (1993) factors and to returns on two characteristic anomaly portfolios. A critique and analysis of the relation between volatility and expected stock returns was also reported by Bali and Cakici (2008). They argue that no robustly significant relation exists between volatility and expected stock returns, and that small-cap stocks are the ones that cause researchers to come across a negative risk-return relation. In addition, Goltz and Sahoo (2011) argue that short holding periods cause these anomalous results and that a longer holding period produces a positive risk-return relation.

Much of the criticism on the existence of a volatility effect has been accounted for in subsequent papers, some of which have already been mentioned in a previous paragraph. Inclusion of the propositions these critiques offered had little influence on the risk-return relation, meaning the volatility effect persisted. Since so many researchers have been able to identify the volatility effect in various markets, developed and emerging, and for a variety of time periods and holding periods, there is little chance for this anomaly to be a consequence of spurious results or of data mining. Given that the traditional finance theory framework could not fully explain the anomaly, many have hypothesized on other possible risk sources. I review some of these in the following section.

1.3 Other risk sources

As different researchers of MV portfolios discovered that these outperform their market benchmark portfolio in terms of risk and return, they started questioning what the reasons behind this phenomenon were. The idea of a possibility of additional risk sources typical for MV strategies quickly arose. Since MV portfolios are constructed in a specific way and have a different composition than their market benchmark portfolio, they may be exposed to different risk sources. Many have found that MV portfolios are biased towards assets that have low covariation with the market, or in other words, they are exposed to low-beta stocks. This discovery has induced the search for alternative risk sources, which drive the returns of low-beta stocks. The existence of the MV outperformance when controlling for these risks has been inspected by several researchers. Among the suggested alternative risk sources that are captured by low-beta stocks are leverage constraints and short-selling constraints which were proposed by Black (1993), Frazzini and Pedersen (2010), de Giorgi, Post and Yalcin (2013) and Hong and Sraer (2012). Another explanation of low-beta outperformance was given by Cowan and Wilderman (2011), who found an absence of implied protection in these stocks. Concentration or industry-specific risk might be an additional risk source as noted by Melas, Briand and Urwin (2011). Other alternative risk sources were identified as behavioral biases (Baker et al., 2011; Blitz & van Vliet, 2007), fund manager incentives and other agency problems (Baker et al., 2011; Baker and Haugen, 2012; Blitz, 2014; Blitz & van Vliet, 2007; Brennan & Li, 2008; Falkenstein, 2009; Karceski, 2002). I review some of these papers and place them into context in the following paragraphs.

A consequence of numerous research papers, empirically showing the security market line to be flat and to disagree with the CAPM premise, was the development of a betting-against-beta strategy by Frazzini and Pedersen (2010). They constructed a betting-against-beta (BAB) factor by holding a short position in high-beta stocks and a long position in low-beta stocks. They deleveraged the short part of their portfolio to a beta of one and leveraged the long part to a beta of one, making the BAB factor market neutral. By taking advantage of the beta effect, the strategy produced significant positive risk-adjusted returns. These returns are due to the leverage constraints that are partly captured by the BAB factor (Frazzini & Pedersen, 2010). Leverage constraints are associated with borrowing constraints of real world investors and their aversion to use leverage. This casts a major caveat on the CAPM, since one of its assumptions is unconstrained borrowing of investors. It assumes that all investors are able to leverage or deleverage their portfolio in order to achieve their risk-return preferences, which in reality is not always possible. Investors therefore achieve implicit leverage by holding high-beta stocks, since low-beta stocks must be leveraged (explicit leverage) to achieve a desired market exposure (Blitz & van Vliet, 2007; Frazzini & Pedersen, 2010). In addition to leverage constraints, other alternative risk sources might also comprise the BAB factor or individually contribute to the MV performance explanation.

Cowan and Wilderman (2011) argue that it is not the implicit leverage of high-beta stocks that causes them to be preferred over leveraged low-beta stocks, but the appeal of protection that the implicit leverage of these stocks offers. This characteristic of high-beta stocks is called implied protection, and can be observed through the convex risk-return relation of high-beta stocks with the market. It is the benefit of high-beta stocks during bull market conditions, and their limited downside risk during bear market conditions, that is appealing to investors and causes them to settle for a lower return. Since MV investors tilt their portfolios towards low-beta stocks and utilize explicit leverage to achieve their desired market exposure, they face the absence of implied protection. Low-beta stocks have a much greater potential for loss in an event of a stock market crash than high-beta stocks. This is due to the fact that low-beta stocks must hold a greater amount of equity to achieve the same level of market exposure as high-beta stocks, and thus lack the implied protection of high-beta stocks. Unlike high-beta stocks, low-beta stocks have a concave risk-return relation with the market, meaning their performance is also inferior in bull markets. The high risk premium for holding low-beta stocks is likely due to the absence of implied protection, which might explain the superior performance of MV portfolios.

Given that MV portfolios are constructed through finding security weights by solving some sort of volatility minimization problem, or just by finding stocks with the lowest ex ante volatility, it is reasonable to assume only a limited number of different stocks from the chosen universe form these portfolios. Variation in volatility is not only a characteristic found across individual stocks, but also across different industries. This is why some researchers have suspected that MV portfolios might be biased towards a small number of industries, which are characterized by low-volatility and low-beta stocks. These suspicions were confirmed when Melas et al. (2011) reported that their MV index showed a concentration of stocks from utility, industrial and consumer goods industry sectors. This overweighing of a small number of sectors is referred to as concentration or industry-specific risk. MV portfolios are therefore exposed to the risk of insufficient diversification. Returns of stocks from a single industry may exhibit strong correlations and therefore react similarly to a negative shock, or in the worst case, contribute to a crash of the whole sector. Since this bias has been empirically demonstrated, the risk-adjusted outperformance of MV portfolios could possibly partly be explained by a risk premium that acts as compensation for incurring concentration risk.

A source of risk that is probably impossible to measure, yet it exists and effects stock price movements, are behavioral biases. According to Baker et al. (2011), volatile stocks are overvalued due to overconfidence, preference for lotteries and representativeness. As the majority of drivers think their driving skills are above average, so do investors overestimate their ability to accurately project future stock prices. This consequently leads to large errors in the estimation of high volatility stocks. In addition to investor overconfidence, there is also reason to suspect that optimism is a trait of the majority of people in the financial markets, which is only another contributing factor to the overvaluation of volatile stocks (Baker et al., 2011). The widespread presence of the lottery industry indicates that people have a bias towards betting their money on extremely low probability events, that promise high possible gains. This bias is also evident in the equity markets, where investors tend to overpay stocks that resemble lotteries tickets. The representativeness heuristic causes investors to project a successful selection of stocks to an entire industry or sector, wrongly assuming that their first selection is somehow representative and may be applied to other stocks that fit the category. Blitz and van Vliet (2007) report that these biases may cause equity investors to overpay for risky stocks and exhibit risk-seeking behavior. Another behavior bias that is difficult to measure are fund manager incentives. Fund managers are incentivized to invest in high-beta stocks during bull markets, since their bonuses reflect the success of the funds they manage, while bear market outperformance is less attractive (Blitz & van Vliet, 2007; Karceski, 2002). Also, their evaluation is based on relative performance of their portfolios when compared to a benchmark, which makes the MV anomaly persist due to limits to arbitrage (Baker et al., 2011).

The reviewed research proposes many alternative explanations for MV portfolio outperformance. One of the risk sources that has shown promise in explaining excess returns of stocks, and has to my knowledge not yet been applied in the MV context, is liquidity risk. Because many low volatility stocks are not traded as often and as regularly as high volatility stocks, they can be considered less liquid or might exhibit stale prices. There is reason to suspect that liquidity may therefore play a role in explaining returns of low volatility stocks. The MV outperformance reported by the literature, is possibly in part just a consequence of a risk premium for lower liquidity. I therefore, in the next section, review some of the literature that demonstrates the applicability of liquidity risk in explaining asset returns.

1.4 Liquidity risk

Liquidity plays a major role in equity markets and finance in general. It is usually described as the ability to buy or sell an asset without paying too much to do so. We most often hear about it when it has significantly reduced in the aggregate, and when it is one of the main subjects of debate after a stock market turmoil or crisis. That is when liquidity dries up and the market becomes less liquid and shallow. Liquidity however, can also be referred to in the context of individual stocks. Those that are traded less frequently, and whose price movements are less numerous, are considered to fall into the category of less liquid stocks or stocks with stale prices. Liquidity risk may be considered yet another risk source that is reflected in the excess returns of stocks, and forms a part of the risk premium. This part would represent compensation for incurring lower stock liquidity or illiquidity. Many authors have indeed considered this and tested it empirically in different forms and approaches.

Amihud (2002) confirms the findings of earlier studies which have shown that illiquidity explains the differences in expected returns across stocks. He extends this by showing the effect of illiquidity over time, and reports that expected market illiquidity has a positive and significant effect on ex ante stock excess returns. The effect is stronger among small capitalization stocks, whose excess returns are more sensitive to the changes in aggregate liquidity. These stocks therefore require a higher risk premium and achieve greater excess returns. Pastor and Stambaugh (2003) show that aggregate liquidity sensitive stocks have substantially higher expected returns, even after accounting for the market, size, value and momentum factors. They too find, that smaller stocks are less liquid, according to their liquidity risk measure, and that the smallest stocks have high sensitivities to aggregate liquidity. Their future research suggestion of exploring the role of liquidity risk in various pricing anomalies in financial markets, is therefore considered in this thesis. In addition to earlier research, Acharya and Pedersen (2005) provide a unified framework for understanding the different channels through which liquidity risk might affect asset returns. The relative and total economic significance of these channels is revealed by their empirical results, and a flight to liquidity is confirmed. Among other discoveries they find that the required return of a security is increasing in the covariance between its illiquidity and market illiquidity. Other research has also supported that there is scope for liquidity risk when it comes to explaining excess returns.

Since the MV effect represents one of the more persistent anomalies in finance, it has become a target of many researchers. They have considered different risk sources in the attempt to explain the risk premium of MV stocks and portfolios, many of which are discussed in the previous sections. Since, to my knowledge, none of the studies have tried to capture the return differences of stocks of different liquidities within the MV framework, I consider the possibility that liquidity risk might be part of the answer to the performance of MV portfolios. To account for liquidity risk, one must reliably measure it. This can prove to be difficult given liquidity's multidimensional nature. Many have proposed ways of measuring liquidity in financial markets, and have accordingly constructed liquidity measures that capture different dimensions and characteristics of liquidity. It is therefore of interest to consider various liquidity measures, in order to make sure that the different dimensions of liquidity are indeed captured, and also to test the robustness of any findings to using different liquidity measures. The dimensions that characterize liquidity and the liquidity measures that are used in this study are presented in the following section.

2 DATA

In this section I describe all the data used in this study and the way it is selected into a sample. I first give the information on the data used to construct the portfolios and follow with the description of factor data. Lastly, I present the liquidity measures used in the study.

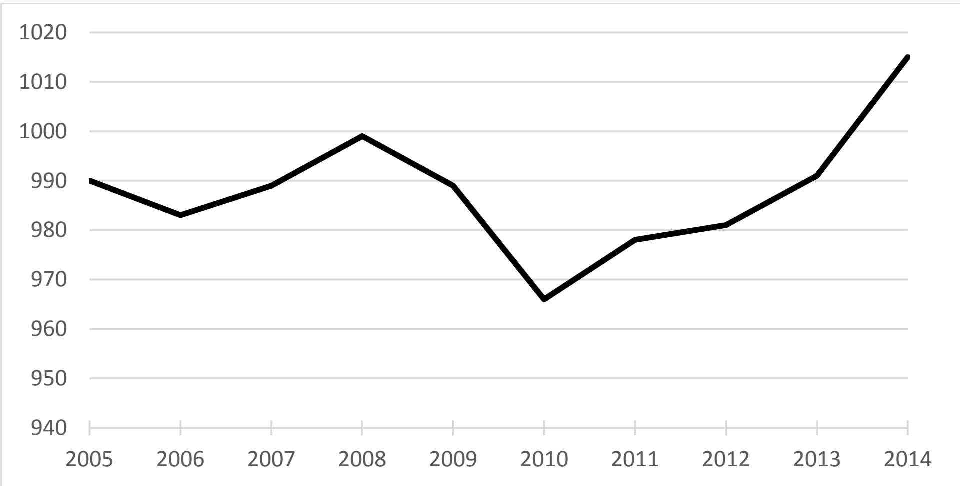
2.1 Data and sample selection

The primary data source for constructing the portfolios is the Bloomberg Professional service Terminal – the Terminal (Bloomberg, n.d.). In order to investigate the research question, data on the constituents of the Russell 1000 Index is collected. According to the Russell Investments website: "The Russell 1000 Index measures the performance of the large-cap segment of the U.S. equity universe. It is a subset of the Russell 3000 Index and includes approximately 1000 of the largest securities based on a combination of their market cap and current index membership. The Russell 1000 represents approximately 92% of the U.S. market (Russell Investments, Russell 1000 Index)."

The studied time period spans from the beginning of January 2005 to the end of December 2014 and thus covers 10 years. I therefore use 10 different constituent lists of the Russell 1000 Index, to gather all the necessary data. By doing this I am able to account for all the yearly membership changes in the Index. As seen in Figure 1, the number of stocks in my sample changes over the studied time period and ranges from a minimum of 966 in year 2010 to a maximum of 1015 in 2014. All the portfolios are constructed based on the stocks' past 3-year liquidity and volatility, so the whole time period of collected data extends from the beginning of January 2002 until the end of December 2014. In addition to the data on the prices of Russell 1000 stocks for the given 13 year period, I also collect other data in order to calculate different liquidity measures used in the study. This data includes the following: dollar volume, ask price, bid price, outstanding stocks and average price. The application of this data in the construction of liquidity measures is presented in the following section. All analyses in this thesis use daily data and prices denominated in U.S. dollars.

Finally, I gather the daily U.S. Treasury bill rate, and the U.S. market, size (SMB), value (HML), and momentum (UMD) factors from the data library of Kenneth French. According to Kenneth French's website description: "The Treasury bill return is the simple daily rate that, over the number of trading days in the month, compounds to the 1-month Treasury bill rate from Ibbotson and Associates Inc. (French, n.d.)." The construction of the Fama and French factors and the momentum factor is described on Kenneth French's website (French, n.d.).

Figure 1. Number of stocks over time



2.2 Liquidity measures

Liquidity is not a one-dimensional variable but includes several dimensions, usually the following four are distinguished (von Wyss, 2004):

- Trading time: the ability to execute a transaction immediately at the prevailing price. The waiting time between subsequent trades or the inverse, the number of trades per time unit are measures for trading time.

- Tightness: the ability to buy and to sell an asset at about the same price at the same time. Tightness shows in the clearest way the cost associated with transacting or the cost of immediacy. Measures for tightness are the different versions of the spread.
- Depth: the ability to buy or to sell a certain amount of an asset without influence on the quoted price. A sign of illiquidity is an adverse market impact for the investor when trading. Market depth can be measured, aside from the depth itself, by the order ratio, the trading volume or the flow ratio.
- Resiliency: the ability to buy or to sell a certain amount of an asset with little influence on the quoted price.

Several different liquidity measures that capture the above dimensions or aspects have been proposed by the literature. Trying to capture these different dimensions and limited by data availability I use five different liquidity measures in this study.

One-dimensional liquidity measures:

- Dollar volume (Sarr & Lybek, 2002; von Wyss, 2004)

$$V_t = \sum_{i=1}^{N_t} P_i \cdot Q_i \tag{5}$$

where P_i denotes the price of trade i, Q_i the number of stocks of trade i and N_t the number of trades in period t.

- Turnover (Sarr & Lybek, 2002)

$$Tn_t = \frac{V_t}{S_t \cdot P_t} \tag{6}$$

where V_t denotes dollar volume, S_t outstanding stocks of the asset and P_t average price of the i trades.

- Relative spread or proportional spread calculated with mid-price (von Wyss, 2004)

$$SrelM_t = \frac{P_t^A - P_t^B}{P_t^M} = \frac{2 \cdot (P_t^A - P_t^B)}{P_t^A + P_t^B} \tag{7}$$

where P_t^A denotes the ask price, P_t^B the bid price and P_t^M the mid-price, which is calculated $\frac{P_t^A + P_t^B}{2}$.

Multi-dimensional liquidity measures:

- Amihud's liquidity measure (Amihud, 2002; von Wyss, 2004)

$$ILLIQ_t = \frac{|R_t|}{V_t} \tag{8}$$

where R_t denotes the return in period t.

- Composite liquidity[1] (Chordia, Roll, & Subrahmanyam, 2001; von Wyss, 2004)

$$CL_t = \frac{\frac{P_t^A - P_t^B}{P_t^M}}{V_t} = \frac{\left(P_t^A - P_t^B\right)}{P_t^M \cdot V_t} \tag{9}$$

where the relative spread calculated with mid-price in the numerator is divided by dollar volume.

3 EMPIRICAL ANALYSIS

In this section I present the empirical analysis of the study. I first give the methodology used in the study, then report the main sample results and follow with the sub-period results. I start with the description of the portfolio construction methodology, and present the performance measurement methods used to evaluate portfolio performance. I then provide the main sample results, and present the key findings they produce. Since the main sample period was a time of turbulent market conditions, it is of interest to examine the volatility effect, and the role of liquidity risk associated with it, in the chosen sub-periods. In order to test the robustness of my findings to using different liquidity measures, five different measures of liquidity were used, both in main sample and sub-period calculations. This produces a substantial amount of results, some of which are presented in this section, while the majority are collected in the appendixes. Accordingly, this section provides concise results with findings that show promise regarding the research aim and question of the thesis.

3.1 Methodology

This section describes the stock-sorting procedures used to construct all the portfolios in this study, and the performance measurement methods which lead to the results presented in the following sections.

At the end of each month between December 2004 and November 2014, I first sort all Russell 1000 Index constituent stocks of the given year into two portfolios (buckets) based on their past 3-year liquidity (buckets B1 and B2). Both liquidity buckets are equally weighted, with bucket B1 containing less liquid stocks and bucket B2 more liquid stocks.

[1] Due to data availability issues, I use dollar volume in the denominator instead of dollar depth as presented by Chordia, Roll and Subrahmanyam (2001) and von Wyss (2004).

Within each liquidity bucket I further sort stocks into decile portfolios based on their past 3-year return volatility (portfolios D1 to D10). All portfolios are equally weighted, with D1 containing stocks with the lowest historical volatility and D10 stocks with the highest historical volatility. The universe is defined as the equally weighted portfolio of all the stocks in the Russell 1000 Index in the given year. I then calculate the return in excess of the daily Treasury bill rate over the subsequent month for each portfolio, and repeat the whole sorting procedure. Since the studied time period is 10 years long, there are 120 repetitions of this procedure and 10 different constituent lists, one for each calendar year. This methodology is similar to that of Blitz and van Vliet (2007) and Blitz et al. (2013). The difference is, that I apply a two-step sorting procedure, where I first sort stocks on liquidity and then on volatility, and instead of using weekly or monthly returns, I use return data with a daily frequency. I then test the robustness of my findings to using different liquidity measures. I therefore repeat the whole process five times, each time using a different liquidity measure. Liquidity measures used are Amihud's liquidity measure, Relative spread, Dollar volume, Turnover and Composite liquidity and are described in the previous section.

For each portfolio I report the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation, and Sharpe ratio. For each of these statistics I also report the t-statistic in order to test the significance of the difference with the Universe portfolio, and the significance of the difference between the extreme portfolios. I also report the differences between corresponding decile portfolios of the two liquidity buckets and their t-values. Following Blitz and van Vliet (2007), I apply the Jobson and Korkie (1981) test with the Memmel (2003) correction, in order to test for the statistical significance of the difference between two Sharpe ratios. This test statistic is calculated according to equation (10) and asymptotically follows a standard normal distribution:

$$z=\frac{SR_1-SR_2}{\sqrt{\frac{1}{T}\cdot\left[2\cdot\left(1-\rho_{1,2}\right)+\frac{1}{2}\cdot\left(SR_1^2+SR_2^2-SR_1\cdot SR_2\cdot\left(1+\rho_{1,2}^2\right)\right)\right]}} \tag{10}$$

where SR_i refers to the Sharpe ratio of portfolio i, $\rho_{i,j}$ to the correlation between portfolios i and j, and T to the number of observations.

From the regression analyses I report the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. All t-statistics are obtained from regressions using robust standard errors. Factors used in the regression analyses are obtained from Kenneth French's website (French, n.d.) and include market, size (SMB), value (HML) and momentum (UMD) factors for the U.S. market. I obtain the 1-factor alpha by regressing the portfolio excess returns on the excess returns of the market portfolio, i.e. the market factor:

$$R_t^i - R_t^f = \alpha^i + \beta_M^i \cdot \left(R_t^M - R_t^f\right) + \varepsilon_t^i \quad (11)$$

where R_t^i is the return on portfolio i in period t, R_t^f is the risk-free return in period t, α^i is the alpha of portfolio i, β_M^i is the beta of portfolio i, R_t^M is the return on the market portfolio in period t and ε_t^i is the idiosyncratic return of portfolio i in period t. To retrieve the 3-factor alpha, I extend the CAPM model depicted in equation (11) by adding the Fama and French (1993) factors for size (SMB) and value (HML):

$$R_t^i - R_t^f = \alpha^i + \beta_M^i \cdot \left(R_t^M - R_t^f\right) + \beta_{SMB}^i \cdot SMB_t + \beta_{HML}^i \cdot HML_t + \varepsilon_t^i \quad (12)$$

where SMB_t and HML_t denote the return on size and value factors and β_{SMB}^i and β_{HML}^i the betas of portfolio i with respect to the size and value factors. In order to obtain the 4-factor alpha, I further extend the model in equation (12) by adding an additional momentum factor (UMD) constructed by Kenneth French (French, n.d.):

$$R_t^i - R_t^f = \alpha^i + \beta_M^i \cdot \left(R_t^M - R_t^f\right) + \beta_{SMB}^i \cdot SMB_t + \beta_{HML}^i \cdot HML_t + \beta_{UMD}^i \cdot UMD_t + \varepsilon_t^i \quad (13)$$

where UMD_t is the return on the momentum factor and β_{UMD}^i the beta of portfolio i with respect to the momentum factor. By using U.S. 1-factor, 3-factor and 4-factor models as in Ang et al. (2006), I am able to determine whether a possible liquidity and volatility effect in the U.S. market is distinct from the previously discovered size, value and momentum effects.

Since the studied time period was a time of varying market conditions, I also perform two sub-period analyses in addition to the main sample part of the study. The first sub-period analysis is based on the Global Financial Crisis (GFC) development and its milestone event, while the second sub-period analysis is based on the presence of Quantitative easing (QE) repercussions.

For the "GFC" sub-period analysis I obtain two sub-periods by dividing the main sample into sub-period GFC 1 and sub-period GFC 2, the division point being the bankruptcy of the investment bank Lehman Brothers in September 2008. Sub-period GFC 1 thus extends from January 2005 to September 2008 and GFC 2 from October 2008 to December 2014. The methodology of sorting and return calculations is analogous to that of the initial analysis. I report the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and the standard deviation, with the corresponding t-statistics.

The two sub-periods of the "QE" analysis are obtained by dividing the main sample into sub-period QE 1 and sub-period QE 2. Sub-period QE 1 contains all the time periods between January 2005 and December 2014 when The Federal Reserve was not executing any quantitative easing program. These time periods are the following (Hancock & Passmore, 2014):

- January 2005 – November 2008,
- April 2010 – October 2010,
- July 2011 – August 2012,
- November 2014 – December 2014.

