ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ

ΤΜΗΜΑ ΛΟΓΙΣΤΙΚΗΣ & ΧΡΗΜΑΤΟΟΙΚΟΝΟΜΙΚΗΣ

ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ

STOCKS' LIQUIDITY AND ASSET PRICING

ΔΙΑΜΑΝΤΟΠΟΥΛΟΥ ΛΥΔΙΑ

Εργασία υποβληθείσα στο

Τμήμα Λογιστικής & Χρηματοοικονομικής

του Οικονομικού Πανεπιστημίου Αθηνών

ως μέρος των απαιτήσεων για την απόκτηση

Μεταπτυχιακού Διπλώματος Ειδίκευσης

Αθήνα

{Οκτώβριος 2012}

Εγκρίνουμε την εργασία της

ΔΙΑΜΑΝΤΟΠΟΥΛΟΥ ΛΥΔΙΑΣ

[ΟΝΟΜΑ ΕΠΙΒΛΕΠΟΝΤΟΣ ΚΑΘΗΓΗΤΗ] [ΥΠΟΓΡΑΦΗ]

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[ΟΚΤΩΒΡΙΟΣ 2012]

ΒΕΒΑΙΩΣΗ ΕΚΠΟΝΗΣΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ

«Δηλώνω υπεύθυνα ότι η συγκεκριμένη πτυχιακή εργασία για τη λήψη του Μεταπτυχιακού Διπλώματος Ειδίκευσης στη Λογιστική και Χρηματοοικονομική έχει συγγραφεί από εμένα προσωπικά και δεν έχει υποβληθεί ούτε έχει εγκριθεί στο πλαίσιο κάποιου άλλου μεταπτυχιακού ή προπτυχιακού τίτλου σπουδών, στην Ελλάδα ή στο εξωτερικό. Η εργασία αυτή έχοντας εκπονηθεί από εμένα, αντιπροσωπεύει τις προσωπικές μου απόψεις επί του θέματος. Οι πηγές στις οποίες ανέτρεξα για την εκπόνηση της συγκεκριμένης διπλωματικής αναφέρονται στο σύνολό τους, δίνοντας πλήρεις αναφορές στους συγγραφείς, συμπεριλαμβανομένων και των πηγών που ενδεχομένως χρησιμοποιήθηκαν από το διαδίκτυο».

[ΟΝΟΜΑΤΕΠΩΝΥΜΟ ΦΟΙΤΗΤΡΙΑΣ]	**[ΥΠΟΓΡΑΦΗ]**
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ABSTRACT:

In this study, we determine whether liquidity is an important variable, probably missing from the augmented four factor asset pricing model. We employ the same methodology as Keene and Peterson (2007). Instead of creating a trisect for liquidity portfolios, we employed the methodology suggested by Martinez, Nieto, Rubio and Tapia (2005). Hence, we created 10 liquidity portfolios. Furthermore, we examine four liquidity proxies used in most recent studies: Amihud Illiquidity ratio, spread, volume and turnover. Through our time series regressions, we find that indeed liquidity, proxied by four different measures, could be a missing factor.

INTRODUCTION:

The term liquidity has three different aspects. First, liquidity can design the liquidity of a firm also called solvency. From the firm perspective, this is the net liquidity of assets and liabilities. Liquidity of the liability side is also called funding liquidity. Funding liquidity risk is when liabilities: cannot be met when they fall due, can only be met in an uneconomic price, and can be name-specific or systematic. Second, liquidity is a characteristic of an asset, also called asset liquidity or market liquidity depending on whether the balance sheet or the markets focus. Market liquidity risk can be accounted for by widening bid/ask spreads, making explicit liquidity reserves, lengthening holding period for VAR calculations. From an investor's perspective, it describes the marketability or ease of trading an asset. Third, liquidity is also used from a monetary perspective and addresses the liquidity of the whole economy (Stange and Kaslrery, 2009).

Liquidity is a rather important issue in the financial markets. It has seen substantial growth in academic research. Literature provides us with several definitions. Liquidity generally denotes the ability to trade large quantities quickly, at low cost and without moving the price (Pastor & Stambaugh, 2003). Liquidity refers to quickly convert investment into cash or assets with minimal cost and in less time (Shaus, Zamanian & Kahreh, 2011). Liquidity is the risk investors face for not being able to readily transfer ownership of a security and is one of the main characteristics used by financial services industry (Keene & Peterson, 2007). Amihud, Mendelson and Pedersen (2005) define three sources of illiquidity. The first is demand pressure and inventory risk. The second source is the exogenous transaction costs. The third is private information.

In order to measure asset liquidity, one could use several proxies. The first one is bid/ask spread. To compare different products the ratio of the spread to the product's mid price can be used. The smaller the ratio the more liquid the asset is. Two measures proposed by Hachmeister are market depth and resiliency. Market depth is the amount of an asset that can be bought or sold at various bid/ask spreads. Resilience is the speed with which prices return to former levels after a large transaction. Finally, immediacy is referred to be a liquidity measure as well. It is the time needed to successfully trade a certain amount of an asset at a prescribed cost.

Mainly, later studies look at illiquidity through its unexplored determinants and find a statistically significant relation among liquidity, its determinants and returns. In this study, we determine whether liquidity is an important variable, probably missing from the augmented four factor asset pricing model. Through our time series regressions, we find that indeed liquidity, proxied by four different measures, could be a missing factor.