Conversely, sub-period QE 2 contains all the time periods between January 2005 and December 2014 when The Federal Reserve was executing a quantitative easing program. There were three such periods (Hancock & Passmore, 2014):

- December 2008 – March 2010,
- November 2010 – June 2011,
- September 2012 – October 2014.

The methodology of sorting and return calculations for this analysis corresponds to that of the initial analysis. As with the previous sub-period analysis, I report the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and the standard deviation, with the corresponding t-statistics.

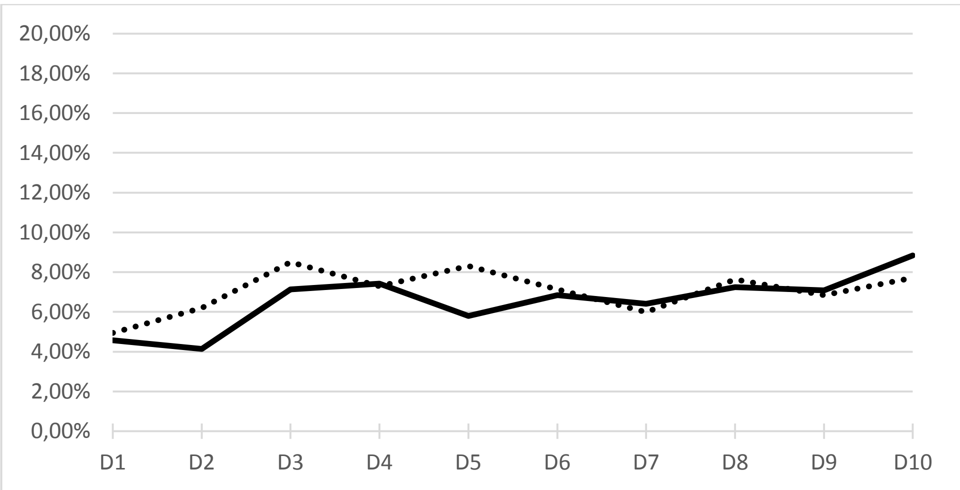
3.2 Main sample results

Results of the main sample are presented in Figures 2-7, Tables 1-8 and in Appendix A. Since the dynamic of the main sample results is similar for all liquidity measures, and in order to keep the presentation of results succinct, I provide only the figures and tables for two liquidity measures here, while the tables in Appendix A depict the results for other liquidity measures. In this section I present the results of the "Turnover" liquidity measure from the group of one-dimensional liquidity measures, and the results of the "Amihud" liquidity measure from the group of multi-dimensional liquidity measures.

Figures 2 and 3 display excess returns of decile portfolios for liquidity bucket B1 (less liquid stocks) and liquidity bucket B2 (more liquid stocks) for each of the two liquidity measures. Similarly, Figures 4 and 5 give standard deviations of the aforementioned portfolios, while Figures 6 and 7 provide the Sharpe ratios. Tables 1 and 2 report the excess return, standard deviation, and Sharpe ratio of liquidity buckets B1 and B2, for "Turnover" and "Amihud" liquidity measures respectively. For each of these statistics they also report a t-statistic, denoting the significance of the difference with the Universe portfolio. The differences between the buckets, with the related t-statistics denoting the significance of these differences, are displayed as well. Regression analyses results are given in the form of the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Tables 3 and 4 report the excess return, standard deviation, and Sharpe ratio of decile portfolios of liquidity bucket B1 for “Turnover” and “Amihud” liquidity measures respectively. Tables 5 and 6 report the same statistics for decile portfolios of liquidity bucket B2 for both liquidity measures. For each of these statistics the tables also report a t-statistic, denoting the significance of the difference with the Universe portfolio. They also display the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. As with Tables 1 and 2, the regression analyses results are given in the form of the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Tables 7 and 8 report the excess return, standard deviation and Sharpe ratio for each decile portfolio within both liquidity buckets, and the differences between corresponding decile portfolios of the two liquidity buckets, for both liquidity measures. They also report the t-statistics denoting the significance of these differences.

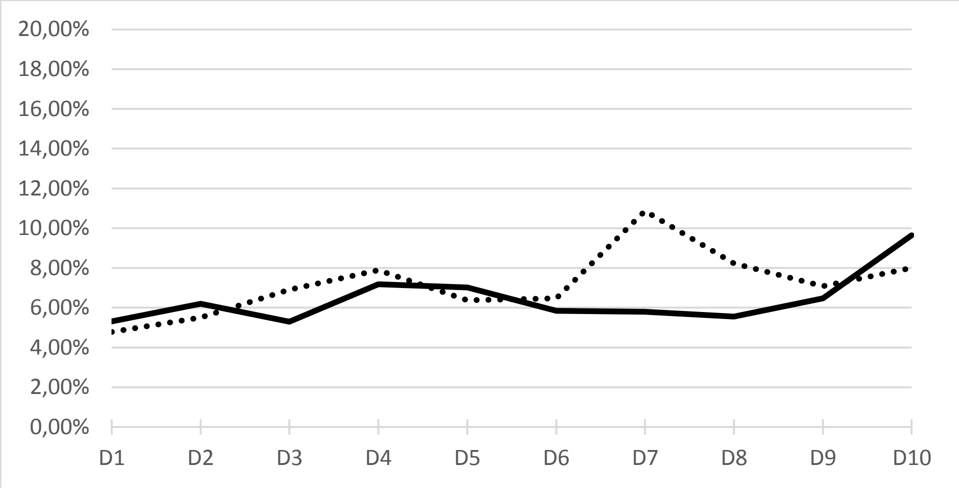
Looking at realized returns of decile portfolios (Figures 2 and 3), I notice there is a very weak relation, if any, between historical volatility and subsequent return. Contrary to Blitz and van Vliet (2007), who also observe a weak relation, the relation in my study is in the opposite direction. High risk stocks do not seem to underperform less volatile stocks. This is also true for other liquidity measures, with the realized return ranging from roughly 3,7 to 11,2 percent annualized, the only exception being the B2 bucket of Composite liquidity, where the most volatile portfolio indeed underperforms the less risky ones (Appendix A).

Figure 2. Excess returns of decile portfolios of “Turnover” liquidity buckets B1 (solid line) and B2 (dashed line)



Note. The figure displays the annualized compounded mean returns in excess of the U.S. dollar risk-free return (excess returns) of decile portfolios based on historical volatility of “Turnover” liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line).

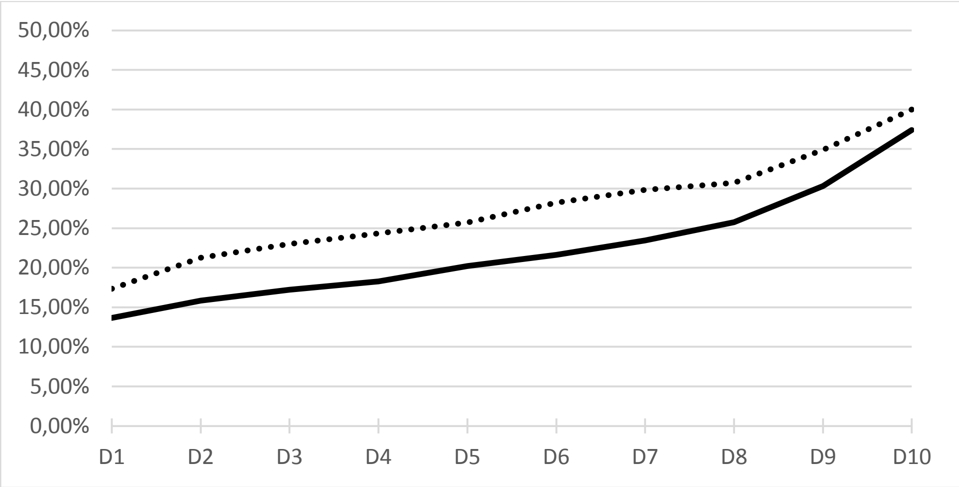
Figure 3. Excess returns of decile portfolios of "Amihud" liquidity buckets B1 (solid line) and B2 (dashed line)



Note. The figure displays the annualized compounded mean returns in excess of the U.S. dollar risk-free return (excess returns) of decile portfolios based on historical volatility of "Amihud" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line).

Considering MV investing strategies rely on historical volatility as their basis for portfolio construction, I observe that past risk is a strong predictor of future risk, as noted by Blitz and van Vliet (2007) and Blitz et al. (2013). We can see this in Figures 4 and 5 for both liquidity measures, where realized volatilities increase monotonically for consecutive decile portfolios, both for less liquid stocks (B1) and for more liquid stocks (B2). The same is true for all liquidity measures, where volatility ranges from approximately 14 to 41 percent annualized. As in Blitz and van Vliet (2007), I also observe that the reduction of volatility of portfolio D1, when compared to the market portfolio, is larger than in Clarke et al. (2006), while portfolio D10 often reaches almost double the volatility of the Universe portfolio. Increasing risk of consecutive portfolios also occurs when considering betas as measures of risk, with betas ranging from 0,55 to 2,34 (Tables 3, 4, 5 and 6 and Appendix A).

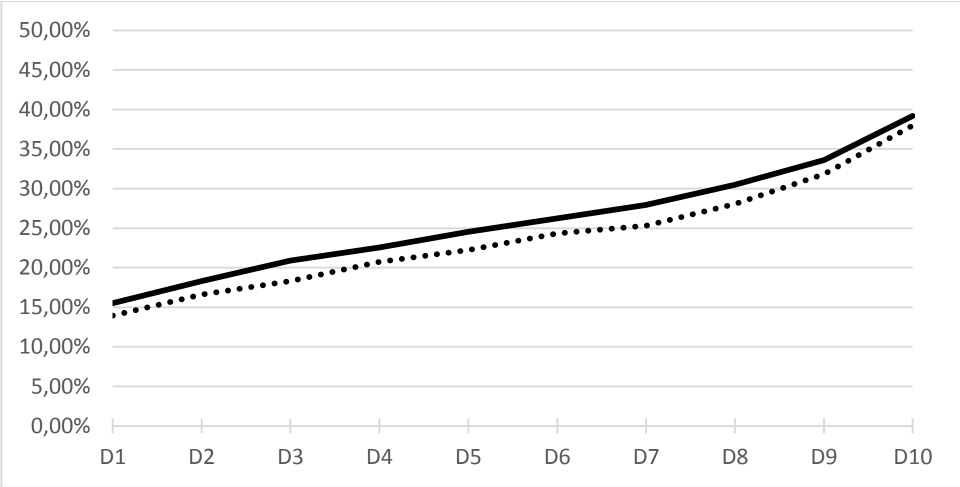
Figure 4. Standard deviations of decile portfolios of "Turnover" liquidity buckets B1 (solid line) and B2 (dashed line)



Note. The figure displays the standard deviations of decile portfolios based on historical volatility of "Turnover" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line).

It seems that the slightly positive observed risk-return relation most likely does not exist, when considering that the differences of extreme portfolio realized returns are statistically insignificant. I therefore move to a risk-adjusted performance perspective, and inspect the Sharpe ratios of decile portfolios. Since the risk-return relation is relatively flat, i.e. the return differences between decile portfolios are small, Sharpe ratios primarily depend on the standard deviation found in the denominator. This can be seen in Figures 6 and 7, where portfolios with lower volatility on average outperform the ones with higher volatility, in terms of Sharpe ratio. The pattern of declining Sharpe ratios with higher volatility of decile portfolios can also be recognized in liquidity buckets of other liquidity measures (Appendix A).

Figure 5. Standard deviations of decile portfolios of "Amihud" liquidity buckets B1 (solid line) and B2 (dashed line)

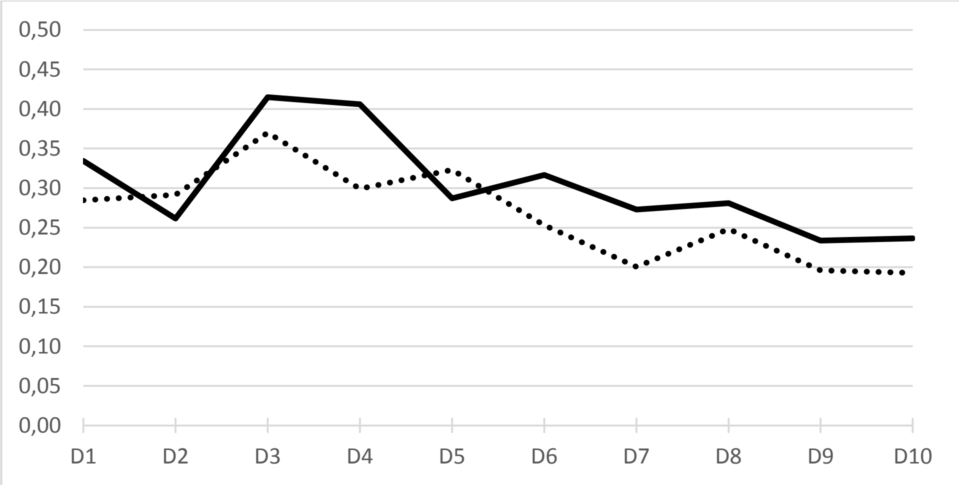


Note. The figure displays the standard deviations of decile portfolios based on historical volatility of "Amihud" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line).

Considering all the main sample results, we can see that the lowest Sharpe ratios are on average associated with more volatile portfolios, while the highest ones are on average found among less volatile decile portfolios. However, through using the Jobson and Korkie (1981) test with the Memmel (2003) correction to test the significance of the difference between different Sharpe ratios, we only rarely find a Sharpe ratio that is statistically significantly different from the Sharpe ratio of the Universe portfolio. The ones that are statistically significantly different from the equally weighted market portfolio, are found among the more volatile decile portfolios and are statistically significantly lower than the Sharpe ratio of the Universe portfolio. On the other hand, none of the top portfolios, consisting of least volatile stocks, have a statistically significantly different Sharpe ratio from the Universe portfolio. This means that the relation between ex ante volatility and ex post risk-adjusted returns, as observed by Blitz and van Vliet (2007), is not as clear as they claim, at least not for the sample period used in this study.

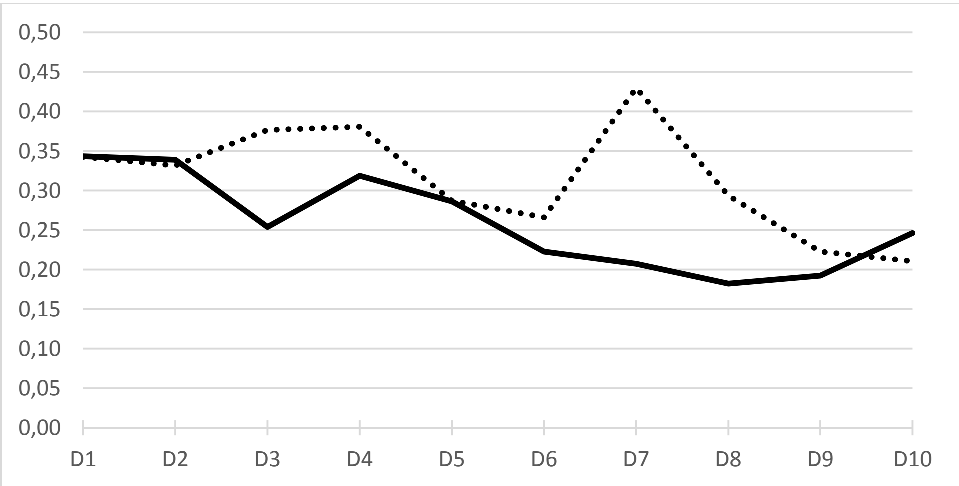
In addition to the excess return, standard deviation and Sharpe ratio results of Figures 2-7, Tables 1-6 and tables in Appendix A also provide regression results in order to see whether systematic exposures to certain risk factors might explain the performance of liquidity and volatility sorted portfolios. Monthly decile portfolio returns are regressed on the monthly Fama and French (1993) market factor in a CAPM type regression. This produces estimated betas that increase monotonically for consecutive decile portfolios in all liquidity buckets and for all liquidity measures, suggesting that volatility and beta are related risk measures, as noted by Blitz and van Vliet (2007). Low risk decile portfolios on average generate betas below one and annual alphas that are statistically insignificantly different from zero. High risk decile portfolios, on the other hand, exhibit very high market exposure with betas often greater than two, and annual alphas that are statistically significantly lower than zero, often at the 1% significance level.

Figure 6. Sharpe ratios of decile portfolios of “Turnover” liquidity buckets B1 (solid line) and B2 (dashed line)



Note. The figure displays the Sharpe ratios of decile portfolios based on historical volatility of “Turnover” liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line).

Figure 7. Sharpe ratios of decile portfolios of “Amihud” liquidity buckets B1 (solid line) and B2 (dashed line)



Note. The figure displays the Sharpe ratios of decile portfolios based on historical volatility of “Amihud” liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line).

Monthly decile portfolio returns are also regressed on the monthly Fama and French (1993) market, size (SMB), and value (HML) factors in a 3-factor regression, and market, size, value and momentum (UMD) factors in a 4-factor regression. To examine systematic exposures to SMB, HML and UMD factors, I also report the annualized 3-factor alphas and 4-factor alphas, in addition to the CAPM betas and 1-factor alphas. Tables 1-6 and tables in Appendix A reveal that exposures to these additional risk factors on average contribute to explaining the excess returns of decile portfolios, especially in the 4-factor regression with the UMD factor. The effect of including additional factors is most noticeable in the more volatile decile portfolios, although statistically significant alphas still remain.

Since the main focus is on the role of liquidity in the volatility effect, I report the differences in realized returns, volatilities and Sharpe ratios between different portfolios and observe the statistical significance of these differences. In Tables 1 and 2 the differences between liquidity buckets B1 and B2 for "Turnover" and "Amihud" liquidity measures are displayed respectively. Unexpectedly, the liquidity bucket containing more liquid stocks (B2) achieves a greater realized return than the less liquid (B1) one, in both liquidity measures. With the "Turnover" liquidity measure this is achieved at the cost of higher volatility, which results in a lower Sharpe ratio for the more liquid bucket. Meanwhile, the "Amihud" B2 liquidity bucket is less volatile than the B1 bucket, in addition to its return outperformance, which results in a higher Sharpe ratio. Looking at the t-values however, any outperformance is statistically insignificant. Tables of Appendix A reveal that the differences between liquidity buckets are not consistent in terms of which liquidity bucket outperforms, and alter with different liquidity measures. An important note is also, that the differences in realized returns and Sharpe ratios between liquidity buckets for all liquidity measures are statistically insignificant, which raises doubt in the existence of a liquidity premium for the main sample part of this study.

Table 1. Liquidity portfolios (buckets) based on Turnover

	B1	B2	B1-B2	Univ.
Excess Return	7,00%	7,53%	-0,53%	7,34%
(t-value)	-0,13	0,07	-0,19	-
Std. Dev.	21,35%	26,63%	-5,28%	23,34%
(t-value)	-0,95	1,39	-2,33**	-
Sharpe Ratio	0,33	0,28	0,05	0,31
(t-value)	0,29	-0,92	0,57	-
Beta	1,14	1,49	-	1,30
1-factor alpha	-1,51%	-3,53%	-	-2,32%
(t-value)	-1,39	-2,74***	-	-2,07**
3-factor alpha	-1,26%	-3,27%	-	-2,08%
(t-value)	-1,20	-2,55**	-	-1,87*
4-factor alpha	-0,69%	-2,41%	-	-1,35%
(t-value)	-0,65	-1,91*	-	-1,22

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation, and Sharpe ratio of "Turnover" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks). For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. From the regression analyses the table reports the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 2. Liquidity portfolios (buckets) based on Amihud's liquidity measure

	B1	B2	B1-B2	Univ.
Excess Return	6,88%	7,68%	-0,80%	7,34%
(t-value)	-0,14	0,11	-0,25	-
Std. Dev.	24,99%	22,83%	2,16%	23,34%
(t-value)	0,60	-0,16	0,77	-
Sharpe Ratio	0,28	0,34	-0,06	0,31
(t-value)	-1,37	0,68	-1,03	-
Beta	1,41	1,21	-	1,30
1-factor alpha	-3,64%	-1,37%	-	-2,32%
(t-value)	-2,88***	-1,32	-	-2,07**
3-factor alpha	-3,30%	-1,21%	-	-2,08%
(t-value)	-2,67***	-1,16	-	-1,87*
4-factor alpha	-2,44%	-0,63%	-	-1,35%
(t-value)	-2,00**	-0,61	-	-1,22

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation, and Sharpe ratio of "Amihud" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks). For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. From the regression analyses the table reports the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 3. Decile portfolios of "Turnover" liquidity bucket B1

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	4,57%	4,14%	7,14%	7,42%	5,81%	6,85%	6,40%	7,24%	7,09%	8,85%	-4,27%	7,34%
(t-value)	-1,18	-1,31	-0,11	0,01	-0,57	-0,18	-0,32	-0,03	-0,05	0,42	-1,20	-
Std. Dev.	13,66%	15,85%	17,21%	18,27%	20,22%	21,64%	23,46%	25,77%	30,30%	37,40%	-23,74%	23,34%
(t-value)	-4,84***	-3,52***	-2,83***	-2,25**	-1,26	-0,55	0,11	0,83	1,95*	3,06***	-6,22***	-
Sharpe Ratio	0,33	0,26	0,41	0,41	0,29	0,32	0,27	0,28	0,23	0,24	0,10	0,31
(t-value)	0,10	-0,37	0,87	0,99	-0,32	0,03	-0,62	-0,53	-1,01	-0,67	0,38	-
Beta	0,55	0,76	0,82	0,89	1,04	1,13	1,29	1,38	1,59	2,04	-	1,30
1-factor alpha	0,51%	-1,57%	0,96%	0,75%	-1,98%	-1,58%	-3,24%	-3,00%	-4,68%	-6,13%	-	-2,32%
(t-value)	0,54	-1,75*	1,12	0,87	-1,91*	-1,34	-2,86***	-2,27**	-2,81***	-2,63***	-	-2,07**
3-factor alpha	0,54%	-1,46%	1,01%	0,83%	-1,79%	-1,43%	-2,98%	-2,72%	-4,10%	-5,27%	-	-2,08%
(t-value)	0,59	-1,67*	1,18	0,97	-1,75*	-1,21	-2,71***	-2,11**	-2,65***	-2,41**	-	-1,87*
4-factor alpha	0,50%	-1,31%	1,25%	1,17%	-1,47%	-1,14%	-2,48%	-2,12%	-3,05%	-3,32%	-	-1,35%
(t-value)	0,54	-1,46	1,44	1,34	-1,40	-0,93	-2,21**	-1,60	-1,97**	-1,54	-	-1,22

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation and Sharpe ratio of decile portfolios based on historical volatility of

“Turnover” liquidity bucket B1 (less liquid stocks). For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. From the regression analyses the table reports the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 4. Decile portfolios of “Amihud” liquidity bucket B1

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	5,32%	6,20%	5,30%	7,19%	7,02%	5,85%	5,79%	5,55%	6,47%	9,65%	-4,33%	7,34%
(t-value)	-0,83	-0,45	-0,73	-0,05	-0,10	-0,45	-0,44	-0,49	-0,18	0,58	-1,13	-
Std. Dev.	15,50%	18,31%	20,90%	22,54%	24,53%	26,25%	27,95%	30,47%	33,62%	39,18%	-23,68%	23,34%
(t-value)	-3,70***	-2,23**	-0,95	-0,26	0,40	1,10	1,65*	2,57**	3,45***	4,60***	-7,39***	-
Sharpe Ratio	0,34	0,34	0,25	0,32	0,29	0,22	0,21	0,18	0,19	0,25	0,10	0,31
(t-value)	0,20	0,26	-0,68	0,06	-0,43	-1,28	-1,54	-1,92*	-1,42	-0,65	0,46	-
Beta	0,75	0,94	1,09	1,23	1,39	1,48	1,56	1,61	1,90	2,25	-	1,30
1-factor alpha	-0,29%	-0,82%	-2,79%	-1,99%	-3,36%	-5,18%	-5,82%	-6,37%	-7,58%	-6,92%	-	-2,32%
(t-value)	-0,29	-0,87	-2,44**	-1,76*	-2,69***	-3,79***	-4,27***	-4,03***	-3,65***	-2,92***	-	-2,07**
3-factor alpha	-0,17%	-0,66%	-2,58%	-1,70%	-3,03%	-4,82%	-5,54%	-6,01%	-7,03%	-6,16%	-	-2,08%
(t-value)	-0,17	-0,71	-2,28**	-1,55	-2,49**	-3,64***	-4,05***	-3,88***	-3,44***	-2,63***	-	-1,87*
4-factor alpha	0,08%	-0,30%	-2,16%	-1,19%	-2,40%	-4,27%	-4,84%	-5,00%	-5,59%	-3,59%	-	-1,35%
(t-value)	0,08	-0,31	-1,88*	-1,08	-1,95*	-3,14***	-3,51***	-3,28***	-2,75***	-1,67*	-	-1,22

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation and Sharpe ratio of decile portfolios based on historical volatility of “Amihud” liquidity bucket B1 (less liquid stocks). For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. From the regression analyses the table reports the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 5. Decile portfolios of “Turnover” liquidity bucket B2

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	4,94%	6,20%	8,51%	7,29%	8,31%	7,13%	5,99%	7,63%	6,84%	7,71%	-2,77%	7,34%
(t-value)	-0,90	-0,41	0,39	-0,01	0,31	-0,05	-0,39	0,10	-0,10	0,15	-0,72	-
Std. Dev.	17,35%	21,26%	23,00%	24,35%	25,73%	28,21%	29,86%	30,74%	34,89%	39,99%	-22,64%	23,34%
(t-value)	-2,69***	-0,78	0,01	0,59	1,07	1,99**	2,82***	3,01***	4,13***	5,05***	-7,19***	-
Sharpe Ratio	0,28	0,29	0,37	0,30	0,32	0,25	0,20	0,25	0,20	0,19	0,09	0,31
(t-value)	-0,29	-0,27	0,75	-0,22	0,12	-0,83	-1,51	-0,81	-1,27	-1,08	0,50	-
Beta	1,00	1,16	1,29	1,34	1,47	1,42	1,53	1,66	1,83	2,24	-	1,30
1-factor alpha	-2,51%	-2,45%	-1,11%	-2,68%	-2,64%	-3,39%	-5,35%	-4,68%	-6,74%	-8,76%	-	-2,32%
(t-value)	-2,50**	-2,30**	-0,96	-1,89*	-2,14**	-2,72***	-3,73***	-2,83***	-3,73***	-3,39***	-	-2,07**
3-factor alpha	-2,35%	-2,33%	-0,89%	-2,50%	-2,48%	-3,28%	-5,16%	-4,35%	-6,57%	-7,87%	-	-2,08%
(t-value)	-2,35**	-2,16**	-0,77	-1,77*	-2,00**	-2,61***	-3,62***	-2,63***	-3,64***	-3,13***	-	-1,87*
4-factor alpha	-1,96%	-1,94%	-0,21%	-2,08%	-1,95%	-2,73%	-4,47%	-3,14%	-5,35%	-5,41%	-	-1,35%

(t-value)	-1,95*	-1,77*	-0,18	-1,45	-1,56	-2,15**	-3,12***	-1,94*	-3,00***	-2,34**	-	-1,22

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation and Sharpe ratio of decile portfolios based on historical volatility of "Turnover" liquidity bucket B2 (more liquid stocks). For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. From the regression analyses the table reports the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 6. Decile portfolios of "Amihud" liquidity bucket B2

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D1-D10**	**Univ.**
Excess Return	4,78%	5,51%	6,90%	7,89%	6,38%	6,47%	10,87%	8,23%	7,09%	8,00%	-3,23%	7,34%
(t-value)	-1,10	-0,76	-0,19	0,19	-0,34	-0,29	1,18	0,28	-0,05	0,21	-0,97	-
Std. Dev.	13,94%	16,62%	18,32%	20,74%	22,22%	24,32%	25,31%	28,04%	31,80%	37,99%	-24,05%	23,34%
(t-value)	-4,67***	-3,14***	-2,18**	-0,97	-0,31	0,47	0,92	2,01**	2,95***	4,45***	-7,96***	-
Sharpe Ratio	0,34	0,33	0,38	0,38	0,29	0,27	0,43	0,29	0,22	0,21	0,13	0,31
(t-value)	0,14	0,13	0,59	0,85	-0,37	-0,69	1,68*	-0,29	-1,16	-0,91	0,51	-
Beta	0,56	0,80	0,89	1,13	1,20	1,29	1,29	1,43	1,67	1,95	-	1,30
1-factor alpha	0,60%	-0,47%	0,24%	-0,55%	-2,60%	-3,15%	1,29%	-2,39%	-5,31%	-6,40%	-	-2,32%
(t-value)	0,68	-0,55	0,26	-0,53	-2,50**	-2,50**	1,14	-1,87*	-3,33***	-3,08***	-	-2,07**
3-factor alpha	0,65%	-0,45%	0,30%	-0,45%	-2,51%	-2,95%	1,40%	-2,34%	-4,97%	-5,73%	-	-2,08%
(t-value)	0,78	-0,54	0,33	-0,43	-2,40**	-2,36**	1,23	-1,80*	-3,15***	-2,84***	-	-1,87*
4-factor alpha	0,64%	-0,35%	0,55%	-0,17%	-2,07%	-2,31%	2,01%	-1,67%	-3,98%	-4,15%	-	-1,35%
(t-value)	0,75	-0,41	0,58	-0,16	-1,94*	-1,83*	1,76*	-1,28	-2,52**	-2,10**	-	-1,22

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation and Sharpe ratio of decile portfolios based on historical volatility of "Amihud" liquidity bucket B2 (more liquid stocks). For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. From the regression analyses the table reports the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Each of the two liquidity buckets is also divided into 10 decile portfolios based on historical volatility of individual stocks. It is therefore of interest to compare the performance of corresponding decile portfolios of the two liquidity buckets. I thus observe the differences in realized return, volatility and Sharpe ratio between decile portfolio D1 from liquidity bucket B1 and decile portfolio D1 from liquidity bucket B2, between portfolio D2 from bucket B1 and portfolio D2 from bucket B2, and so on up to decile portfolios D10. These differences and their corresponding t-values for "Turnover" and "Amihud" liquidity measures are depicted in Tables 7 and 8 respectively. Inspecting the results of the "Turnover" liquidity measure, we can see that all the differences in realized returns and Sharpe ratios are statistically insignificant, despite the significant differences between corresponding portfolio volatilities. A similar finding holds for the "Amihud" liquidity measure, where on the other hand no statistically significant differences between corresponding volatilities are observed. The only exception with the "Amihud" results is the difference of Sharpe ratios of D7 portfolios, where the more liquid decile portfolio exhibits a statistically significant outperformance at the 5% level. Looking at the tables of Appendix A, we can find similar results for all the other liquidity measures as well, where no statistically significant differences of realized returns and Sharpe ratios between corresponding decile portfolios can be found (one other exception being the statistically significant difference between Sharpe ratios of D5 portfolios of the Relative spread liquidity measure, at the 10% level). This supports the doubt from the previous paragraph of there being no liquidity risk premium, at least in this particular sample period. If liquidity risk were to explain the performance of MV portfolios, one would expect to find a statistically significant outperformance of less liquid, low volatile portfolios (like D1 of B1) over more liquid, low volatile portfolios (like D1 of B2), yet this does not seem to be the case.

Table 7. Differences between corresponding decile portfolios of "Turnover" liquidity buckets B1 and B2

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
Excess Return										
B1	4,57%	4,14%	7,14%	7,42%	5,81%	6,85%	6,40%	7,24%	7,09%	8,85%
B2	4,94%	6,20%	8,51%	7,29%	8,31%	7,13%	5,99%	7,63%	6,84%	7,71%
B1-B2	-0,37%	-2,05%	-1,37%	0,13%	-2,50%	-0,29%	0,42%	-0,39%	0,25%	1,13%
(t-value)	-0,20	-0,89	-0,57	0,02	-0,86	-0,11	0,10	-0,12	0,05	0,21
Std. Dev.										
B1	13,66%	15,85%	17,21%	18,27%	20,22%	21,64%	23,46%	25,77%	30,30%	37,40%
B2	17,35%	21,26%	23,00%	24,35%	25,73%	28,21%	29,86%	30,74%	34,89%	39,99%
B1-B2	-3,69%	-5,41%	-5,79%	-6,08%	-5,51%	-6,57%	-6,40%	-4,98%	-4,59%	-2,59%
(t-value)	-2,58***	-2,88***	-2,92***	-2,90***	-2,35**	-2,56**	-2,73***	-2,12**	-1,96**	-1,46
Sharpe Ratio										
B1	0,33	0,26	0,41	0,41	0,29	0,32	0,27	0,28	0,23	0,24
B2	0,28	0,29	0,37	0,30	0,32	0,25	0,20	0,25	0,20	0,19
B1-B2	0,05	-0,03	0,04	0,11	-0,04	0,06	0,07	0,03	0,04	0,04
(t-value)	0,29	-0,19	0,34	0,89	-0,30	0,55	0,63	0,29	0,30	0,34

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation, and Sharpe ratio. It also reports the differences in excess return, standard deviation and Sharpe ratio between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 8. Differences between corresponding decile portfolios of “Amihud” liquidity buckets B1 and B2

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	5,32%	6,20%	5,30%	7,19%	7,02%	5,85%	5,79%	5,55%	6,47%	9,65%
B2	4,78%	5,51%	6,90%	7,89%	6,38%	6,47%	10,87%	8,23%	7,09%	8,00%
B1-B2	0,54%	0,70%	-1,60%	-0,71%	0,64%	-0,62%	-5,08%	-2,67%	-0,62%	1,64%
(t-value)	0,31	0,35	-0,65	-0,25	0,23	-0,18	-1,50	-0,72	-0,13	0,33
Std. Dev.										
B1	15,50%	18,31%	20,90%	22,54%	24,53%	26,25%	27,95%	30,47%	33,62%	39,18%
B2	13,94%	16,62%	18,32%	20,74%	22,22%	24,32%	25,31%	28,04%	31,80%	37,99%
B1-B2	1,56%	1,68%	2,57%	1,80%	2,31%	1,93%	2,64%	2,43%	1,81%	1,19%
(t-value)	1,24	1,00	1,28	0,71	0,72	0,64	0,77	0,65	0,51	0,21
Sharpe Ratio										
B1	0,34	0,34	0,25	0,32	0,29	0,22	0,21	0,18	0,19	0,25
B2	0,34	0,33	0,38	0,38	0,29	0,27	0,43	0,29	0,22	0,21
B1-B2	0,00	0,01	-0,12	-0,06	0,00	-0,04	-0,22	-0,11	-0,03	0,04
(t-value)	0,00	0,07	-1,10	-0,62	-0,01	-0,42	-2,20**	-1,25	-0,32	0,30

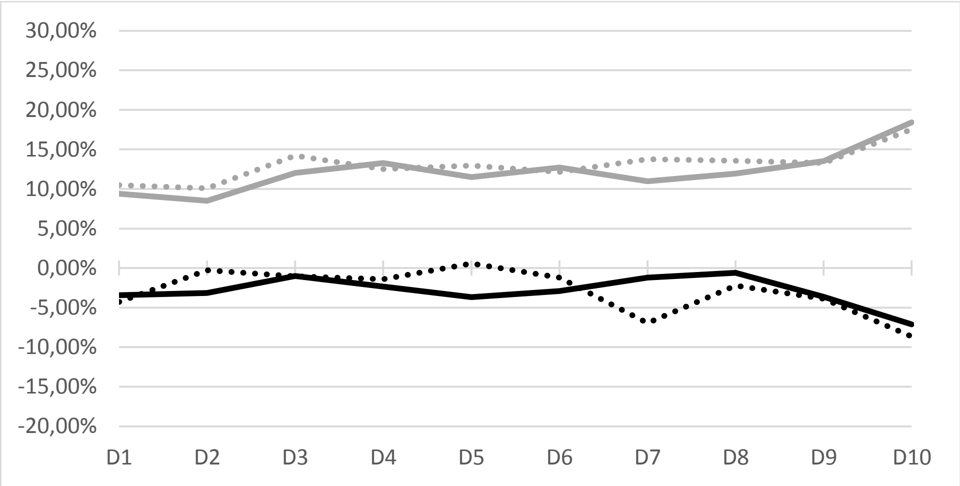
Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation, and Sharpe ratio. It also reports the differences in excess return, standard deviation and Sharpe ratio between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

3.3 Sub-period results

Given the main sample period includes the global financial crisis and measures of the Federal Reserve to alleviate its consequences, it is of interest to account for these developments in forming sub-periods, since the markets were greatly influenced by them. Calculations are therefore performed for sub-periods, whose formation is described in the Methodology section. Results are obtained in a similar fashion to those in the main sample part of the study, and are presented in Figures 8-15, Tables 9-40 and in Appendixes B and C. For similar reasons as with the main sample period, I provide only the figures and tables for “Turnover” and “Amihud” liquidity measures here, while the tables in Appendixes B and C depict the results for other liquidity measures.

Figures 8 and 9 display excess returns of decile portfolios of liquidity buckets B1 and B2 for sub-periods GFC 1 and GFC 2 for “Turnover” and “Amihud” liquidity measures respectively. Similarly, Figures 10 and 11 provide the standard deviations of the aforementioned portfolios. Following the same logic, Figures 12 and 13 display excess returns of decile portfolios of liquidity buckets B1 and B2 for sub-periods QE 1 and QE 2 for both liquidity measures, and Figures 14 and 15 the standard deviations of these portfolios. Tables 9, 17, 25 and 33 report the excess return and standard deviation of “Turnover” liquidity buckets B1 and B2 for sub-periods GFC 1, GFC 2, QE 1 and QE 2 respectively, while tables 10, 18, 26 and 34 report these statistics for “Amihud” liquidity buckets for all the sub periods. For each of these statistics, they display a t-statistic denoting the significance of the difference with the Universe portfolio. They also display the differences between the buckets, with the related t-statistics denoting the significance of these differences. Tables 11 and 12 report the excess return and standard deviation of decile portfolios of liquidity bucket B1 for sub-period GFC 1 for “Turnover” and “Amihud” liquidity measures, while Tables 13 and 14 report these statistics for liquidity bucket B2 for sub-period GFC 1 for both liquidity measures. For each of these statistics a t-statistic denoting the significance of the difference with the Universe portfolio is given. The tables also display the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Tables 19-22 report the results in a similar way for sub-period GFC 2, Tables 27-30 for QE 1 and Tables 35-38 for QE 2. Tables 15 and 16 report the excess return and standard deviation for each decile portfolio within both liquidity buckets for sub-period GFC 1 for “Turnover” and “Amihud” liquidity measures respectively. They also give the differences between corresponding decile portfolios of the two liquidity buckets, with the related t-statistics denoting the significance of these differences. Similarly, Tables 23 and 24 provide the results for sub-period GFC 2, Tables 31 and 32 for sub-period QE 1 and Tables 39 and 40 for sub-period QE 2. Tables in Appendixes B and C provide the results for other liquidity measures.

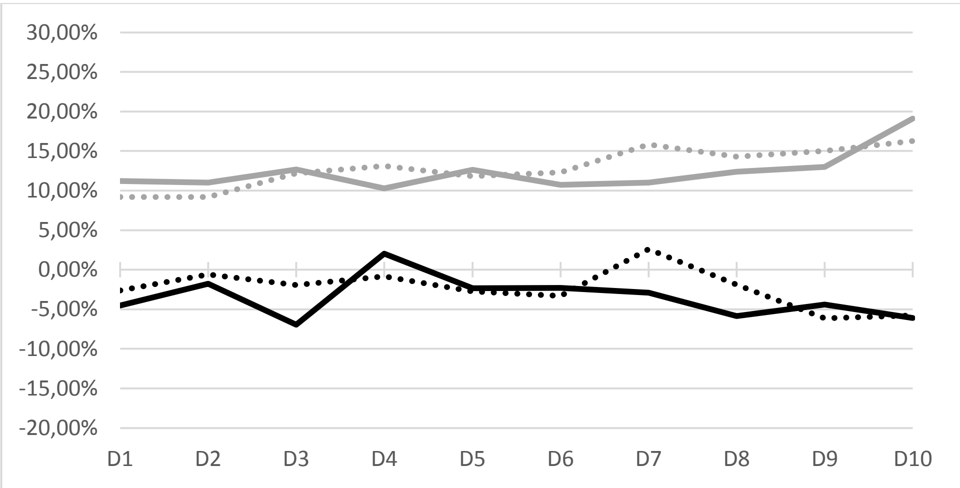
Figure 8. Excess returns of decile portfolios of “Turnover” liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period GFC 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period GFC 2 (grey lines)



Note. The figure displays the annualized compounded mean returns in excess of the U.S. dollar risk-free return (excess returns) of decile portfolios based on historical volatility of “Turnover” liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 2 (grey lines).

Observing the GFC sub-periods (Figure 8 for the "Turnover" liquidity measure, Figure 9 for the "Amihud" liquidity measure and Appendix B for other measures), there seems to be no significant relation between risk and return. Sub-period GFC 1 shows a very weak negative relation, yet it is statistically insignificant. Realized returns of sub-period GFC 2 are across all decile portfolios greater than those of GFC 1 and suggest a slightly positive risk-return relation. Examining the t-values, however, reveals that this relation is also insignificant. Decile portfolio returns of all liquidity buckets in the GFC framework only rarely significantly differ from the Universe portfolio returns, meaning the risk-return relation seems to be flat, as with the main sample results.

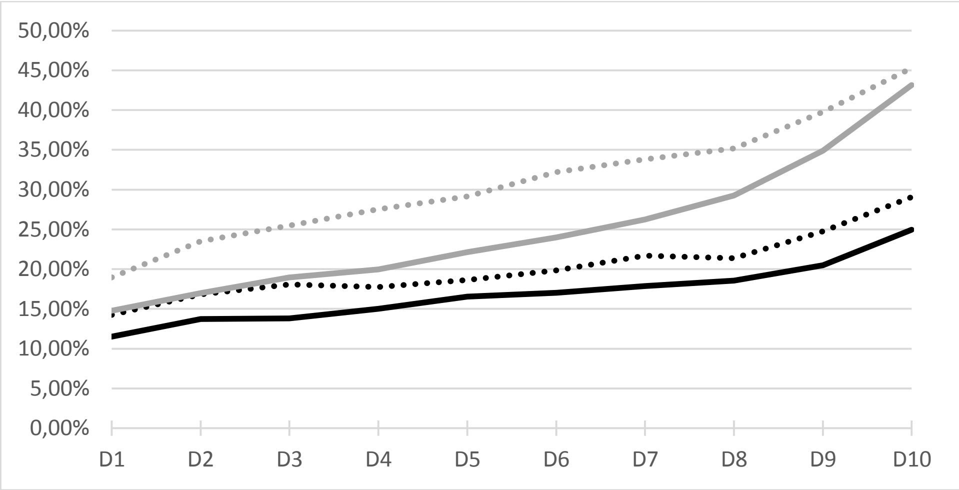
Figure 9. Excess returns of decile portfolios of "Amihud" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period GFC 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period GFC 2 (grey lines)



Note. The figure displays the annualized compounded mean returns in excess of the U.S. dollar risk-free return (excess returns) of decile portfolios based on historical volatility of "Amihud" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 2 (grey lines).

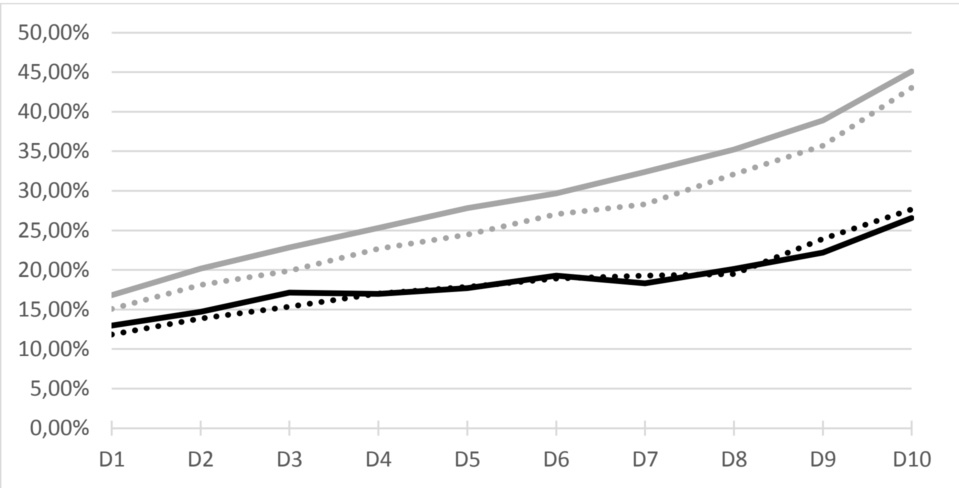
The division of the main sample into sub-periods reveals that realized volatilities increase for consecutive decile portfolios in all sub-periods (GFC 1, GFC 2, QE 1 and QE 2), for all liquidity measures and in all liquidity buckets. Figures 10 and 14 display this for the "Turnover" liquidity measure, Figures 11 and 15 for the "Amihud" liquidity measure, while tables in Appendixes B and C show this for other liquidity measures. This shows the robustness of Blitz and van Vliet's (2007) finding that past risk is a strong predictor of future risk. The fundamental differences in volatilities between sub-periods are due to the events captured within each sub-period, which is a direct consequence of the chosen methodology of dividing the main sample.

Figure 10. Standard deviations of decile portfolios of "Turnover" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period GFC 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period GFC 2 (grey lines)



Note. The figure displays the standard deviations of decile portfolios based on historical volatility of "Turnover" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 2 (grey lines).

Figure 11. Standard deviations of decile portfolios of "Amihud" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period GFC 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period GFC 2 (grey lines)

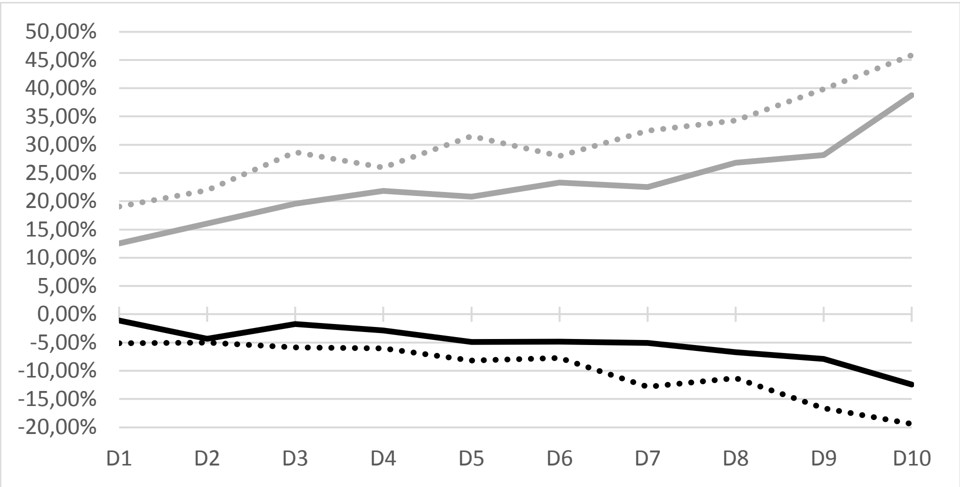


Note. The figure displays the standard deviations of decile portfolios based on historical volatility of "Amihud" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period GFC 2 (grey lines).

Moving to the QE division of the sample and observing Figures 12 and 13, a much clearer risk-return relation appears upon visual inspection. Sub-period QE 1 shows promise in terms of revealing the existence of a possible volatility effect, since the observed risk-return relation seems to be negative. This negative relation appears to be significant, given the extreme decile portfolios of all liquidity buckets of all liquidity measures are statistically significantly different from the Universe portfolio, most often at the 1% significance level (Appendix C). On the other hand, sub-period QE 2 displays a clear positive risk-return relation. This too holds true for other liquidity measures and shows statistical significance at the 1% level.

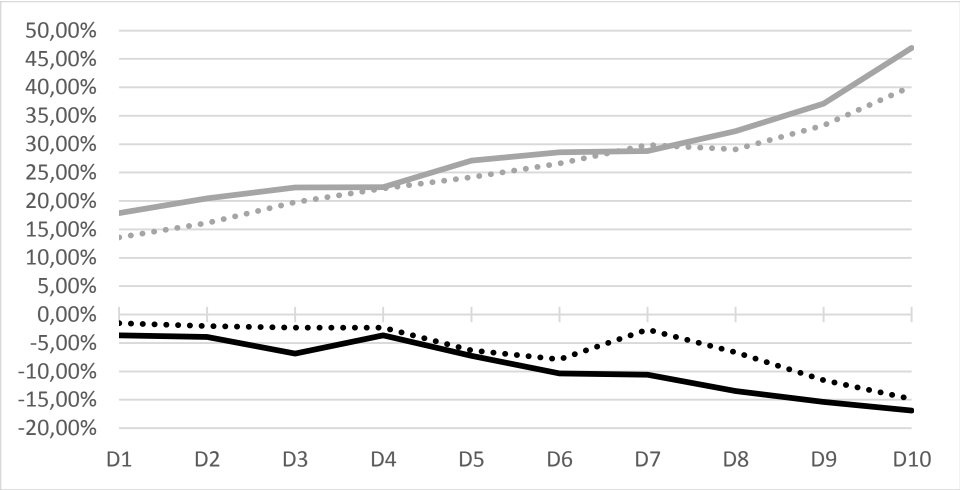
By observing these sub-periods, and examining the risk-return relations for different liquidity measures, I am able to see whether liquidity risk has any power in explaining decile portfolio returns when certain risk-return relations indeed exist. This is of interest especially in the case where a negative risk-return relation is identified, as in the QE 1 sub-period, suggesting the presence of a volatility effect. I therefore continue by reporting the differences in realized returns and volatilities between different portfolios and observing the statistical significance of these differences.

Figure 12. Excess returns of decile portfolios of "Turnover" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period QE 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period QE 2 (grey lines)



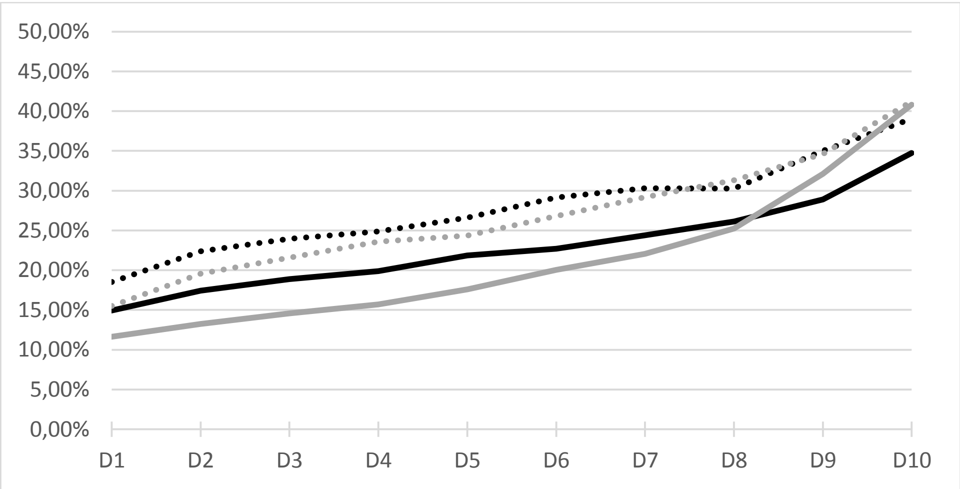
Note. The figure displays the annualized compounded mean returns in excess of the U.S. dollar risk-free return (excess returns) of decile portfolios based on historical volatility of "Turnover" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 2 (grey lines).

Figure 13. Excess returns of decile portfolios of "Amihud" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period QE 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period QE 2 (grey lines)



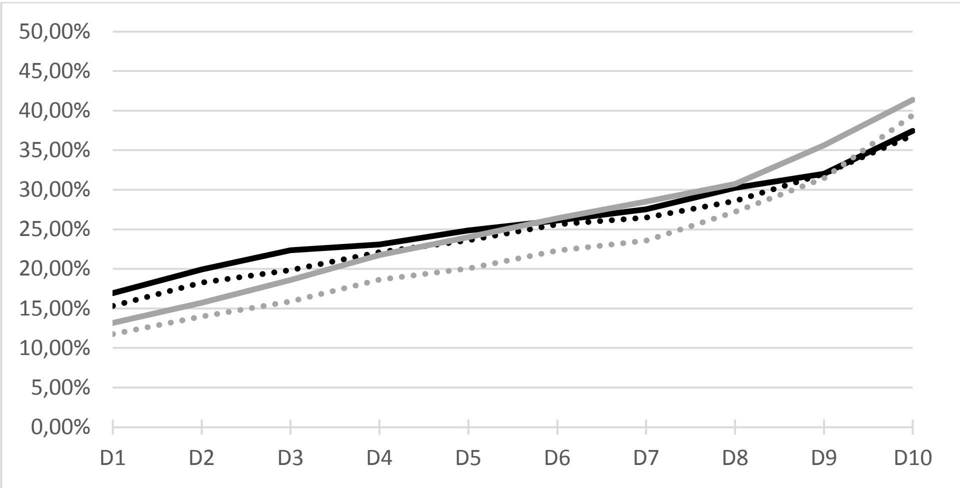
Note. The figure displays the annualized compounded mean returns in excess of the U.S. dollar risk-free return (excess returns) of decile portfolios based on historical volatility of "Amihud" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 2 (grey lines).

Figure 14. Standard deviations of decile portfolios of "Turnover" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period QE 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period QE 2 (grey lines)



Note. The figure displays the standard deviations of decile portfolios based on historical volatility of "Turnover" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 2 (grey lines).

Figure 15. Standard deviations of decile portfolios of "Amihud" liquidity buckets B1 (solid line) and B2 (dashed line) for sub-period QE 1 (black lines) and B1 (solid line) and B2 (dashed line) for sub-period QE 2 (grey lines)



Note. The figure displays the standard deviations of decile portfolios based on historical volatility of "Amihud" liquidity buckets B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 1 (black lines) and B1 (less liquid stocks; solid line) and B2 (more liquid stocks; dashed line) for sub-period QE 2 (grey lines).

Tables 9 and 10 display the differences in realized returns and volatilities between liquidity buckets B1 and B2 for sub-period GFC 1 for "Turnover" and "Amihud" liquidity measures respectively, while Tables 17 and 18 report these statistics for sub-period GFC 2 for both liquidity measures. In both sub-periods and for both liquidity measures the liquidity bucket containing more liquid stocks (B2) seems to perform better than the less liquid one (B1). For the "Turnover" liquidity measure it is at the cost of a higher volatility, which is not the case with the "Amihud" liquidity measure, where B2 has a lower volatility when compared to B1. These differences however, are statistically insignificant as in the main sample part of the study. The insignificance of the differences between liquidity buckets holds true for other liquidity measures as well, as seen in the tables of Appendix B, suggesting no liquidity risk premium exists.

Table 9. Liquidity portfolios (buckets) based on Turnover (sub-period: GFC 1)

	B1	**B2**	**B1-B2**	**Univ.**
Excess Return	-2,69%	-2,50%	-0,19%	-2,81%
(t-value)	0,07	0,07	-0,01	-
Std. Dev.	16,03%	19,19%	-3,16%	17,09%
(t-value)	-0,52	1,02	-1,54	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of "Turnover" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period GFC 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 10. Liquidity portfolios (buckets) based on Amihud's liquidity measure (sub-period: GFC 1)

	B1	B2	B1-B2	Univ.
Excess Return	-3,25%	-2,02%	-1,23%	-2,81%
(t-value)	-0,14	0,27	-0,41	-
Std. Dev.	17,52%	17,46%	0,06%	17,09%
(t-value)	0,18	0,23	-0,05	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of "Amihud" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period GFC 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 11. Decile portfolios of "Turnover" liquidity bucket B1 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-3,45%	-3,17%	-1,01%	-2,34%	-3,67%	-2,91%	-1,19%	-0,60%	-3,62%	-7,11%	3,66%	-2,81%
(t-value)	-0,17	-0,09	0,74	0,22	-0,26	-0,03	0,59	0,82	-0,22	-1,27	1,30	-
Std. Dev.	11,51%	13,72%	13,81%	15,03%	16,53%	17,01%	17,86%	18,55%	20,48%	24,95%	-13,43%	17,09%
(t-value)	-2,72***	-1,37	-1,36	-0,88	-0,24	0,07	0,30	0,44	0,71	1,32	-2,95***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Turnover" liquidity bucket B1 (less liquid stocks) for sub-period GFC 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 12. Decile portfolios of "Amihud" liquidity bucket B1 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-4,51%	-1,78%	-6,96%	2,04%	-2,35%	-2,31%	-2,90%	-5,87%	-4,40%	-6,11%	1,60%	-2,81%
(t-value)	-0,57	0,41	-1,36	1,76*	0,18	0,17	-0,05	-0,94	-0,49	-0,74	0,45	-
Std. Dev.	12,98%	14,70%	17,13%	16,96%	17,69%	19,27%	18,33%	20,14%	22,18%	26,57%	-13,59%	17,09%
(t-value)	-1,83*	-0,99	0,03	-0,04	0,19	0,69	0,54	1,52	2,08**	2,96***	-4,50***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B1 (less liquid stocks) for sub-period GFC 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 13. Decile portfolios of "Turnover" liquidity bucket B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-4,30%	-0,29%	-1,03%	-1,41%	0,59%	-1,22%	-6,96%	-2,23%	-3,88%	-8,64%	4,34%	-2,81%
(t-value)	-0,50	0,87	0,57	0,45	1,07	0,49	-1,31	0,13	-0,31	-1,11	0,85	-
Std. Dev.	14,24%	16,83%	18,07%	17,76%	18,66%	19,85%	21,72%	21,39%	24,75%	29,07%	-14,83%	17,09%
(t-value)	-1,12	-0,01	0,50	0,52	0,92	1,56	2,20**	2,18**	3,05***	3,37***	-4,32***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Turnover" liquidity bucket B2 (more liquid stocks) for sub-period GFC 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 14. Decile portfolios of "Amihud" liquidity bucket B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-2,61%	-0,62%	-1,93%	-0,84%	-2,73%	-3,30%	2,59%	-1,89%	-6,14%	-5,77%	3,17%	-2,81%
(t-value)	0,16	0,91	0,35	0,66	0,02	-0,17	1,84*	0,25	-1,02	-0,74	0,91	-
Std. Dev.	11,85%	13,84%	15,35%	17,03%	17,86%	18,93%	19,28%	19,49%	23,92%	27,64%	-15,79%	17,09%
(t-value)	-2,49**	-1,34	-0,57	0,15	0,42	0,63	0,92	1,41	2,16**	3,32***	-5,28***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B2 (more liquid stocks) for sub-period GFC 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Comparing the performances of corresponding decile portfolios of the two liquidity buckets, I observe the differences in realized returns and volatilities. Tables 15 and 16 display these differences with their corresponding t-values for sub-period GFC 1 for "Turnover" and "Amihud" liquidity measures respectively, while Tables 23 and 24 report these differences and t-values for sub-period GFC 2 for both liquidity measures. Similarly to the main sample results, we can notice that the majority of the differences in realized returns are statistically insignificant. This is true for all the other liquidity measures as well (Appendix B). These GFC sub-period results thus support the finding from the main sample. Liquidity risk does not seem to explain the performance of MV portfolios, since there is no statistically significant outperformance of less liquid, low volatile portfolios over more liquid, low volatile portfolios.

Table 15. Differences between corresponding decile portfolios of "Turnover" liquidity buckets B1 and B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-3,45%	-3,17%	-1,01%	-2,34%	-3,67%	-2,91%	-1,19%	-0,60%	-3,62%	-7,11%
B2	-4,30%	-0,29%	-1,03%	-1,41%	0,59%	-1,22%	-6,96%	-2,23%	-3,88%	-8,64%
B1-B2	0,85%	-2,88%	0,03%	-0,93%	-4,25%	-1,69%	5,76%	1,63%	0,26%	1,53%
(t-value)	0,43	-1,08	0,06	-0,29	-1,34	-0,52	1,87*	0,55	0,12	0,27
Std. Dev.										
B1	11,51%	13,72%	13,81%	15,03%	16,53%	17,01%	17,86%	18,55%	20,48%	24,95%
B2	14,24%	16,83%	18,07%	17,76%	18,66%	19,85%	21,72%	21,39%	24,75%	29,07%
B1-B2	-2,73%	-3,11%	-4,27%	-2,73%	-2,12%	-2,84%	-3,86%	-2,84%	-4,27%	-4,13%
(t-value)	-2,03**	-1,43	-1,93*	-1,47	-1,18	-1,54	-1,87*	-1,60	-1,98**	-1,51

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period GFC 1. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 16. Differences between corresponding decile portfolios of "Amihud'" liquidity buckets B1 and B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-4,51%	-1,78%	-6,96%	2,04%	-2,35%	-2,31%	-2,90%	-5,87%	-4,40%	-6,11%
B2	-2,61%	-0,62%	-1,93%	-0,84%	-2,73%	-3,30%	2,59%	-1,89%	-6,14%	-5,77%
B1-B2	-1,90%	-1,17%	-5,04%	2,89%	0,38%	1,00%	-5,49%	-3,98%	1,75%	-0,33%
(t-value)	-0,94	-0,49	-1,81*	1,11	0,16	0,33	-1,66*	-1,10	0,45	-0,08
Std. Dev.										
B1	12,98%	14,70%	17,13%	16,96%	17,69%	19,27%	18,33%	20,14%	22,18%	26,57%
B2	11,85%	13,84%	15,35%	17,03%	17,86%	18,93%	19,28%	19,49%	23,92%	27,64%
B1-B2	1,13%	0,86%	1,77%	-0,07%	-0,17%	0,33%	-0,96%	0,65%	-1,73%	-1,07%
(t-value)	0,87	0,36	0,62	-0,19	-0,22	0,07	-0,40	0,17	-0,30	-0,37

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period GFC 1. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 17. Liquidity portfolios (buckets) based on Turnover (sub-period: GFC 2)

	B1	B2	B1-B2	Univ.
Excess Return	12,81%	13,55%	-0,73%	13,42%
(t-value)	-0,17	0,04	-0,19	-
Std. Dev.	23,97%	30,22%	-6,25%	26,38%
(t-value)	-0,82	1,10	-1,89*	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of "Turnover" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period GFC 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 18. Liquidity portfolios (buckets) based on Amihud's liquidity measure (sub-period: GFC 2)

	B1	B2	B1-B2	Univ.
Excess Return	12,95%	13,50%	-0,55%	13,42%
(t-value)	-0,10	0,01	-0,12	-
Std. Dev.	28,54%	25,51%	3,03%	26,38%
(t-value)	0,59	-0,28	0,87	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of "Amihud" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period GFC 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 19. Decile portfolios of "Turnover" liquidity bucket B1 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	9,38%	8,52%	12,02%	13,27%	11,48%	12,69%	10,95%	11,94%	13,50%	18,41%	-9,03%	13,42%
(t-value)	-1,28	-1,47	-0,43	-0,06	-0,54	-0,20	-0,60	-0,34	0,04	0,95	-1,88*	-
Std. Dev.	14,79%	16,99%	18,96%	19,95%	22,13%	23,98%	26,25%	29,25%	34,89%	43,16%	-28,37%	26,38%
(t-value)	-4,18***	-3,29***	-2,54**	-2,10**	-1,30	-0,64	0,00	0,73	1,88*	2,85***	-5,64***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Turnover" liquidity bucket B1 (less liquid stocks) for sub-period GFC 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 20. Decile portfolios of "Amihud" liquidity bucket B1 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	11,21%	10,99%	12,66%	10,27%	12,63%	10,74%	11,00%	12,40%	12,99%	19,09%	-7,88%	13,42%
(t-value)	-0,68	-0,70	-0,21	-0,78	-0,18	-0,60	-0,52	-0,20	-0,05	1,02	-1,52	-
Std. Dev.	16,83%	20,16%	22,85%	25,30%	27,83%	29,66%	32,38%	35,24%	38,89%	45,08%	-28,25%	26,38%
(t-value)	-3,31***	-2,03**	-1,07	-0,28	0,38	0,88	1,59	2,24**	2,95***	3,89***	-6,37***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B1 (less liquid stocks) for sub-period GFC 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 21. Decile portfolios of "Turnover" liquidity bucket B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	10,48%	10,08%	14,23%	12,50%	12,93%	12,14%	13,74%	13,55%	13,26%	17,52%	-7,04%	13,42%
(t-value)	-0,82	-0,87	0,20	-0,23	-0,10	-0,29	0,09	0,05	0,00	0,77	-1,35	-
Std. Dev.	18,97%	23,52%	25,50%	27,55%	29,16%	32,19%	33,80%	35,18%	39,75%	45,28%	-26,32%	26,38%
(t-value)	-2,49**	-0,86	-0,24	0,43	0,76	1,54	2,17**	2,43**	3,29***	4,13***	-6,10***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Turnover" liquidity bucket B2 (more liquid stocks) for sub-period GFC 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 22. Decile portfolios of "Amihud" liquidity bucket B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	9,20%	9,18%	12,19%	13,13%	11,84%	12,32%	15,84%	14,29%	15,02%	16,26%	-7,06%	13,42%
(t-value)	-1,34	-1,27	-0,38	-0,09	-0,41	-0,27	0,60	0,21	0,37	0,57	-1,55	-
Std. Dev.	15,05%	18,09%	19,89%	22,67%	24,46%	27,03%	28,32%	32,09%	35,70%	43,01%	-27,96%	26,38%
(t-value)	-4,09***	-2,89***	-2,16**	-1,14	-0,54	0,22	0,61	1,63	2,30**	3,48***	-6,51***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B2 (more liquid stocks) for sub-period GFC 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 23. Differences between corresponding decile portfolios of "Turnover" liquidity buckets B1 and B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	9,38%	8,52%	12,02%	13,27%	11,48%	12,69%	10,95%	11,94%	13,50%	18,41%
B2	10,48%	10,08%	14,23%	12,50%	12,93%	12,14%	13,74%	13,55%	13,26%	17,52%
B1-B2	-1,10%	-1,56%	-2,21%	0,77%	-1,45%	0,55%	-2,79%	-1,61%	0,24%	0,89%
(t-value)	-0,42	-0,50	-0,66	0,19	-0,38	0,12	-0,63	-0,34	0,03	0,13
Std. Dev.										
B1	14,79%	16,99%	18,96%	19,95%	22,13%	23,98%	26,25%	29,25%	34,89%	43,16%
B2	18,97%	23,52%	25,50%	27,55%	29,16%	32,19%	33,80%	35,18%	39,75%	45,28%
B1-B2	-4,17%	-6,52%	-6,54%	-7,60%	-7,02%	-8,21%	-7,56%	-5,92%	-4,86%	-2,12%
(t-value)	-1,97**	-2,54**	-2,35**	-2,55**	-2,05**	-2,17**	-2,19**	-1,68*	-1,31	-0,91

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period GFC 2. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 24. Differences between corresponding decile portfolios of "Amihud'" liquidity buckets B1 and B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	11,21%	10,99%	12,66%	10,27%	12,63%	10,74%	11,00%	12,40%	12,99%	19,09%
B2	9,20%	9,18%	12,19%	13,13%	11,84%	12,32%	15,84%	14,29%	15,02%	16,26%
B1-B2	2,01%	1,81%	0,46%	-2,86%	0,79%	-1,58%	-4,84%	-1,89%	-2,03%	2,83%
(t-value)	0,84	0,64	0,16	-0,74	0,21	-0,35	-1,04	-0,37	-0,34	0,43
Std. Dev.										
B1	16,83%	20,16%	22,85%	25,30%	27,83%	29,66%	32,38%	35,24%	38,89%	45,08%
B2	15,05%	18,09%	19,89%	22,67%	24,46%	27,03%	28,32%	32,09%	35,70%	43,01%
B1-B2	1,77%	2,07%	2,96%	2,63%	3,37%	2,63%	4,06%	3,15%	3,19%	2,06%
(t-value)	0,99	0,95	1,14	0,88	0,91	0,67	1,00	0,66	0,67	0,40

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period GFC 2. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

In the attempt to identify the role of liquidity risk in the MV effect, I lastly turn to the QE sub-period results. Tables 25 and 26 depict the differences in realized returns and volatilities between liquidity buckets B1 and B2 for sub-period QE 1 for "Turnover" and

“Amihud” liquidity measures respectively, while Tables 33 and 34 report these statistics for sub-period QE 2 for both liquidity measures. For the “Turnover” liquidity measure in sub-period QE 1 the less liquid liquidity bucket B1 seems to outperform the more liquid B2 in terms of realized returns, while also having a lower volatility. Conversely, the more liquid B2 outperforms the less liquid B1 for the “Amihud” liquidity measure in sub-period QE 1, while having a lower volatility as well. In QE 2 however, B2 delivers greater returns for the “Turnover” liquidity measure, although at the cost of a higher volatility. For the “Amihud” liquidity measure there is also a change when moving to sub-period QE 2. This time it is the less liquid B1 bucket that generates a greater performance, although at a higher level of risk as well. Again, these differences are statistically insignificant as in the main sample and the GFC sub-samples. Results for other liquidity measures deliver mixed findings with no clear evidence of a liquidity risk premium, despite some of the differences in realized returns and volatilities being statistically significant (Appendix C).

Table 25. Liquidity portfolios (buckets) based on Turnover (sub-period: QE 1)

	B1	**B2**	**B1-B2**	**Univ.**
Excess Return	-4,84%	-9,27%	4,44%	-6,96%
(t-value)	0,73	-0,66	1,35	-
Std. Dev.	22,13%	27,10%	-4,97%	23,90%
(t-value)	-0,61	1,00	-1,61	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of “Turnover” liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period QE 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 26. Liquidity portfolios (buckets) based on Amihud's liquidity measure (sub-period: QE 1)

	B1	**B2**	**B1-B2**	**Univ.**
Excess Return	-8,78%	-5,34%	-3,45%	-6,96%
(t-value)	-0,54	0,52	-1,05	-
Std. Dev.	25,17%	23,89%	1,29%	23,90%
(t-value)	0,35	0,03	0,33	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of “Amihud” liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period QE 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 27. Decile portfolios of “Turnover” liquidity bucket B1 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-1,10%	-4,32%	-1,71%	-2,86%	-4,88%	-4,87%	-5,06%	-6,70%	-7,93%	-12,43%	11,34%	-6,96%
(t-value)	2,33**	1,02	1,92*	1,47	0,71	0,69	0,60	0,10	-0,29	-1,43	3,46***	-
Std. Dev.	14,92%	17,44%	18,86%	19,87%	21,88%	22,69%	24,39%	26,11%	28,92%	34,72%	-19,79%	23,90%
(t-value)	-3,21***	-2,09**	-1,64	-1,26	-0,57	-0,19	0,19	0,52	1,06	1,89*	-4,24***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of “Turnover” liquidity bucket B1 (less liquid stocks) for sub-period QE 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 28. Decile portfolios of “Amihud” liquidity bucket B1 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-3,63%	-3,94%	-6,85%	-3,66%	-7,28%	-10,33%	-10,59%	-13,47%	-15,34%	-16,89%	13,26%	-6,96%
(t-value)	1,28	1,02	0,07	1,04	-0,10	-0,98	-0,94	-1,73*	-2,11**	-2,13**	3,12***	-
Std. Dev.	16,95%	19,93%	22,37%	23,07%	24,88%	26,10%	27,52%	30,23%	32,04%	37,46%	-20,51%	23,90%
(t-value)	-2,28**	-1,23	-0,35	-0,16	0,23	0,65	0,89	1,78*	2,27**	3,15***	-5,05***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of “Amihud” liquidity bucket B1 (less liquid stocks) for sub-period QE 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 29. Decile portfolios of “Turnover” liquidity bucket B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-5,12%	-5,00%	-5,86%	-6,02%	-8,19%	-7,71%	-12,86%	-11,32%	-16,65%	-19,41%	14,28%	-6,96%
(t-value)	0,62	0,60	0,31	0,22	-0,35	-0,19	-1,62	-1,15	-2,31**	-2,53**	2,99***	-
Std. Dev.	18,53%	22,38%	23,94%	24,86%	26,62%	29,15%	30,30%	30,28%	35,04%	39,03%	-20,50%	23,90%
(t-value)	-1,68*	-0,36	0,16	0,40	0,84	1,46	2,11**	2,11**	2,99***	3,54***	-4,98***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of “Turnover” liquidity bucket B2 (more liquid stocks) for sub-period QE 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 30. Decile portfolios of "Amihud" liquidity bucket B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-1,50%	-2,04%	-2,27%	-2,31%	-6,27%	-7,85%	-2,63%	-6,63%	-11,57%	-14,89%	13,39%	-6,96%
(t-value)	2,15**	1,84*	1,66*	1,52	0,21	-0,29	1,32	0,10	-1,26	-1,90*	3,64***	-
Std. Dev.	15,31%	18,27%	19,86%	22,10%	23,62%	25,62%	26,47%	28,60%	32,01%	36,87%	-21,56%	23,90%
(t-value)	-3,06***	-1,86*	-1,21	-0,41	0,04	0,47	0,78	1,40	2,15**	3,29***	-5,86***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B2 (more liquid stocks) for sub-period QE 1. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

I next inspect the differences in realized returns and volatilities between corresponding decile portfolios of the two liquidity buckets for both liquidity measures. These differences with their corresponding t-values are given in Tables 31 and 32 for sub-period QE 1 for "Turnover" and "Amihud" liquidity measures respectively, while Tables 39 and 40 report them for sub-period QE 2 for both measures. Despite QE 1 being the most promising sub-sample, given that it has a significant negative risk-return relation which would suggest a MV effect, it also does not produce an outperformance of less liquid, low volatile portfolios over more liquid, low volatile portfolios. In fact, for the "Amihud" liquidity measure the opposite is true, with all of the more liquid decile portfolios outperforming all the corresponding less liquid ones (Figure 13). However, only D7 and D8 portfolios show statistically significant outperformances (Table 32).

Table 31. Differences between corresponding decile portfolios of "Turnover" liquidity buckets B1 and B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-1,10%	-4,32%	-1,71%	-2,86%	-4,88%	-4,87%	-5,06%	-6,70%	-7,93%	-12,43%
B2	-5,12%	-5,00%	-5,86%	-6,02%	-8,19%	-7,71%	-12,86%	-11,32%	-16,65%	-19,41%
B1-B2	4,02%	0,68%	4,16%	3,16%	3,31%	2,84%	7,79%	4,62%	8,72%	6,97%
(t-value)	1,79*	0,30	1,44	1,13	0,98	0,81	2,14**	1,20	1,99**	1,28
Std. Dev.										
B1	14,92%	17,44%	18,86%	19,87%	21,88%	22,69%	24,39%	26,11%	28,92%	34,72%
B2	18,53%	22,38%	23,94%	24,86%	26,62%	29,15%	30,30%	30,28%	35,04%	39,03%
B1-B2	-3,61%	-4,94%	-5,08%	-4,99%	-4,75%	-6,45%	-5,91%	-4,17%	-6,12%	-4,32%
(t-value)	-1,80*	-1,82*	-1,87*	-1,69*	-1,42	-1,69*	-1,92*	-1,52	-1,80*	-1,35

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period QE 1. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 32. Differences between corresponding decile portfolios of "Amihud'" liquidity buckets B1 and B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-3,63%	-3,94%	-6,85%	-3,66%	-7,28%	-10,33%	-10,59%	-13,47%	-15,34%	-16,89%
B2	-1,50%	-2,04%	-2,27%	-2,31%	-6,27%	-7,85%	-2,63%	-6,63%	-11,57%	-14,89%
B1-B2	-2,13%	-1,91%	-4,58%	-1,35%	-1,00%	-2,48%	-7,96%	-6,85%	-3,78%	-2,00%
(t-value)	-1,11	-0,83	-1,65*	-0,44	-0,31	-0,68	-2,06**	-1,71*	-0,85	-0,36
Std. Dev.										
B1	16,95%	19,93%	22,37%	23,07%	24,88%	26,10%	27,52%	30,23%	32,04%	37,46%
B2	15,31%	18,27%	19,86%	22,10%	23,62%	25,62%	26,47%	28,60%	32,01%	36,87%
B1-B2	1,64%	1,67%	2,50%	0,96%	1,26%	0,48%	1,05%	1,64%	0,02%	0,59%
(t-value)	0,96	0,68	0,90	0,25	0,19	0,18	0,13	0,40	0,08	-0,04

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period QE 1. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

The outperformance of less liquid over more liquid portfolios is found for the "Turnover" liquidity measure, where all of the less liquid decile portfolios outperform all the corresponding more liquid ones (Figure 12). However, as with the "Amihud" liquidity measure, only rarely do we find a statistically significant difference (Table 31). The results for other liquidity measures vary in terms of which decile portfolios outperform, yet all measures share the common feature of not producing statistically significant differences between corresponding decile portfolios, and refute the existence of a liquidity risk premium (Appendix C). Results for sub-period QE 2, in addition to having a significantly positive risk-return relation (MV portfolios underperform), do not produce evidence in favor of identifying a role of liquidity risk in the MV effect.

Table 33. Liquidity portfolios (buckets) based on Turnover (sub-period: QE 2)

	B1	B2	B1-B2	Univ.
Excess Return	23,64%	31,14%	-7,51%	27,44%
(t-value)	-0,96	0,88	-1,81*	-
Std. Dev.	20,17%	25,90%	-5,73%	22,49%
(t-value)	-0,77	0,94	-1,69*	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of "Turnover" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period QE 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 34. Liquidity portfolios (buckets) based on Amihud's liquidity measure (sub-period: QE 2)

	B1	B2	B1-B2	Univ.
Excess Return	28,89%	25,98%	2,91%	27,44%
(t-value)	0,35	-0,38	0,72	-
Std. Dev.	24,67%	21,22%	3,45%	22,49%
(t-value)	0,53	-0,33	0,85	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of "Amihud" liquidity buckets B1 (less liquid stocks) and B2 (more liquid stocks) for sub-period QE 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (B1-B2) displays the differences between the buckets, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 35. Decile portfolios of "Turnover" liquidity bucket B1 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	12,53%	16,03%	19,57%	21,86%	20,82%	23,30%	22,51%	26,82%	28,19%	38,75%	-26,22%	27,44%
(t-value)	-4,36***	-3,29***	-2,28**	-1,59	-1,84*	-1,06	-1,19	-0,15	0,17	1,78*	-4,33***	-
Std. Dev.	11,65%	13,26%	14,57%	15,71%	17,60%	20,03%	22,05%	25,24%	32,12%	40,81%	-29,16%	22,49%
(t-value)	-3,89***	-3,20***	-2,63***	-2,15**	-1,41	-0,67	-0,05	0,69	1,74*	2,43**	-4,53***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Turnover" liquidity bucket B1 (less liquid stocks) for sub-period QE 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 36. Decile portfolios of "Amihud" liquidity bucket B1 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	17,89%	20,46%	22,38%	22,41%	27,10%	28,59%	28,81%	32,29%	37,14%	46,94%	-29,06%	27,44%
(t-value)	-2,70***	-1,98**	-1,35	-1,24	-0,07	0,28	0,33	1,07	1,74*	3,08***	-4,80***	-
Std. Dev.	13,17%	15,71%	18,60%	21,75%	24,00%	26,41%	28,50%	30,74%	35,64%	41,38%	-28,21%	22,49%
(t-value)	-3,23***	-2,16**	-1,16	-0,21	0,38	0,90	1,50	1,84*	2,56**	3,34***	-5,40***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B1 (less liquid stocks) for sub-period QE 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 37. Decile portfolios of "Turnover" liquidity bucket B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	19,08%	21,92%	28,70%	25,99%	31,49%	27,99%	32,46%	34,27%	39,85%	45,84%	-26,76%	27,44%
(t-value)	-2,29**	-1,49	0,31	-0,36	0,98	0,13	1,17	1,45	2,48**	2,99***	-4,50***	-
Std. Dev.	15,51%	19,55%	21,56%	23,58%	24,36%	26,80%	29,16%	31,32%	34,60%	41,20%	-25,69%	22,49%
(t-value)	-2,29**	-0,84	-0,24	0,43	0,61	1,31	1,81*	2,10**	2,81***	3,57***	-5,19***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Turnover" liquidity bucket B2 (more liquid stocks) for sub-period QE 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 38. Decile portfolios of "Amihud" liquidity bucket B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	13,59%	16,11%	19,79%	22,22%	24,16%	26,59%	29,85%	29,09%	33,30%	40,18%	-26,59%	27,44%
(t-value)	-4,10***	-3,30***	-2,19**	-1,37	-0,86	-0,23	0,60	0,38	1,25	2,21**	-4,94***	-
Std. Dev.	11,74%	13,98%	15,89%	18,63%	20,05%	22,32%	23,55%	27,20%	31,45%	39,43%	-27,69%	22,49%
(t-value)	-3,84***	-2,88***	-2,09**	-1,10	-0,61	0,12	0,46	1,43	2,00**	2,93***	-5,32***	-

Note. The table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation of decile portfolios based on historical volatility of "Amihud" liquidity bucket B2 (more liquid stocks) for sub-period QE 2. For each of these statistics there is a t-statistic denoting the significance of the difference with the Universe portfolio. Second to last column (D1-D10) displays the differences between the extreme decile portfolios, with the related t-statistics denoting the significance of these differences. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 39. Differences between corresponding decile portfolios of "Turnover" liquidity buckets B1 and B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	12,53%	16,03%	19,57%	21,86%	20,82%	23,30%	22,51%	26,82%	28,19%	38,75%
B2	19,08%	21,92%	28,70%	25,99%	31,49%	27,99%	32,46%	34,27%	39,85%	45,84%
B1-B2	-6,55%	-5,89%	-9,14%	-4,13%	-10,67%	-4,69%	-9,96%	-7,45%	-11,67%	-7,09%
(t-value)	-2,25**	-1,96**	-2,71***	-1,17	-2,87***	-1,21	-2,28**	-1,54	-2,00**	-0,89
Std. Dev.										

B1	11,65%	13,26%	14,57%	15,71%	17,60%	20,03%	22,05%	25,24%	32,12%	40,81%
B2	15,51%	19,55%	21,56%	23,58%	24,36%	26,80%	29,16%	31,32%	34,60%	41,20%
B1-B2	-3,86%	-6,29%	-7,00%	-7,86%	-6,76%	-6,77%	-7,11%	-6,08%	-2,48%	-0,39%
(t-value)	-2,10**	-2,53**	-2,44**	-2,64***	-2,05**	-2,01**	-1,89*	-1,42	-0,86	-0,66

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period QE 2. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Table 40. Differences between corresponding decile portfolios of "Amihud'" liquidity buckets B1 and B2 (sub-period: QE 2)

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
Excess Return										
B1	17,89%	20,46%	22,38%	22,41%	27,10%	28,59%	28,81%	32,29%	37,14%	46,94%
B2	13,59%	16,11%	19,79%	22,22%	24,16%	26,59%	29,85%	29,09%	33,30%	40,18%
B1-B2	4,30%	4,35%	2,59%	0,20%	2,94%	2,00%	-1,04%	3,20%	3,83%	6,76%
(t-value)	1,57	1,58	0,84	0,07	0,76	0,49	-0,24	0,68	0,64	0,89
Std. Dev.										
B1	13,17%	15,71%	18,60%	21,75%	24,00%	26,41%	28,50%	30,74%	35,64%	41,38%
B2	11,74%	13,98%	15,89%	18,63%	20,05%	22,32%	23,55%	27,20%	31,45%	39,43%
B1-B2	1,43%	1,73%	2,71%	3,12%	3,94%	4,09%	4,95%	3,54%	4,19%	1,94%
(t-value)	0,93	0,89	1,00	0,89	1,00	0,81	1,09	0,55	0,66	0,37

Note. For each decile portfolio within both liquidity buckets (B1 – less liquid stocks, B2 – more liquid stocks), the table reports the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and standard deviation for sub-period QE 2. It also reports the differences in excess return and standard deviation between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

CONCLUSION

In this thesis I explore the research on the strategy of MV investing, which takes advantage of the fact that securities with low volatility tend to outperform the ones with high volatility, also called the volatility effect (Blitz & van Vliet, 2007). Since this outperformance is in violation of the traditional finance theory assumptions, it is considered an anomaly. For this reason many authors have tried explaining the performance of MV portfolios by considering different risk sources, and examining whether MV outperformance consists of risk premiums as rewards for incurring these risks. Following in their footsteps, I study the role of liquidity risk to see whether it offers an explanation of the volatility effect. Since other papers do not consider the effects of liquidity risk in MV strategies directly, I add a different perspective to the existing research on the possible risk sources that might explain the anomaly. In addition, my research differs due to the time period used, which includes the global financial crisis and its aftermath. Given that liquidity is a multidimensional variable, and that liquidity risk cannot be measured directly, I use different liquidity measures to ensure the robustness of any findings relating liquidity risk to the volatility effect. I control for liquidity by dividing the sample of Russell 1000 constituent stocks into two separate liquidity buckets based on past 3-year liquidity of individual stocks, and further into separate decile portfolios based on past 3-year volatility of individual stocks. I rebalance the equally weighted portfolios each month, and observe their performances. In addition, I also divide the main sample period into different sub-periods based on criteria associated with the global financial crisis and its repercussions.

The clearest finding that emerges from the results of all liquidity buckets of all liquidity measures, is the finding of past risk being a strong predictor of future risk. I observe that both volatility and beta increase monotonically for consecutive decile portfolios, thus confirming the discovery of Blitz and van Vliet (2007) and Blitz et al. (2013). This does not seem to be the case when we turn to the relation between ex ante volatility and ex post returns. On average no statistically significant positive or negative relation is found, rendering the risk-return relation flat. As many researchers have noted, this speaks against the theoretical models such as the CAPM, which argue that the risk-return relation is positive. The corollary that follows from these two findings is a risk-adjusted outperformance of MV decile portfolios, measured by the Sharpe ratio, which is primarily driven by the volatility of these portfolios. This outperformance is also found for liquidity buckets of other liquidity measures. However, when we observe the significance of Sharpe ratio differences between decile portfolios, only rarely do we find a portfolio with a Sharpe ratio that is statistically significantly different from the Universe portfolio Sharpe ratio. This discovery does not seem to fully conform to the findings of Blitz and van Vliet (2007) and Blitz et al. (2013) of there being a significant risk-adjusted volatility effect. I therefore conclude that the risk-return relation in the studied time period is at most flat, even when considering risk-adjusted excess returns, which means that no significant volatility effect is found.

By dividing the main sample into two liquidity buckets based on individual stock liquidity, I am able to control for the effect of liquidity risk and observe the differences in realized returns, volatilities and Sharpe ratios between the two liquidity buckets. For all the liquidity measures I use in my study, the differences in realized returns and Sharpe ratios between the two liquidity buckets are statistically insignificant, which already suggests a lack of a liquidity risk premium. Since each liquidity bucket is further divided into decile portfolios based on individual stock volatility, I compare the performance of corresponding decile portfolios of the two liquidity buckets. I find that almost all the differences of realized returns and Sharpe ratios between corresponding decile portfolios are statistically insignificant, which holds true for all liquidity measures. There are a few exceptions where the differences are statistically significant, yet none of them point to any clear relation between liquidity and volatility. Adhering to the above findings, no apparent role for liquidity risk in explaining the performance of MV portfolios seems to exist. I therefore turn to the sub-period results for a clearer picture.

The main sample period was a time of turbulent market conditions, which includes the events of the global financial crisis, and periods when markets were affected by quantitative easing measures deployed by the Federal Reserve. Since risk-return relations might have been changing during these times, I extend the study by including calculations for certain sub-periods. Four different sub-periods (GFC 1, GFC 2, QE 1 and QE 2), whose formation is described in the Methodology section, are studied. Sub-period GFC 1 captures the earlier part of the main sample period, during which poor performance of the markets can be identified. Sub-period GFC 2 on the other hand, covers the later part of the main sample period, when markets rebound and show signs of recovery. However, no statistically significant positive or negative risk-return relation for sub-period GFC 1, nor GFC 2 is identified. For these two sub-periods, I find a (non-risk-adjusted) flat risk-return relation akin to the main sample, yet at different levels of realized returns. This holds true for all the liquidity measures used. Sub-periods QE 1 and QE 2 divide the main sample period based on the presence or lack of quantitative easing measures of the Federal Reserve, as described in the Methodology section. Sub-period QE 1, which covers the times when no quantitative easing was present, produces inferior performance of the markets, with all portfolio returns being negative. QE 2 thus covers all the periods when a quantitative easing program was present and produces high excess returns. In contrast to the GFC framework, both QE 1 and QE 2 show a statistically significant (non-risk-adjusted) risk-return relation, QE 1 a negative one, while QE 2 a positive one. This too, holds true for all the liquidity measures used. Given that no significant volatility effect is recognized in the main sample period of this study, this finding is of great interest, since the QE 1 sub-period exhibits a significant volatility effect, which might be explained by liquidity risk.

As with the main sample findings, I discover that in all sub-periods and for all liquidity measures, the differences between liquidity buckets are inconsistent in terms of which bucket outperforms, and more importantly, are often statistically insignificant. This again raises doubt in whether a liquidity risk premium exists, and whether liquidity risk has any role at all in explaining the MV outperformance. By comparing the performances of corresponding decile portfolios of the two liquidity buckets, I again find that almost all the differences of realized returns between corresponding decile portfolios are statistically insignificant, which holds true for all liquidity measures and for all sub-periods. As noted earlier, sub-period QE 1 is most interesting among all the studied sub-periods, since it delivers a statistically significant (non-risk-adjusted) negative risk-return relation, which suggests the presence of a volatility effect. However, it too fails to produce a statistically significant outperformance of less liquid low volatile portfolios, over more liquid low volatile portfolios, regardless of which liquidity measure is used. This finding thus confirms the main sample discovery that no apparent role for liquidity risk in explaining the performance of MV portfolios exists.

All of the results seem to show that liquidity risk has no significant power in explaining the performance of MV portfolios. Using different liquidity measures and performing calculations for different sub-periods, fails to produce any significant outperformance of decile portfolios with low liquidity. For the sample period used in this study no liquidity risk premium is identified, and all the hypotheses of liquidity not having a significant influence on MV portfolio performance can be confirmed.

Since the studied time period is relatively short and includes extreme market events, it would be interesting to apply the same approach to a longer data set. This could improve the validity of the results, given that different market conditions would be captured. Since only Russell 1000 constituent stocks are used, it would also be an interesting extension to include smaller capitalization stocks, given that these were often shown to be less liquid. The inclusion of other capital markets would also be an extension worth exploring. Further, it would be interesting to construct liquidity factor data using an approach similar to that of Kenneth French when constructing the Fama and French (1993) factors, or to the liquidity analyses of Pastor and Stambaugh (2003) and Acharya and Pedersen (2005), and see whether this produces different findings. Due to constraints regarding prioritizing which tests to examine and certain data limitations, these recommendations were not included in the thesis.

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APPENDIXES

TABLE OF APPENDIXES

Appendix A: Main sample results of portfolios sorted on liquidity and volatility for other liquidity measures

This appendix presents main sample results of portfolios sorted on liquidity and volatility for other liquidity measures used in this thesis and gives a brief description of the sorting procedure.

At the end of each month between December 2004 and November 2014, I first sort all Russell 1000 Index constituent stocks of the given year into two portfolios (buckets) based on their past 3-year liquidity. Both liquidity buckets are equally weighted, with bucket B1 containing less liquid stocks and bucket B2 more liquid stocks. Within each liquidity bucket I further sort stocks into decile portfolios based on their past 3-year return volatility. All portfolios are equally weighted, with D1 containing stocks with the lowest historical volatility and D10 stocks with the highest historical volatility. The universe is defined as the equally weighted portfolio of all the stocks in the Russell 1000 Index in the given year. I then calculate returns over the subsequent month for each portfolio and repeat the sorting procedure. Since the studied time period is 10 years long, there are 120 repetitions of this procedure and 10 different constituent lists, one for each calendar year. The whole process is then repeated five times, each time using a different liquidity measure. Liquidity measures used are Amihud's liquidity measure, Relative spread, Dollar volume, Turnover and Composite liquidity. All analyses in this thesis use daily data and prices denominated in U.S. dollars.

Results are presented in four tables for each liquidity measure (results for the "Turnover" and "Amihud" liquidity measures appear in the Empirical analysis section of the thesis) and all follow the configuration described in this paragraph. First three tables of each liquidity measure have a similar configuration. For each portfolio I report the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return), standard deviation, and Sharpe ratio. For each of these statistics I also report the t-statistic in order to test the significance of the difference with the Universe portfolio. Second to last columns of the first three tables (B1-B2 and D1-D10) denote the differences between the extreme portfolios, with the related t-statistics displaying the significance of these differences. From the regression analyses I report the CAPM beta, annualized CAPM alpha (1-factor alpha), 3-factor alpha, 4-factor alpha and their t-statistics. Factors used in the regression analyses are obtained from Kenneth French's website and include the market factor, SMB, HML and UMD. All alphas are based on geometric average returns. In the last table of each liquidity measure, I additionally report the differences in realized return, standard deviation and Sharpe ratio between corresponding decile portfolios of the two liquidity buckets. The significance of these differences is provided by the t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Relative spread

Table 1. Liquidity portfolios (buckets) based on Relative spread

	B1	B2	B1-B2	Univ.
Excess Return	7,36%	6,97%	0,39%	7,34%
(t-value)	0,02	-0,15	0,16	-
Std. Dev.	27,60%	20,50%	7,10%	23,34%
(t-value)	1,30	-1,01	2,27**	-
Sharpe Ratio	0,27	0,34	-0,07	0,31
(t-value)	-1,31	0,51	-0,86	-
Beta	1,54	1,09	-	1,30
1-factor alpha	-4,06%	-1,20%	-	-2,32%
(t-value)	-2,95***	-1,27	-	-2,07**
3-factor alpha	-3,67%	-1,10%	-	-2,08%
(t-value)	-2,72***	-1,16	-	-1,87*
4-factor alpha	-2,70%	-0,65%	-	-1,35%
(t-value)	-2,03**	-0,68	-	-1,22

Table 2. Decile portfolios of “Relative spread” liquidity bucket B1

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	5,40%	3,76%	5,31%	6,67%	6,15%	10,24%	7,41%	6,85%	6,00%	10,85%	-5,45%	7,34%
(t-value)	-0,78	-1,29	-0,67	-0,20	-0,34	0,89	0,05	-0,09	-0,30	0,82	-1,31	-
Std. Dev.	17,27%	20,78%	24,12%	25,14%	27,99%	29,22%	30,91%	33,30%	36,29%	41,41%	-24,13%	23,34%
(t-value)	-2,86***	-1,21	-0,05	0,46	1,32	1,91*	2,54**	3,10***	3,98***	4,97***	-7,07***	-
Sharpe Ratio	0,31	0,18	0,22	0,27	0,22	0,35	0,24	0,21	0,17	0,26	0,05	0,31
(t-value)	-0,02	-1,51	-1,15	-0,68	-1,43	0,50	-0,98	-1,35	-1,58	-0,43	0,25	-
Beta	0,84	1,06	1,30	1,37	1,54	1,55	1,70	1,82	1,96	2,31	-	1,30
1-factor alpha	-0,84%	-4,15%	-4,37%	-3,48%	-5,33%	-1,29%	-5,17%	-6,62%	-8,47%	-6,07%	-	-2,32%
(t-value)	-0,89	-3,73***	-3,63***	-2,54**	-3,87***	-0,93	-3,23***	-3,39***	-4,73***	-2,13**	-	-2,07**
3-factor alpha	-0,70%	-3,94%	-3,99%	-3,10%	-5,07%	-1,04%	-4,78%	-6,11%	-8,04%	-5,10%	-	-2,08%
(t-value)	-0,76	-3,61***	-3,48***	-2,35**	-3,69***	-0,74	-3,06***	-3,19***	-4,46***	-1,84*	-	-1,87*
4-factor alpha	-0,49%	-3,70%	-3,45%	-2,56%	-4,26%	-0,36%	-3,84%	-4,92%	-6,26%	-2,53%	-	-1,35%
(t-value)	-0,52	-3,26***	-2,97***	-1,90*	-3,09***	-0,25	-2,48**	-2,55**	-3,65***	-0,96	-	-1,22

Table 3. Decile portfolios of "Relative spread" liquidity bucket B2

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	3,75%	5,88%	7,20%	7,53%	8,49%	7,43%	5,91%	9,23%	5,47%	6,10%	-2,35%	7,34%
(t-value)	-1,53	-0,61	-0,08	0,06	0,40	0,02	-0,48	0,61	-0,60	-0,36	-0,87	-
Std. Dev.	13,59%	16,04%	17,27%	18,95%	20,60%	21,85%	23,62%	24,57%	26,38%	30,22%	-16,63%	23,34%
(t-value)	-4,85***	-3,41***	-2,68***	-1,75*	-0,87	-0,31	0,48	0,91	1,58	3,42***	-8,39***	-
Sharpe Ratio	0,28	0,37	0,42	0,40	0,41	0,34	0,25	0,38	0,21	0,20	0,07	0,31
(t-value)	-0,20	0,39	0,92	0,86	1,23	0,35	-0,89	0,87	-1,48	-1,25	0,32	-
Beta	0,56	0,78	0,85	0,96	1,15	1,19	1,29	1,30	1,38	1,53	-	1,30
1-factor alpha	-0,43%	0,06%	0,84%	0,40%	-0,10%	-1,43%	-3,74%	-0,50%	-4,80%	-5,27%	-	-2,32%
(t-value)	-0,47	0,06	0,97	0,42	-0,10	-1,24	-3,30***	-0,39	-4,08***	-3,45***	-	-2,07**
3-factor alpha	-0,39%	0,15%	0,85%	0,47%	0,03%	-1,34%	-3,50%	-0,34%	-4,67%	-5,14%	-	-2,08%
(t-value)	-0,44	0,18	0,99	0,50	0,03	-1,15	-3,12***	-0,27	-3,94***	-3,36***	-	-1,87*
4-factor alpha	-0,41%	0,35%	1,08%	0,72%	0,47%	-0,85%	-2,88%	0,37%	-4,06%	-4,28%	-	-1,35%
(t-value)	-0,45	0,40	1,24	0,74	0,45	-0,73	-2,55**	0,29	-3,43***	-2,86***	-	-1,22

Table 4. Differences between corresponding decile portfolios of "Relative spread" liquidity buckets B1 and B2

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	5,40%	3,76%	5,31%	6,67%	6,15%	10,24%	7,41%	6,85%	6,00%	10,85%
B2	3,75%	5,88%	7,20%	7,53%	8,49%	7,43%	5,91%	9,23%	5,47%	6,10%
B1-B2	1,65%	-2,12%	-1,89%	-0,86%	-2,34%	2,81%	1,50%	-2,37%	0,53%	4,75%
(t-value)	0,91	-0,92	-0,70	-0,28	-0,71	0,89	0,46	-0,58	0,17	1,02
Std. Dev.										
B1	17,27%	20,78%	24,12%	25,14%	27,99%	29,22%	30,91%	33,30%	36,29%	41,41%
B2	13,59%	16,04%	17,27%	18,95%	20,60%	21,85%	23,62%	24,57%	26,38%	30,22%
B1-B2	3,68%	4,74%	6,85%	6,20%	7,39%	7,37%	7,29%	8,73%	9,91%	11,18%
(t-value)	2,18**	2,20**	2,45**	2,14**	2,15**	2,26**	2,19**	2,40**	2,68***	2,35**
Sharpe Ratio										
B1	0,31	0,18	0,22	0,27	0,22	0,35	0,24	0,21	0,17	0,26
B2	0,28	0,37	0,42	0,40	0,41	0,34	0,25	0,38	0,21	0,20
B1-B2	0,04	-0,19	-0,20	-0,13	-0,19	0,01	-0,01	-0,17	-0,04	0,06
(t-value)	0,26	-1,43	-1,45	-1,10	-1,70*	0,09	-0,09	-1,55	-0,35	0,41

Dollar volume

Table 5. Liquidity portfolios (buckets) based on Dollar volume

	B1	B2	B1-B2	Univ.
Excess Return	7,58%	7,05%	0,54%	7,34%
(t-value)	0,08	-0,10	0,18	-
Std. Dev.	23,70%	24,12%	-0,43%	23,34%
(t-value)	0,13	0,34	-0,22	-
Sharpe Ratio	0,32	0,29	0,03	0,31
(t-value)	0,18	-0,74	0,48	-
Beta	1,34	1,28	-	1,30
1-factor alpha	-2,43%	-2,52%	-	-2,32%
(t-value)	-2,07**	-2,23**	-	-2,07**
3-factor alpha	-2,11%	-2,33%	-	-2,08%
(t-value)	-1,84*	-2,06**	-	-1,87*
4-factor alpha	-1,34%	-1,67%	-	-1,35%
(t-value)	-1,18	-1,47	-	-1,22

Table 6. Decile portfolios of "Dollar volume" liquidity bucket B1

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	4,82%	6,08%	5,47%	6,15%	7,86%	8,61%	6,79%	7,99%	9,85%	8,01%	-3,19%	7,34%
(t-value)	-1,03	-0,51	-0,69	-0,42	0,18	0,41	-0,15	0,22	0,72	0,22	-0,87	-
Std. Dev.	15,34%	17,47%	19,67%	21,38%	23,09%	25,30%	26,57%	28,92%	31,47%	37,14%	-21,79%	23,34%
(t-value)	-3,82***	-2,65***	-1,55	-0,73	-0,07	0,75	1,25	2,17**	2,82***	4,09***	-7,05***	-
Sharpe Ratio	0,31	0,35	0,28	0,29	0,34	0,34	0,26	0,28	0,31	0,22	0,10	0,31
(t-value)	0,00	0,32	-0,40	-0,36	0,35	0,40	-0,83	-0,54	-0,02	-0,93	0,44	-
Beta	0,72	0,89	1,07	1,14	1,26	1,42	1,53	1,56	1,71	2,22	-	1,30
1-factor alpha	-0,55%	-0,54%	-2,51%	-2,31%	-1,49%	-1,96%	-4,56%	-3,56%	-2,87%	-8,32%	-	-2,32%
(t-value)	-0,56	-0,60	-2,27**	-2,12**	-1,41	-1,50	-3,21***	-2,59***	-1,65*	-3,66***	-	-2,07**
3-factor alpha	-0,45%	-0,40%	-2,28%	-2,11%	-1,23%	-1,64%	-4,17%	-3,32%	-2,40%	-7,47%	-	-2,08%
(t-value)	-0,47	-0,45	-2,10**	-1,94*	-1,19	-1,29	-3,02***	-2,43**	-1,40	-3,40***	-	-1,87*
4-factor alpha	-0,34%	-0,12%	-1,83%	-1,75%	-0,73%	-1,05%	-3,37%	-2,61%	-1,08%	-5,12%	-	-1,35%
(t-value)	-0,34	-0,13	-1,67*	-1,57	-0,69	-0,82	-2,42**	-1,88*	-0,65	-2,50**	-	-1,22

Table 7. Decile portfolios of “Dollar volume” liquidity bucket B2

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D1-D10**	**Univ.**
Excess Return	3,92%	6,98%	7,39%	7,02%	5,14%	7,90%	8,41%	4,56%	4,59%	8,71%	-4,79%	7,34%
(t-value)	-1,46	-0,17	0,00	-0,12	-0,73	0,18	0,35	-0,81	-0,72	0,37	-1,31	-
Std. Dev.	14,01%	17,09%	19,52%	21,90%	23,54%	25,25%	26,98%	30,63%	33,76%	39,99%	-25,98%	23,34%
(t-value)	-4,62***	-2,85***	-1,54	-0,37	0,08	0,77	1,44	2,70***	3,55***	4,95***	-8,33***	-
Sharpe Ratio	0,28	0,41	0,38	0,32	0,22	0,31	0,31	0,15	0,14	0,22	0,06	0,31
(t-value)	-0,19	0,78	0,67	0,08	-1,34	-0,02	-0,04	-2,09**	-2,04**	-0,83	0,25	-
Beta	0,58	0,81	0,98	1,17	1,31	1,30	1,37	1,55	1,74	2,10	-	1,30
1-factor alpha	-0,40%	0,89%	0,05%	-1,74%	-4,60%	-1,78%	-1,83%	-6,94%	-8,28%	-6,82%	-	-2,32%
(t-value)	-0,47	1,04	0,06	-1,49	-3,89***	-1,43	-1,60	-4,67***	-4,52***	-2,99***	-	-2,07**
3-factor alpha	-0,35%	0,88%	0,18%	-1,67%	-4,39%	-1,61%	-1,73%	-6,67%	-8,03%	-6,13%	-	-2,08%
(t-value)	-0,43	1,05	0,19	-1,41	-3,76***	-1,30	-1,49	-4,50***	-4,35***	-2,75***	-	-1,87*
4-factor alpha	-0,35%	1,08%	0,41%	-1,20%	-3,83%	-0,94%	-1,22%	-5,87%	-7,06%	-4,08%	-	-1,35%
(t-value)	-0,42	1,27	0,42	-1,00	-3,24***	-0,76	-1,05	-3,92***	-3,80***	-1,93*	-	-1,22

Table 8. Differences between corresponding decile portfolios of “Dollar volume” liquidity buckets B1 and B2

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**
Excess Return										
B1	4,82%	6,08%	5,47%	6,15%	7,86%	8,61%	6,79%	7,99%	9,85%	8,01%
B2	3,92%	6,98%	7,39%	7,02%	5,14%	7,90%	8,41%	4,56%	4,59%	8,71%
B1-B2	0,89%	-0,89%	-1,92%	-0,87%	2,72%	0,71%	-1,62%	3,43%	5,26%	-0,70%
(t-value)	0,52	-0,43	-0,78	-0,31	0,91	0,23	-0,46	0,94	1,25	-0,12
Std. Dev.										
B1	15,34%	17,47%	19,67%	21,38%	23,09%	25,30%	26,57%	28,92%	31,47%	37,14%
B2	14,01%	17,09%	19,52%	21,90%	23,54%	25,25%	26,98%	30,63%	33,76%	39,99%
B1-B2	1,34%	0,38%	0,15%	-0,52%	-0,45%	0,06%	-0,41%	-1,71%	-2,29%	-2,85%
(t-value)	0,99	0,22	-0,03	-0,39	-0,15	-0,02	-0,19	-0,57	-0,76	-0,88
Sharpe Ratio										
B1	0,31	0,35	0,28	0,29	0,34	0,34	0,26	0,28	0,31	0,22
B2	0,28	0,41	0,38	0,32	0,22	0,31	0,31	0,15	0,14	0,22
B1-B2	0,03	-0,06	-0,10	-0,03	0,12	0,03	-0,06	0,13	0,18	0,00
(t-value)	0,29	-0,56	-0,95	-0,34	1,28	0,29	-0,52	1,29	1,82*	-0,02

Composite liquidity

Table 9. Liquidity portfolios (buckets) based on Composite liquidity

	B1	B2	B1-B2	Univ.
Excess Return	8,15%	6,34%	1,81%	7,34%
(t-value)	0,26	-0,36	0,61	-
Std. Dev.	25,01%	22,91%	2,10%	23,34%
(t-value)	0,62	-0,13	0,75	-
Sharpe Ratio	0,33	0,28	0,05	0,31
(t-value)	0,36	-1,06	0,75	-
Beta	1,44	1,19	-	1,30
1-factor alpha	-2,54%	-2,56%	-	-2,32%
(t-value)	-2,00**	-2,46**	-	-2,07**
3-factor alpha	-2,18%	-2,42%	-	-2,08%
(t-value)	-1,76*	-2,33**	-	-1,87*
4-factor alpha	-1,27%	-1,91%	-	-1,35%
(t-value)	-1,04	-1,81*	-	-1,22

Table 10. Decile portfolios of "Composite liquidity" liquidity bucket B1

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	5,02%	6,56%	5,24%	8,29%	9,16%	6,67%	8,19%	8,34%	8,05%	11,22%	-6,21%	7,34%
(t-value)	-0,95	-0,32	-0,75	0,33	0,59	-0,19	0,28	0,31	0,22	0,91	-1,51	-
Std. Dev.	15,43%	18,17%	21,07%	22,41%	24,80%	26,19%	28,55%	30,29%	33,97%	39,44%	-24,00%	23,34%
(t-value)	-3,74***	-2,34**	-0,85	-0,31	0,44	1,11	1,96*	2,50**	3,53***	4,63***	-7,44***	-
Sharpe Ratio	0,33	0,36	0,25	0,37	0,37	0,25	0,29	0,28	0,24	0,28	0,04	0,31
(t-value)	0,07	0,47	-0,77	0,76	0,83	-0,83	-0,39	-0,53	-0,88	-0,26	0,18	-
Beta	0,72	0,93	1,11	1,22	1,35	1,52	1,59	1,71	1,94	2,34	-	1,30
1-factor alpha	-0,39%	-0,36%	-3,01%	-0,82%	-0,91%	-4,65%	-3,62%	-4,33%	-6,33%	-5,98%	-	-2,32%
(t-value)	-0,39	-0,39	-2,58***	-0,75	-0,74	-3,24***	-2,78***	-2,53**	-3,18***	-2,31**	-	-2,07**
3-factor alpha	-0,29%	-0,21%	-2,80%	-0,53%	-0,57%	-4,30%	-3,32%	-3,86%	-5,84%	-5,04%	-	-2,08%
(t-value)	-0,29	-0,22	-2,42**	-0,50	-0,48	-3,05***	-2,56**	-2,30**	-2,97***	-2,01**	-	-1,87*
4-factor alpha	-0,15%	0,15%	-2,40%	-0,07%	0,02%	-3,48%	-2,63%	-2,55%	-4,26%	-2,49%	-	-1,35%
(t-value)	-0,15	0,16	-2,04**	-0,06	0,01	-2,47**	-1,99**	-1,57	-2,20**	-1,05	-	-1,22

Table 11. Decile portfolios of "Composite liquidity" liquidity bucket B2

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	4,25%	5,66%	6,97%	7,82%	4,88%	5,93%	7,68%	7,57%	4,48%	3,70%	0,55%	7,34%
(t-value)	-1,32	-0,70	-0,16	0,16	-0,85	-0,46	0,12	0,08	-0,84	-0,92	0,10	-
Std. Dev.	14,07%	16,86%	18,60%	20,71%	22,34%	24,22%	25,41%	27,60%	31,75%	37,61%	-23,54%	23,34%
(t-value)	-4,60***	-3,01***	-2,02**	-0,93	-0,27	0,40	0,92	1,76*	2,97***	4,53***	-8,07***	-
Sharpe Ratio	0,30	0,34	0,37	0,38	0,22	0,24	0,30	0,27	0,14	0,10	0,20	0,31
(t-value)	-0,07	0,17	0,58	0,77	-1,22	-1,02	-0,18	-0,54	-2,13**	-2,17**	0,83	-
Beta	0,58	0,80	0,93	1,10	1,24	1,32	1,28	1,37	1,54	1,82	-	1,30
1-factor alpha	-0,09%	-0,35%	0,03%	-0,38%	-4,40%	-3,92%	-1,85%	-2,66%	-6,97%	-9,79%	-	-2,32%
(t-value)	-0,10	-0,40	0,03	-0,36	-4,15***	-3,11***	-1,51	-2,16**	-4,59***	-5,06***	-	-2,07**
3-factor alpha	-0,02%	-0,32%	0,09%	-0,28%	-4,30%	-3,68%	-1,78%	-2,57%	-6,73%	-9,39%	-	-2,08%
(t-value)	-0,03	-0,38	0,10	-0,26	-4,03***	-2,95***	-1,44	-2,05**	-4,46***	-4,88***	-	-1,87*
4-factor alpha	-0,01%	-0,16%	0,40%	0,06%	-3,90%	-3,09%	-1,20%	-2,01%	-5,97%	-8,13%	-	-1,35%
(t-value)	-0,01	-0,18	0,43	0,06	-3,58***	-2,45**	-0,96	-1,60	-3,92***	-4,26***	-	-1,22

Table 12. Differences between corresponding decile portfolios of "Composite liquidity" liquidity buckets B1 and B2

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	5,02%	6,56%	5,24%	8,29%	9,16%	6,67%	8,19%	8,34%	8,05%	11,22%
B2	4,25%	5,66%	6,97%	7,82%	4,88%	5,93%	7,68%	7,57%	4,48%	3,70%
B1-B2	0,77%	0,90%	-1,73%	0,47%	4,28%	0,74%	0,51%	0,77%	3,56%	7,53%
(t-value)	0,44	0,45	-0,69	0,18	1,43	0,23	0,17	0,24	0,87	1,48
Std. Dev.										
B1	15,43%	18,17%	21,07%	22,41%	24,80%	26,19%	28,55%	30,29%	33,97%	39,44%
B2	14,07%	16,86%	18,60%	20,71%	22,34%	24,22%	25,41%	27,60%	31,75%	37,61%
B1-B2	1,36%	1,31%	2,47%	1,70%	2,46%	1,98%	3,14%	2,69%	2,22%	1,83%
(t-value)	1,11	0,73	1,22	0,62	0,71	0,72	1,06	0,78	0,59	0,23
Sharpe Ratio										
B1	0,33	0,36	0,25	0,37	0,37	0,25	0,29	0,28	0,24	0,28
B2	0,30	0,34	0,37	0,38	0,22	0,24	0,30	0,27	0,14	0,10
B1-B2	0,02	0,03	-0,13	-0,01	0,15	0,01	-0,02	0,00	0,10	0,19
(t-value)	0,19	0,22	-1,13	-0,08	1,50	0,10	-0,15	0,01	0,92	1,60

Appendix B: Sub-period results of portfolios sorted on liquidity and volatility for other liquidity measures (sub-periods: GFC 1, GFC 2)

This appendix presents sub-period results of portfolios sorted on liquidity and volatility for other liquidity measures used in this thesis (results for the "Turnover" and "Amihud" liquidity measures appear in the Empirical analysis section of the thesis). The two sub-periods are obtained by dividing the main sample into sub-period GFC 1 and sub-period GFC 2, the division point being the bankruptcy of the investment bank Lehman Brothers in September 2008. Sub-period GFC 1 thus extends from January 2005 to September 2008 and GFC 2 from October 2008 to December 2014. The methodology of sorting and return calculations is analogous to the description in Appendix A. Results are presented in a similar fashion to those in Appendix A, with the exception of the tables depicting only the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and the standard deviation, with the corresponding differences and t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Relative spread (sub-period: GFC 1)

Table 13. Liquidity portfolios (buckets) based on Relative spread (sub-period: GFC 1)

	B1	**B2**	**B1-B2**	**Univ.**
Excess Return	-2,82%	-2,58%	-0,24%	-2,81%
(t-value)	-0,01	0,10	-0,11	-
Std. Dev.	18,74%	16,38%	2,36%	17,09%
(t-value)	0,57	-0,14	0,73	-

Table 14. Decile portfolios of "Relative spread" liquidity bucket B1 (sub-period: GFC 1)

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D1-D10**	**Univ.**
Excess Return	-2,34%	-4,14%	-1,30%	-0,53%	-5,14%	2,46%	-4,22%	-1,88%	-5,90%	-8,78%	6,44%	-2,81%
(t-value)	0,23	-0,42	0,57	0,81	-0,73	1,53	-0,45	0,22	-0,87	-1,14	1,28	-
Std. Dev.	13,82%	16,12%	17,98%	18,16%	18,84%	18,52%	19,92%	22,39%	24,66%	30,17%	-16,35%	17,09%
(t-value)	-1,41	-0,31	0,18	0,24	0,50	0,79	1,43	1,87*	2,70***	3,33***	-4,35***	-

Table 15. Decile portfolios of "Relative spread" liquidity bucket B2 (sub-period: GFC 1)

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D1-D10**	**Univ.**
Excess Return	-5,11%	-1,04%	-1,75%	-0,94%	-0,77%	-3,49%	-2,39%	-0,91%	-6,41%	-4,87%	-0,24%	-2,81%
(t-value)	-0,87	0,78	0,43	0,70	0,66	-0,22	0,14	0,68	-1,17	-0,59	-0,03	-
Std. Dev.	11,65%	13,66%	14,24%	16,29%	17,12%	17,52%	18,64%	18,68%	20,24%	24,05%	-12,39%	17,09%
(t-value)	-2,62***	-1,42	-1,12	-0,16	0,32	0,34	0,61	0,78	1,47	2,75***	-5,21***	-

Table 16. Differences between corresponding decile portfolios of "Relative spread" liquidity buckets B1 and B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-2,34%	-4,14%	-1,30%	-0,53%	-5,14%	2,46%	-4,22%	-1,88%	-5,90%	-8,78%
B2	-5,11%	-1,04%	-1,75%	-0,94%	-0,77%	-3,49%	-2,39%	-0,91%	-6,41%	-4,87%
B1-B2	2,77%	-3,10%	0,45%	0,41%	-4,37%	5,95%	-1,83%	-0,97%	0,51%	-3,90%
(t-value)	1,30	-1,30	0,21	0,15	-1,33	1,69*	-0,56	-0,35	0,12	-0,73
Std. Dev.										
B1	13,82%	16,12%	17,98%	18,16%	18,84%	18,52%	19,92%	22,39%	24,66%	30,17%
B2	11,65%	13,66%	14,24%	16,29%	17,12%	17,52%	18,64%	18,68%	20,24%	24,05%
B1-B2	2,16%	2,47%	3,74%	1,87%	1,72%	1,00%	1,28%	3,72%	4,42%	6,12%
(t-value)	1,42	1,17	1,24	0,40	0,24	0,46	0,77	1,17	1,38	1,11

Dollar volume (sub-period: GFC 1)

Table 17. Liquidity portfolios (buckets) based on Dollar volume (sub-period: GFC 1)

	B1	B2	B1-B2	Univ.
Excess Return	-1,75%	-3,41%	1,66%	-2,81%
(t-value)	0,37	-0,21	0,58	-
Std. Dev.	16,64%	18,35%	-1,72%	17,09%
(t-value)	-0,17	0,57	-0,74	-

Table 18. Decile portfolios of "Dollar volume" liquidity bucket B1 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-4,47%	-2,16%	-5,26%	-0,67%	-0,08%	1,35%	-2,36%	-0,23%	-1,50%	-4,64%	0,17%	-2,81%
(t-value)	-0,56	0,29	-0,81	0,77	1,02	1,36	0,16	0,74	0,38	-0,45	0,12	-
Std. Dev.	12,63%	14,05%	15,81%	16,80%	16,65%	18,25%	18,00%	19,35%	20,35%	24,18%	-11,55%	17,09%
(t-value)	-2,04**	-1,26	-0,50	-0,24	-0,12	0,40	0,47	1,22	1,50	2,29**	-4,06***	-

Table 19. Decile portfolios of "Dollar volume" liquidity bucket B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-2,89%	-0,40%	-1,10%	-4,70%	-3,39%	-1,05%	-1,53%	-6,98%	-8,02%	-8,61%	5,72%	-2,81%
(t-value)	0,03	0,98	0,65	-0,63	-0,19	0,60	0,39	-1,33	-1,48	-1,34	1,48	-
Std. Dev.	12,06%	14,32%	16,58%	18,44%	18,66%	19,24%	19,91%	21,18%	25,29%	29,51%	-17,45%	17,09%
(t-value)	-2,34**	-1,10	0,00	0,67	0,61	0,72	1,08	1,96*	2,65***	3,65***	-5,41***	-

Table 20. Differences between corresponding decile portfolios of "Dollar volume" liquidity buckets B1 and B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-4,47%	-2,16%	-5,26%	-0,67%	-0,08%	1,35%	-2,36%	-0,23%	-1,50%	-4,64%
B2	-2,89%	-0,40%	-1,10%	-4,70%	-3,39%	-1,05%	-1,53%	-6,98%	-8,02%	-8,61%
B1-B2	-1,59%	-1,76%	-4,16%	4,03%	3,31%	2,40%	-0,83%	6,76%	6,52%	3,97%
(t-value)	-0,78	-0,79	-1,51	1,38	1,23	0,78	-0,20	1,87*	1,69*	0,72
Std. Dev.										
B1	12,63%	14,05%	15,81%	16,80%	16,65%	18,25%	18,00%	19,35%	20,35%	24,18%
B2	12,06%	14,32%	16,58%	18,44%	18,66%	19,24%	19,91%	21,18%	25,29%	29,51%
B1-B2	0,57%	-0,26%	-0,77%	-1,65%	-2,01%	-0,98%	-1,92%	-1,83%	-4,95%	-5,34%
(t-value)	0,38	-0,17	-0,53	-0,90	-0,74	-0,33	-0,65	-0,81	-1,38	-1,49

Composite liquidity (sub-period: GFC 1)

Table 21. Liquidity portfolios (buckets) based on Composite liquidity (sub-period: GFC 1)

	B1	B2	B1-B2	Univ.
Excess Return	-1,80%	-3,57%	1,77%	-2,81%
(t-value)	0,33	-0,26	0,59	-
Std. Dev.	17,36%	17,72%	-0,36%	17,09%
(t-value)	0,14	0,33	-0,19	-

Table 22. Decile portfolios of "Composite liquidity" liquidity bucket B1 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-4,31%	-1,36%	-6,07%	2,15%	1,31%	-4,18%	2,81%	-3,89%	-2,88%	-4,29%	-0,02%	-2,81%
(t-value)	-0,50	0,56	-1,05	1,82*	1,42	-0,42	1,67*	-0,35	-0,05	-0,33	0,09	-
Std. Dev.	12,82%	14,60%	16,97%	16,62%	17,33%	18,93%	18,57%	19,78%	21,71%	27,44%	-14,62%	17,09%
(t-value)	-1,91*	-1,07	0,02	-0,25	0,07	0,64	0,91	1,34	1,99**	3,07***	-4,63***	-

Table 23. Decile portfolios of "Composite liquidity" liquidity bucket B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-3,32%	-0,89%	-2,54%	-2,21%	-5,45%	-1,77%	0,02%	-4,28%	-9,52%	-8,76%	5,44%	-2,81%
(t-value)	-0,14	0,82	0,12	0,20	-0,85	0,34	0,99	-0,50	-2,05**	-1,57	1,65*	-
Std. Dev.	11,98%	14,04%	15,74%	17,47%	18,59%	19,02%	19,01%	19,98%	23,80%	28,34%	-16,36%	17,09%
(t-value)	-2,41**	-1,22	-0,41	0,39	0,61	0,69	0,75	1,28	2,33**	3,38***	-5,20***	-

Table 24. Differences between corresponding decile portfolios of "Composite liquidity" liquidity buckets B1 and B2 (sub-period: GFC 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-4,31%	-1,36%	-6,07%	2,15%	1,31%	-4,18%	2,81%	-3,89%	-2,88%	-4,29%
B2	-3,32%	-0,89%	-2,54%	-2,21%	-5,45%	-1,77%	0,02%	-4,28%	-9,52%	-8,76%
B1-B2	-1,00%	-0,47%	-3,54%	4,36%	6,77%	-2,41%	2,79%	0,39%	6,64%	4,47%
(t-value)	-0,48	-0,22	-1,24	1,66*	2,20**	-0,72	0,84	0,12	1,76*	0,72
Std. Dev.										
B1	12,82%	14,60%	16,97%	16,62%	17,33%	18,93%	18,57%	19,78%	21,71%	27,44%
B2	11,98%	14,04%	15,74%	17,47%	18,59%	19,02%	19,01%	19,98%	23,80%	28,34%
B1-B2	0,85%	0,55%	1,23%	-0,85%	-1,26%	-0,10%	-0,44%	-0,20%	-2,09%	-0,90%
(t-value)	0,68	0,13	0,44	-0,65	-0,55	-0,06	0,08	0,00	-0,52	-0,36

Relative spread (sub-period: GFC 2)

Table 25. Liquidity portfolios (buckets) based on Relative spread (sub-period: GFC 2)

	B1	B2	B1-B2	Univ.
Excess Return	13,45%	12,69%	0,76%	13,42%
(t-value)	0,02	-0,21	0,21	-
Std. Dev.	31,74%	22,60%	9,14%	26,38%
(t-value)	1,21	-1,06	2,21**	-

Table 26. Decile portfolios of "Relative spread" liquidity bucket B1 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	10,04%	8,49%	9,27%	10,99%	12,92%	14,90%	14,38%	12,09%	13,12%	22,62%	-12,58%	13,42%
(t-value)	-1,01	-1,34	-1,00	-0,57	-0,09	0,35	0,23	-0,23	-0,02	1,60	-2,33**	-
Std. Dev.	19,04%	23,12%	27,14%	28,52%	32,25%	34,05%	35,91%	38,38%	41,73%	46,86%	-27,81%	26,38%
(t-value)	-2,55**	-1,19	-0,10	0,40	1,24	1,77*	2,24**	2,65***	3,28***	4,05***	-5,90***	-

Table 27. Decile portfolios of "Relative spread" liquidity bucket B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	9,07%	10,03%	12,56%	12,60%	14,05%	13,97%	10,89%	15,30%	12,58%	12,68%	-3,62%	13,42%
(t-value)	-1,38	-1,01	-0,27	-0,24	0,16	0,14	-0,63	0,46	-0,19	-0,15	-1,00	-
Std. Dev.	14,62%	17,30%	18,84%	20,37%	22,43%	24,07%	26,15%	27,50%	29,44%	33,38%	-18,76%	26,38%
(t-value)	-4,24***	-3,16***	-2,48**	-1,89*	-1,12	-0,51	0,23	0,65	1,08	2,52**	-6,88***	-

Table 28. Differences between corresponding decile portfolios of "Relative spread" liquidity buckets B1 and B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	10,04%	8,49%	9,27%	10,99%	12,92%	14,90%	14,38%	12,09%	13,12%	22,62%
B2	9,07%	10,03%	12,56%	12,60%	14,05%	13,97%	10,89%	15,30%	12,58%	12,68%
B1-B2	0,97%	-1,54%	-3,28%	-1,61%	-1,12%	0,92%	3,49%	-3,21%	0,54%	9,94%
(t-value)	0,40	-0,48	-0,89	-0,40	-0,23	0,23	0,76	-0,59	0,13	1,63
Std. Dev.										
B1	19,04%	23,12%	27,14%	28,52%	32,25%	34,05%	35,91%	38,38%	41,73%	46,86%
B2	14,62%	17,30%	18,84%	20,37%	22,43%	24,07%	26,15%	27,50%	29,44%	33,38%
B1-B2	4,42%	5,82%	8,30%	8,15%	9,82%	9,98%	9,76%	10,88%	12,29%	13,48%
(t-value)	1,80*	1,93*	2,21**	2,19**	2,27**	2,29**	2,11**	2,16**	2,39**	2,13**

Dollar volume (sub-period: GFC 2)

Table 29. Liquidity portfolios (buckets) based on Dollar volume (sub-period: GFC 2)

	B1	B2	B1-B2	Univ.
Excess Return	13,18%	13,32%	-0,14%	13,42%
(t-value)	-0,06	-0,03	-0,03	-
Std. Dev.	27,06%	26,99%	0,07%	26,38%
(t-value)	0,20	0,13	0,07	-

Table 30. Decile portfolios of "Dollar volume" liquidity bucket B1 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	10,38%	11,02%	11,89%	10,24%	12,62%	12,96%	12,27%	12,91%	16,65%	15,59%	-5,20%	13,42%
(t-value)	-0,93	-0,70	-0,43	-0,82	-0,19	-0,10	-0,24	-0,09	0,69	0,43	-1,04	-
Std. Dev.	16,75%	19,23%	21,65%	23,70%	26,21%	28,71%	30,57%	33,36%	36,55%	43,07%	-26,32%	26,38%
(t-value)	-3,35***	-2,39**	-1,50	-0,71	-0,02	0,66	1,16	1,89*	2,50**	3,62***	-6,22***	-

Table 31. Decile portfolios of "Dollar volume" liquidity bucket B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	8,00%	11,40%	12,47%	14,04%	10,26%	13,26%	14,36%	11,48%	12,15%	19,09%	-11,08%	13,42%
(t-value)	-1,71*	-0,61	-0,28	0,15	-0,77	-0,04	0,23	-0,43	-0,24	1,06	-2,25**	-
Std. Dev.	15,05%	18,56%	21,08%	23,73%	26,03%	28,24%	30,43%	35,09%	37,94%	45,11%	-30,06%	26,38%
(t-value)	-4,10***	-2,68***	-1,71*	-0,72	-0,20	0,53	1,11	2,18**	2,75***	3,87***	-6,82***	-

Table 32. Differences between corresponding decile portfolios of "Dollar volume" liquidity buckets B1 and B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	10,38%	11,02%	11,89%	10,24%	12,62%	12,96%	12,27%	12,91%	16,65%	15,59%
B2	8,00%	11,40%	12,47%	14,04%	10,26%	13,26%	14,36%	11,48%	12,15%	19,09%
B1-B2	2,38%	-0,38%	-0,58%	-3,80%	2,36%	-0,30%	-2,09%	1,43%	4,51%	-3,50%
(t-value)	1,02	-0,13	-0,17	-1,02	0,57	-0,06	-0,44	0,30	0,82	-0,49
Std. Dev.										
B1	16,75%	19,23%	21,65%	23,70%	26,21%	28,71%	30,57%	33,36%	36,55%	43,07%
B2	15,05%	18,56%	21,08%	23,73%	26,03%	28,24%	30,43%	35,09%	37,94%	45,11%
B1-B2	1,70%	0,67%	0,57%	-0,02%	0,18%	0,47%	0,14%	-1,73%	-1,39%	-2,04%
(t-value)	0,93	0,32	0,22	0,01	0,18	0,13	0,04	-0,34	-0,29	-0,34

Composite liquidity (sub-period: GFC 2)

Table 33. Liquidity portfolios (buckets) based on Composite liquidity (sub-period: GFC 2)

	B1	B2	B1-B2	Univ.
Excess Return	14,11%	12,28%	1,83%	13,42%
(t-value)	0,17	-0,30	0,46	-
Std. Dev.	28,63%	25,51%	3,12%	26,38%
(t-value)	0,62	-0,29	0,91	-

Table 34. Decile portfolios of "Composite liquidity" liquidity bucket B1 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	10,61%	11,31%	12,02%	11,97%	13,86%	13,18%	11,41%	15,66%	14,60%	20,53%	-9,92%	13,42%
(t-value)	-0,86	-0,62	-0,38	-0,36	0,11	-0,04	-0,42	0,49	0,26	1,26	-1,88*	-
Std. Dev.	16,80%	20,00%	23,18%	25,25%	28,35%	29,71%	33,13%	35,11%	39,54%	45,12%	-28,32%	26,38%
(t-value)	-3,31***	-2,11**	-0,96	-0,24	0,47	0,93	1,77*	2,23**	3,10***	3,84***	-6,30***	-

Table 35. Decile portfolios of "Composite liquidity" liquidity bucket B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	8,78%	9,58%	12,67%	13,83%	11,07%	10,55%	12,27%	14,67%	12,87%	11,17%	-2,38%	13,42%
(t-value)	-1,46	-1,14	-0,23	0,10	-0,61	-0,70	-0,28	0,30	-0,11	-0,41	-0,58	-
Std. Dev.	15,18%	18,34%	20,11%	22,42%	24,31%	26,85%	28,57%	31,28%	35,67%	42,20%	-27,02%	26,38%
(t-value)	-4,06***	-2,80***	-2,05**	-1,21	-0,60	0,12	0,68	1,39	2,26**	3,50***	-6,61***	-

Table 36. Differences between corresponding decile portfolios of "Composite liquidity" liquidity buckets B1 and B2 (sub-period: GFC 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	10,61%	11,31%	12,02%	11,97%	13,86%	13,18%	11,41%	15,66%	14,60%	20,53%
B2	8,78%	9,58%	12,67%	13,83%	11,07%	10,55%	12,27%	14,67%	12,87%	11,17%
B1-B2	1,83%	1,73%	-0,65%	-1,86%	2,79%	2,63%	-0,86%	1,00%	1,72%	9,36%
(t-value)	0,77	0,61	-0,19	-0,49	0,69	0,59	-0,17	0,22	0,33	1,43
Std. Dev.										
B1	16,80%	20,00%	23,18%	25,25%	28,35%	29,71%	33,13%	35,11%	39,54%	45,12%
B2	15,18%	18,34%	20,11%	22,42%	24,31%	26,85%	28,57%	31,28%	35,67%	42,20%
B1-B2	1,62%	1,67%	3,07%	2,83%	4,04%	2,85%	4,56%	3,83%	3,87%	2,92%
(t-value)	0,94	0,76	1,14	1,01	1,07	0,81	1,12	0,87	0,84	0,43

Appendix C: Sub-period results of portfolios sorted on liquidity and volatility for other liquidity measures (sub-periods: QE 1, QE 2)

This appendix presents sub-period results of portfolios sorted on liquidity and volatility for other liquidity measures used in this thesis (results for the “Turnover” and “Amihud” liquidity measures appear in the Empirical analysis section of the thesis). The two sub-periods are obtained by dividing the main sample into sub-period QE 1 and sub-period QE 2. Sub-period QE 1 contains all the time periods between January 2005 and December 2014 when The Federal Reserve was not executing any quantitative easing program. These time periods are the following:

- January 2005 – November 2008,
- April 2010 – October 2010,
- July 2011 – August 2012,
- November 2014 – December 2014.

Conversely, sub-period QE 2 contains all the time periods between January 2005 and December 2014 when The Federal Reserve was executing a quantitative easing program. There were three such periods:

- December 2008 – March 2010,
- November 2010 – June 2011,
- September 2012 – October 2014.

The methodology of sorting and return calculations is analogous to the descriptions in Appendix A. Results are presented in a similar fashion to those in Appendix A, with the exception of the tables depicting only the annualized compounded mean return in excess of the U.S. dollar risk-free return (excess return) and the standard deviation, with the corresponding differences and t-statistics. Statistical significance at the 10%, 5% and 1% levels is denoted by *, ** and *** respectively.

Relative spread (sub-period: QE 1)

Table 37. Liquidity portfolios (buckets) based on Relative spread (sub-period: QE 1)

	B1	B2	B1-B2	Univ.
Excess Return	-9,22%	-5,06%	-4,17%	-6,96%
(t-value)	-0,65	0,64	-1,27	-
Std. Dev.	27,45%	21,79%	5,66%	23,90%
(t-value)	0,82	-0,49	1,31	-

Table 38. Decile portfolios of "Relative spread" liquidity bucket B1 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-2,48%	-6,32%	-7,16%	-7,39%	-11,37%	-5,41%	-9,77%	-12,20%	-18,14%	-16,80%	14,32%	-6,96%
(t-value)	1,63	0,24	-0,06	-0,16	-1,21	0,43	-0,78	-1,36	-2,68***	-2,01**	3,13***	-
Std. Dev.	19,06%	22,09%	24,95%	25,31%	27,50%	28,66%	29,77%	32,82%	35,22%	39,70%	-20,64%	23,90%
(t-value)	-1,64	-0,54	0,12	0,24	0,70	1,15	1,60	2,13**	2,79***	3,54***	-4,87***	-

Table 39. Decile portfolios of "Relative spread" liquidity bucket B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-2,52%	-3,06%	-1,99%	-2,54%	-2,62%	-5,46%	-6,51%	-4,81%	-11,26%	-12,70%	10,18%	-6,96%
(t-value)	1,78*	1,47	1,79*	1,52	1,41	0,47	0,15	0,62	-1,22	-1,52	3,20***	-
Std. Dev.	14,84%	17,47%	18,80%	20,58%	21,84%	23,00%	24,52%	25,28%	27,72%	31,30%	-16,45%	23,90%
(t-value)	-3,21***	-2,10**	-1,57	-0,88	-0,36	-0,02	0,39	0,64	1,30	2,62***	-5,93***	-

Table 40. Differences between corresponding decile portfolios of "Relative spread" liquidity buckets B1 and B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-2,48%	-6,32%	-7,16%	-7,39%	-11,37%	-5,41%	-9,77%	-12,20%	-18,14%	-16,80%
B2	-2,52%	-3,06%	-1,99%	-2,54%	-2,62%	-5,46%	-6,51%	-4,81%	-11,26%	-12,70%
B1-B2	0,05%	-3,26%	-5,17%	-4,85%	-8,76%	0,05%	-3,26%	-7,39%	-6,88%	-4,10%
(t-value)	0,01	-1,31	-1,80*	-1,60	-2,47**	0,02	-0,89	-1,85*	-1,58	-0,79
Std. Dev.										
B1	19,06%	22,09%	24,95%	25,31%	27,50%	28,66%	29,77%	32,82%	35,22%	39,70%
B2	14,84%	17,47%	18,80%	20,58%	21,84%	23,00%	24,52%	25,28%	27,72%	31,30%
B1-B2	4,21%	4,62%	6,16%	4,73%	5,66%	5,65%	5,25%	7,55%	7,50%	8,40%
(t-value)	1,65*	1,59	1,61	1,10	1,07	1,22	1,27	1,60	1,64	1,39

Dollar volume (sub-period: QE 1)

Table 41. Liquidity portfolios (buckets) based on Dollar volume (sub-period: QE 1)

	B1	B2	B1-B2	Univ.
Excess Return	-6,71%	-7,32%	0,61%	-6,96%
(t-value)	0,08	-0,11	0,19	-
Std. Dev.	24,07%	24,99%	-0,92%	23,90%
(t-value)	0,04	0,35	-0,31	-

Table 42. Decile portfolios of "Dollar volume" liquidity bucket B1 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-3,32%	-2,75%	-6,41%	-5,13%	-4,69%	-5,13%	-9,09%	-8,78%	-9,97%	-15,79%	12,47%	-6,96%
(t-value)	1,42	1,49	0,20	0,59	0,72	0,50	-0,59	-0,47	-0,83	-1,95*	3,04***	-
Std. Dev.	16,75%	19,14%	21,22%	22,55%	23,84%	25,62%	26,25%	28,77%	30,47%	34,70%	-17,96%	23,90%
(t-value)	-2,42**	-1,49	-0,77	-0,35	-0,02	0,47	0,70	1,45	1,81*	2,69***	-4,81***	-

Table 43. Decile portfolios of "Dollar volume" liquidity bucket B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-2,42%	-1,17%	-2,71%	-5,04%	-8,15%	-6,84%	-6,63%	-12,25%	-15,41%	-18,53%	16,11%	-6,96%
(t-value)	1,80*	2,12**	1,46	0,60	-0,38	0,02	0,10	-1,48	-2,12**	-2,66***	4,15***	-
Std. Dev.	15,37%	18,71%	21,03%	23,12%	24,84%	26,43%	27,87%	30,24%	33,99%	39,02%	-23,65%	23,90%
(t-value)	-3,00***	-1,66*	-0,75	0,00	0,26	0,63	1,03	1,86*	2,63***	3,63***	-6,04***	-

Table 44. Differences between corresponding decile portfolios of "Dollar volume" liquidity buckets B1 and B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-3,32%	-2,75%	-6,41%	-5,13%	-4,69%	-5,13%	-9,09%	-8,78%	-9,97%	-15,79%
B2	-2,42%	-1,17%	-2,71%	-5,04%	-8,15%	-6,84%	-6,63%	-12,25%	-15,41%	-18,53%
B1-B2	-0,90%	-1,57%	-3,71%	-0,10%	3,47%	1,71%	-2,46%	3,46%	5,44%	2,74%
(t-value)	-0,46	-0,69	-1,32	-0,02	1,07	0,47	-0,66	0,88	1,18	0,52
Std. Dev.										
B1	16,75%	19,14%	21,22%	22,55%	23,84%	25,62%	26,25%	28,77%	30,47%	34,70%
B2	15,37%	18,71%	21,03%	23,12%	24,84%	26,43%	27,87%	30,24%	33,99%	39,02%
B1-B2	1,38%	0,43%	0,19%	-0,57%	-1,00%	-0,81%	-1,62%	-1,47%	-3,52%	-4,32%
(t-value)	0,66	0,19	-0,02	-0,38	-0,29	-0,16	-0,35	-0,42	-0,86	-0,99

Composite liquidity (sub-period: QE 1)

Table 45. Liquidity portfolios (buckets) based on Composite liquidity (sub-period: QE 1)

	B1	B2	B1-B2	Univ.
Excess Return	-7,36%	-6,82%	-0,55%	-6,96%
(t-value)	-0,12	0,05	-0,17	-
Std. Dev.	25,13%	24,03%	1,10%	23,90%
(t-value)	0,35	0,06	0,29	-

Table 46. Decile portfolios of "Composite liquidity" liquidity bucket B1 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-3,05%	-2,93%	-7,16%	-2,56%	-4,47%	-10,97%	-7,32%	-11,13%	-15,03%	-13,38%	10,33%	-6,96%
(t-value)	1,51	1,39	-0,02	1,38	0,73	-1,13	-0,09	-1,12	-1,99**	-1,32	2,33**	-
Std. Dev.	16,91%	19,84%	22,41%	23,13%	25,01%	26,05%	28,18%	29,48%	32,46%	37,51%	-20,60%	23,90%
(t-value)	-2,32**	-1,28	-0,31	-0,21	0,22	0,68	1,20	1,63	2,32**	3,22***	-5,17***	-

Table 47. Decile portfolios of "Composite liquidity" liquidity bucket B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	-2,30%	-2,74%	-2,95%	-2,51%	-8,13%	-7,78%	-5,22%	-7,79%	-13,41%	-19,70%	17,41%	-6,96%
(t-value)	1,84*	1,57	1,39	1,45	-0,34	-0,26	0,52	-0,23	-1,80*	-3,13***	4,88***	-
Std. Dev.	15,46%	18,53%	20,18%	22,18%	23,75%	25,47%	26,45%	28,43%	32,10%	37,07%	-21,61%	23,90%
(t-value)	-2,99***	-1,75*	-1,08	-0,33	0,10	0,44	0,72	1,24	2,19**	3,37***	-5,89***	-

Table 48. Differences between corresponding decile portfolios of "Composite liquidity" liquidity buckets B1 and B2 (sub-period: QE 1)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	-3,05%	-2,93%	-7,16%	-2,56%	-4,47%	-10,97%	-7,32%	-11,13%	-15,03%	-13,38%
B2	-2,30%	-2,74%	-2,95%	-2,51%	-8,13%	-7,78%	-5,22%	-7,79%	-13,41%	-19,70%
B1-B2	-0,76%	-0,19%	-4,21%	-0,05%	3,66%	-3,19%	-2,10%	-3,34%	-1,62%	6,32%
(t-value)	-0,38	-0,10	-1,47	-0,02	1,05	-0,85	-0,53	-0,86	-0,39	1,18
Std. Dev.										
B1	16,91%	19,84%	22,41%	23,13%	25,01%	26,05%	28,18%	29,48%	32,46%	37,51%
B2	15,46%	18,53%	20,18%	22,18%	23,75%	25,47%	26,45%	28,43%	32,10%	37,07%
B1-B2	1,45%	1,32%	2,23%	0,95%	1,26%	0,58%	1,73%	1,04%	0,36%	0,44%
(t-value)	0,81	0,50	0,81	0,11	0,13	0,23	0,48	0,37	0,11	-0,07

Relative spread (sub-period: QE 2)

Table 49. Liquidity portfolios (buckets) based on Relative spread (sub-period: QE 2)

	B1	B2	B1-B2	Univ.
Excess Return	30,65%	23,87%	6,79%	27,44%
(t-value)	0,73	-0,97	1,64	-
Std. Dev.	27,76%	18,50%	9,26%	22,49%
(t-value)	1,06	-1,06	2,02**	-

Table 50. Decile portfolios of "Relative spread" liquidity bucket B1 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	16,46%	17,92%	22,83%	26,44%	30,78%	32,23%	31,55%	33,64%	39,92%	49,73%	-33,27%	27,44%
(t-value)	-3,14***	-2,54**	-1,14	-0,23	0,77	1,11	0,88	1,18	2,32**	3,29***	-5,11***	-
Std. Dev.	14,38%	18,76%	22,86%	24,86%	28,61%	29,94%	32,39%	33,91%	37,66%	43,59%	-29,21%	22,49%
(t-value)	-2,71***	-1,31	-0,18	0,42	1,20	1,57	2,00**	2,23**	2,77***	3,45***	-5,11***	-

Table 51. Decile portfolios of "Relative spread" liquidity bucket B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	12,57%	18,45%	20,10%	21,68%	24,10%	25,53%	23,37%	28,95%	28,97%	32,53%	-19,97%	27,44%
(t-value)	-4,35***	-2,60***	-2,11**	-1,64	-0,88	-0,49	-1,00	0,36	0,36	1,15	-5,23***	-
Std. Dev.	11,59%	13,74%	14,82%	16,35%	18,69%	20,08%	22,26%	23,50%	24,30%	28,59%	-16,99%	22,49%
(t-value)	-3,92***	-2,99***	-2,47**	-1,84*	-1,01	-0,52	0,23	0,63	0,84	2,13**	-6,14***	-

Table 52. Differences between corresponding decile portfolios of "Relative spread" liquidity buckets B1 and B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	16,46%	17,92%	22,83%	26,44%	30,78%	32,23%	31,55%	33,64%	39,92%	49,73%
B2	12,57%	18,45%	20,10%	21,68%	24,10%	25,53%	23,37%	28,95%	28,97%	32,53%
B1-B2	3,89%	-0,53%	2,73%	4,76%	6,68%	6,69%	8,18%	4,69%	10,94%	17,19%
(t-value)	1,42	-0,14	0,80	1,34	1,60	1,61	1,73*	0,89	2,04**	2,49**
Std. Dev.										
B1	14,38%	18,76%	22,86%	24,86%	28,61%	29,94%	32,39%	33,91%	37,66%	43,59%
B2	11,59%	13,74%	14,82%	16,35%	18,69%	20,08%	22,26%	23,50%	24,30%	28,59%
B1-B2	2,79%	5,02%	8,04%	8,51%	9,92%	9,86%	10,13%	10,40%	13,35%	15,01%
(t-value)	1,70*	1,64	2,06**	2,11**	2,10**	2,07**	1,89*	1,80*	2,20**	1,99**

Dollar volume (sub-period: QE 2)

Table 53. Liquidity portfolios (buckets) based on Dollar volume (sub-period: QE 2)

	B1	B2	B1-B2	Univ.
Excess Return	27,66%	27,23%	0,43%	27,44%
(t-value)	0,06	-0,05	0,11	-
Std. Dev.	23,11%	22,80%	0,31%	22,49%
(t-value)	0,16	0,10	0,06	-

Table 54. Decile portfolios of “Dollar volume” liquidity bucket B1 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	16,24%	18,49%	22,16%	22,01%	25,49%	27,92%	29,09%	31,55%	37,71%	41,46%	-25,21%	27,44%
(t-value)	-3,18***	-2,53**	-1,44	-1,41	-0,49	0,12	0,39	0,95	2,05**	2,20**	-4,14***	-
Std. Dev.	13,10%	14,78%	17,21%	19,59%	21,97%	24,82%	26,95%	29,07%	32,77%	40,23%	-27,13%	22,49%
(t-value)	-3,24***	-2,55**	-1,62	-0,77	-0,06	0,62	1,09	1,62	2,15**	3,05***	-5,12***	-

Table 55. Decile portfolios of “Dollar volume” liquidity bucket B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	12,83%	18,43%	21,56%	23,96%	23,83%	28,62%	29,54%	28,18%	32,70%	47,00%	-34,17%	27,44%
(t-value)	-4,35***	-2,65***	-1,62	-0,89	-0,90	0,28	0,52	0,16	1,10	3,20***	-5,96***	-
Std. Dev.	11,82%	14,50%	17,13%	20,04%	21,54%	23,45%	25,63%	31,11%	33,38%	41,21%	-29,39%	22,49%
(t-value)	-3,82***	-2,64***	-1,63	-0,65	-0,26	0,42	0,99	1,94*	2,34**	3,31***	-5,67***	-

Table 56. Differences between corresponding decile portfolios of “Dollar volume” liquidity buckets B1 and B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	16,24%	18,49%	22,16%	22,01%	25,49%	27,92%	29,09%	31,55%	37,71%	41,46%
B2	12,83%	18,43%	21,56%	23,96%	23,83%	28,62%	29,54%	28,18%	32,70%	47,00%
B1-B2	3,41%	0,06%	0,59%	-1,95%	1,67%	-0,70%	-0,44%	3,37%	5,01%	-5,55%
(t-value)	1,27	0,05	0,20	-0,54	0,43	-0,15	-0,09	0,72	0,89	-0,70
Std. Dev.										
B1	13,10%	14,78%	17,21%	19,59%	21,97%	24,82%	26,95%	29,07%	32,77%	40,23%
B2	11,82%	14,50%	17,13%	20,04%	21,54%	23,45%	25,63%	31,11%	33,38%	41,21%
B1-B2	1,27%	0,28%	0,08%	-0,45%	0,43%	1,38%	1,32%	-2,04%	-0,61%	-0,99%
(t-value)	0,96	0,12	0,01	-0,12	0,20	0,21	0,14	-0,37	-0,17	-0,23

Composite liquidity (sub-period: QE 2)

Table 57. Liquidity portfolios (buckets) based on Composite liquidity (sub-period: QE 2)

	B1	B2	B1-B2	Univ.
Excess Return	29,94%	24,82%	5,12%	27,44%
(t-value)	0,59	-0,68	1,25	-
Std. Dev.	24,79%	21,19%	3,60%	22,49%
(t-value)	0,55	-0,33	0,87	-

Table 58. Decile portfolios of "Composite liquidity" liquidity bucket B1 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	16,35%	19,89%	22,66%	23,53%	28,31%	31,46%	29,99%	35,70%	40,48%	45,81%	-29,46%	27,44%
(t-value)	-3,12***	-2,14**	-1,27	-0,98	0,22	0,92	0,60	1,64	2,36**	2,79***	-4,63***	-
Std. Dev.	13,06%	15,49%	18,99%	21,33%	24,47%	26,33%	29,03%	31,33%	35,91%	41,91%	-28,86%	22,49%
(t-value)	-3,26***	-2,27**	-1,03	-0,24	0,46	0,89	1,59	1,90*	2,62***	3,29***	-5,31***	-

Table 59. Decile portfolios of "Composite liquidity" liquidity bucket B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D1-D10	Univ.
Excess Return	13,44%	17,45%	20,91%	22,33%	23,15%	25,19%	25,81%	29,15%	29,63%	36,59%	-23,15%	27,44%
(t-value)	-4,14***	-2,93***	-1,86*	-1,34	-1,11	-0,55	-0,42	0,42	0,49	1,74*	-4,82***	-
Std. Dev.	11,83%	14,17%	16,09%	18,42%	20,16%	22,29%	23,85%	26,34%	31,20%	38,28%	-26,46%	22,49%
(t-value)	-3,82***	-2,80***	-1,99**	-1,17	-0,63	0,05	0,55	1,24	1,98**	2,97***	-5,49***	-

Table 60. Differences between corresponding decile portfolios of "Composite liquidity" liquidity buckets B1 and B2 (sub-period: QE 2)

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Excess Return										
B1	16,35%	19,89%	22,66%	23,53%	28,31%	31,46%	29,99%	35,70%	40,48%	45,81%
B2	13,44%	17,45%	20,91%	22,33%	23,15%	25,19%	25,81%	29,15%	29,63%	36,59%
B1-B2	2,91%	2,44%	1,75%	1,20%	5,16%	6,27%	4,17%	6,55%	10,85%	9,22%
(t-value)	1,06	0,90	0,56	0,33	1,34	1,41	1,00	1,30	1,89*	1,25
Std. Dev.										
B1	13,06%	15,49%	18,99%	21,33%	24,47%	26,33%	29,03%	31,33%	35,91%	41,91%
B2	11,83%	14,17%	16,09%	18,42%	20,16%	22,29%	23,85%	26,34%	31,20%	38,28%
B1-B2	1,23%	1,33%	2,91%	2,91%	4,32%	4,04%	5,18%	5,00%	4,71%	3,63%
(t-value)	0,97	0,64	1,00	0,97	1,07	0,86	1,10	0,80	0,74	0,44

Appendix D: Summary in Slovenian (povzetek v slovenskem jeziku)

V magistrski nalogi raziščem področje investicijske strategije izbora naložb na podlagi najmanjše volatilnosti (minimum volatility - MV), ki izkorišča nadpovprečne presežne donosnosti vrednostnih papirjev z nizko volatilnostjo v primerjavi s tistimi z visoko, kar imenujemo učinek volatilnosti (volatility effect; Blitz & van Vliet, 2007). Glede na to, da so te donosnosti v nasprotju s tradicionalno teorijo financ in njenimi predpostavkami, se ta pojav smatra kot anomalija. Zaradi tega je mnogo raziskovalcev poskusilo pojasniti uspešnost MV portfeljev z obravnavanjem različnih virov tveganja. Skušali so ugotoviti, ali so premije za tveganje, ki predstavljajo nagrado za prevzemanje teh virov tveganja, odgovorne za nadpovprečno donosnost MV portfeljev. V sledenju njihovih raziskav, raziščem vlogo likvidnostnega tveganja, in skušam ugotoviti ali lahko le-to pojasni učinek volatilnosti. Glede na to, da ostale raziskave neposredno ne obravnavajo vplivov likvidnostnega tveganja v MV strategijah, z nalogo dajem drugačno perspektivo dosedanjim raziskavam o možnih virih tveganja, ki bi lahko pojasnili anomalijo. Moja raziskava se razlikuje tudi v tem, da obravnavam drugačno časovno obdobje, ki vključuje globalno finančno krizo in njene posledice. Ker je likvidnost večdimenzionalna spremenljivka, in ker likvidnostnega tveganja ne moremo meriti direktno, v nalogi uporabim različne mere likvidnosti. S tem zagotovim, da so kakršnekoli ugotovitve, ki povezujejo likvidnostno tveganje z učinkom volatilnosti, tudi robustne. Za likvidnost kontroliram tako, da vzorec sestavljen iz delnic indeksa Russell 1000 razdelim v dva portfelja glede na likvidnost posameznih delnic v zadnjih treh letih. Nato vsakega od teh dveh portfeljev razdelim še na deset portfeljev, oziroma decilov, glede na volatilnost posameznih delnic v zadnjih treh letih. Vsi portfelji imajo enakomerne uteži na posameznih delnicah v portfelju. Vsak mesec na novo uravnotežim vse portfelje glede na spremembe v likvidnosti in volatilnosti posameznih delnic, in opazujem njihovo uspešnost. Glede na kriterije v povezavi z globalno finančno krizo in njenimi posledicami, obdobje vzorca razdelim tudi na različna pod-obdobja.

Da je preteklo tveganje dober kazalnik bodočega tveganja, je najjasnejša ugotovitev iz rezultatov moje študije. Ta ugotovitev je namreč razvidna iz rezultatov vseh portfeljev delitve po likvidnosti, in pri uporabi vseh mer likvidnosti. Iz rezultatov lahko opazimo da tako volatilnost, kot tudi beta, monotono naraščata z vsakim decilom znotraj vseh portfeljev delnic razvrščenih po likvidnosti, kar potrjuje ugotovitve od Blitz in van Vliet (2007) in Blitz et al. (2013). To razmerje pa ne drži za ex ante volatilnost in ex post donosnosti. V povprečju ne najdemo nobenega statistično značilnega pozitivnega ali negativnega razmerja, kar pomeni da je razmerje med tveganjem in donosnostjo plosko. To je v nasprotju s teoretičnimi modeli kot je CAPM, ki kažejo na pozitivno razmerje med tveganjem in donosnostjo. Posledica teh dveh ugotovitev je tveganju prilagojena nadpovprečna donosnost MV portfeljev. Ta je razvidna iz Sharpe-ovih razmerij, ki imajo visoke vrednosti predvsem zaradi nizke volatilnosti teh portfeljev. Nadpovprečno donosnost najdemo tudi pri ostalih portfeljih delitve po likvidnosti, in ostalih merah likvidnosti. Ampak, ko se osredotočimo na statistične značilnosti razlik v Sharpe-ovih razmerjih med portfelji, lahko le redko najdemo decil s statistično značilno različnim Sharpe-ovim razmerjem od portfelja celotnega vzorca (Universe portfolio). To odkritje ni popolnoma v skladu z ugotovitvijo o obstoju značilnega tveganju-prilagojenega učinka volatilnosti, kot so zapisali Blitz in van Vliet (2007) in Blitz et al. (2013). Zaradi tega sklepam, da je razmerje med tveganjem in donosnostjo v preučevanem obdobju največ plosko, tudi če upoštevamo tveganju-prilagojene presežne donosnosti. To pomeni, da ne obstaja statistično značilen učinek volatilnosti.

Z delitvijo vzorca v dva portfelja glede na likvidnost posameznih delnic, sem lahko kontroliral za učinek likvidnostnega tveganja, in opazoval razlike v realiziranih donosnostih, volatilnostih in Sharpe-ovih razmerjih med obema portfeljema. Za vse mere tveganja, ki jih uporabim v raziskavi, so razlike v realiziranih donosnostih in Sharpe-ovih razmerjih med obema likvidnostnima portfeljema statistično neznačilne, kar že nakazuje na neobstoj premije za likvidnostno tveganje. Glede na to, da je vsak likvidnostni portfelj razdeljen še na decile na podlagi volatilnosti posameznih delnic, naredim še primerjavo uspešnosti pripadajočih decilov obeh likvidnostnih portfeljev (primerjavo med decili obeh likvidnostnih portfeljev). Ugotovim, da so skoraj vse razlike v realiziranih donosnostih in Sharpe-ovih razmerjih med pripadajočimi decili statistično neznačilne, kar drži za vse mere likvidnosti. Obstaja nekaj izjem pri katerih so razlike statistično značilne, a nobena od njih ne nakazuje na kakršnokoli jasno razmerje med likvidnostjo in volatilnostjo. Ob upoštevanju zgornjih spoznanj vidimo, da likvidnostno tveganje najbrž nima vloge pri pojasnjevanju uspešnosti MV portfeljev. Za jasnejšo sliko, se moramo poslužiti še rezultatov pod-obdobij.

Obdobje vzorca je bilo čas turbulentnih razmer na trgih, saj vključuje dogodke globalne finančne krize, ter obdobja ko so bili trgi pod vplivom kvantitativnega popuščanja s strani ameriške centralne banke (Federal Reserve). Ker so se morda v tem obdobju razmerja med likvidnostjo in volatilnostjo spreminjala, sem raziskavo razširil z vključitvijo izračunov za določena pod-obdobja. Raziskal sem štiri različna pod-obdobja (GFC 1, GFC 2, QE 1 in QE 2), ki so opisana v poglavju metodologija (Methodology). Pod-obdobje GFC 1 zajema začetni del celotnega obdobja, in pokriva čas ko so trgi beležili slabše rezultate. Po drugi strani pa obdobje GFC 2 zajema zadnji del celotnega obdobja, za katerega je značilen odboj trgov in znaki okrevanja. Vendar za nobeno od navedenih pod-obdobij ne najdemo niti pozitivnega, niti negativnega, statistično značilnega razmerja med tveganjem in donosnostjo. Za obe pod-obdobji ugotovim (tveganju neprilagojeno) plosko razmerje med tveganjem in donosnostjo, podobno kot pri celotnem vzorcu, a pri drugačni ravni realiziranih donosnosti. To velja za vse uporabljene mere likvidnosti. Pod-obdobji QE 1 in QE 2 razdelita celotno obdobje vzorca glede na prisotnost, oziroma odsotnost, mer kvantitativnega popuščanja s strani ameriške centralne banke, kot to opiše poglavje o metodologiji. Pod-obdobje QE 1, ki obsega čase ko ni bilo kvantitativnega popuščanja, producira slabše rezultate trgov in negativne donosnosti vseh portfeljev. Po drugi strani obdobje QE 2 pokriva čase, ko je bil prisoten program kvantitativnega popuščanja in producira visoke presežne donosnosti. V nasprotju z GFC okvirjem, tako QE 1 kot tudi QE 2 kažeta na statistično značilno (tveganju neprilagojeno) razmerje med tveganjem in donosnostjo. Pri QE 1 je to razmerje negativno, medtem ko je pri QE 2 pozitivno. Tudi v tem primeru navedeno velja za vse uporabljene mere likvidnosti. Glede na to, da za pod-obdobje QE 1 najdemo značilen učinek volatilnosti, medtem ko za obdobje celotnega vzorca le-ta ni prisoten, je to pod-obdobje najbolj zanimivo v smislu morebitne prisotnosti premije za likvidnostno tveganje.

Podobno kot pri ugotovitvah za celoten vzorec, so tudi pri vseh pod-obdobjih in vseh merah likvidnosti razlike med likvidnostnimi portfelji nekonsistentne in pogosto statistično neznačilne. To ponovno vzbuja dvom o obstoju premije za likvidnostno tveganje, in dvom o vlogi likvidnostnega tveganja pri pojasnjevanju nadpovprečnih donosnosti MV portfeljev. S primerjavo uspešnosti pripadajočih decilov obeh likvidnostnih portfeljev, ponovno ugotovim da so skoraj vse razlike realiziranih donosnosti med pripadajočimi decili statistično neznačilne. To velja za vse mere likvidnosti in vsa pod-obdobja. Kot že omenjeno, je pod-obdobje QE 1 najzanimivejše med vsemi pod-obdobji, saj zanj najdem statistično značilno (tveganju neprilagojeno) negativno razmerje med tveganjem in donosnostjo, kar kaže na prisotnost učinka volatilnosti. Vendar tudi pri tem pod-obdobju ni moč najti statistično značilno višjih donosnosti manj likvidnih in manj volatilnih portfeljev nad tistimi, ki so bolj likvidnimi in manj volatilni, ne glede na mero likvidnosti. Ta ugotovitev potrjuje odkritje iz prvega dela raziskave, da likvidnostno tveganje ne pojasnjuje uspešnosti MV portfeljev.

Vsi rezultati kažejo na to, da likvidnostno tveganje nima moči pri pojasnjevanju uspešnosti MV portfeljev. Uporaba različnih mer likvidnosti in izračunov za različna pod-obdobja, ne povzroči nobenih značilno večjih donosnosti decilov z nizko likvidnostjo. Za vzorec uporabljen pri tej raziskavi, ni moč najti premije za likvidnostno tveganje. To pomeni, da lahko potrdim vse hipoteze o tem, da likvidnost nima značilnega vpliva na uspešnost MV portfeljev.