LITTERATURE REVIEW:

Many researchers focused their work to the role information plays in liquidity. Kyle (1985) states that the depth of the market is constant overtime and all private information is incorporated into prices by the end of trading., Glosten and Milgrom (1985) concluded that traders with superior information lead to a general on liquidity positive spread even when the specialist is risk neutral and makes zero expected profits. Constantinides (1986) finds that transaction costs have only second order effect on the liquidity premia implied by the equilibrium asset returns. Brown and Zhang (1997) state that markets that allow limit orders tend to have a lower execution premium and a higher level of liquidity. Easley, Hvidkjaer and O' Hara (2002) study the role of information-based trading in affecting expected stock returns in the US market. They find that information does affect asset prices. Allen and Gale (2005) conclude that as the liquidity shocks become vanishing small, the asset price volatility is bounded away from zero. Gharghori, Chan and Faff (2007) by examining the Australian market conclude that Fama and French factors are not proxying for default risk.

Fama and French (1992) claim that CAPM has no explanatory power regarding the cross-sectional expected returns, while size and book-to market ratio have an important role. In this sense, Fama and French (1993) argue that the apparent superior returns of size portfolios and book-to market portfolios represent compensation for extra market risk. The below mentioned researchers examined if and how stocks' liquidity affects the asset pricing, using a variety of liquidity proxies.

Amihud and Medelson (1986) by examining US market find significant positive relations between returns and liquidity proxied by bid ask spread. Subrahmanyan (1996) use as a liquidity proxy the trading costs and the price information. They find that there is a significant return premium associated with both fixed and variable elements of the cost of transacting. Chordia and Subrahmanyan (1998) using data from US, state that there is a strong negative relation between average returns and trading volume, which is consistent with a liquidity premium is asset prices. Datar, Naik and Radcliffe (1998) state that liquidity, as proxied by turnover, plays a significant role in explaining cross sectional variation in stock returns.

Choria, Subrahmanyan and Anshuman (2001) once again by using data from the US market conclude that liquidity, proxied by volatility of trading activity (trading volume and share turnover) has a negative and strong cross sectional relationship with the stock returns. Amihud (2002) find that expected market illiquidity positively affects ex ante stock excess returns, suggesting that expected stock return partly represent an illiquidity premium. In 2002, Chan and Faff find that liquidity proxied by turnover is negatively related to stock returns. Furthermore, momentum factor is positively related to stock returns. Jones (2002) presents evidence that the transaction cost measures that also proxy for liquidity-spreads and turnover predict returns one year or more ahead. High spreads predict high stock returns; while high turnover predicts low stock returns. Pastor and Stambaugh (2003) used the temporary price changes accompanying order flow as a liquidity measure. They find that market wide liquidity appears to be a state variable that is important for pricing common stocks. Lesmond (2005) examined emerging markets and used as a liquidity proxy the LVD. He states that the levels of the LVD liquidity estimates are increasing with trading difficulty. Acharya and Pederson (2005) find that required returns of a security is increasing in covariance between its illiquidity and market illiquidity, decreasing in the covariance between security's return and market illiquidity and decreasing in the covariance between its illiquidity and market returns. Furthermore, positive shocks to illiquidity, if persistent, are associated with a low contemporaneous returns and high predicted future returns. Martinez, Nieto, Rubio and Tapia (2005) find that liquidity factor can explain the cross-section of average returns in Spain. Chan and Faff (2005) examined the Australian market. Liquidity, proxied by the turnover, plays an important role in asset pricing and support for a liquidity augmented Fama and French model.

Liu (2006) finds that the LMx liquidity is an important source of risk. Chan, Hong and Subrahmanyan (2006), after a cross country examination, document that a higher ADR premium is associated with higher ADR liquidity. They conclude that a higher liquidity of a given asset should be reflected in a higher price or a lower required return. Keene and Peterson (2007) find that liquidity is an important factor affecting portfolio returns, even after the effects of market, size, book-to market equity and momentum are considered. Bekaert, Harvey and Lundbald (2007) used data from emerging markets and compared their results to the US. They concluded that liquidity, proxied by a transformation of the proportion of zero daily form returns averaged over the month, significantly predicts future return. However, alternative measures such turnover do not. Durand and Watson (2008) find strong support for a liquidity augmented Fama-French model and evidence that liquidity plays an important role in asset pricing.

By examining the Tehran Stock Exchange, Shaus, Zamanian, Kahreh and Kahreh conclude that illiquidity has a positive and highly significant effect on price. Stock price is found to be an increasing function of illiquidity. In 2011, Shams, Zamanian and Kahreh report that stock price and illiquidity are positively related. In the same year, Hubinette & Jonsson added a liquidity factor to the Chen, Novy- Marx & Zhang three factor model. They find that liquidity factor is priced and the alternative model is overall better than the Carhart (1997) at explaining anomalies such as standardized unexpected earnings, financial distress and total accruals. Phong (2012) by examining the Vietnamese market finds that the CAPM is not appropriate for forecasting rates of return. However, liquidity indicators explain the results of rate of return and risk of stocks, which are posted better.

Eleswrapu and Reinganum (1993) again by focusing on the US market find that liquidity, proxied by spread, premium is reliably positive during January. Vayanos (1998) states that transaction costs have very small effects on stock prices but large effects on turnover. Marsall and Young (2003) focused on the Australian market. They conclude that there is a small liquidity premium which persists for the entire year. Korajczyk and Sadka (2006) use a variety of liquidity measures. They find that across-measure systematic liquidity is a priced factor, while within measure systematic liquidity does not exhibit additional pricing information. Asparonhova, Besse, Binder and Kalcheva (2009) by examining the US market, find a significant upward bias in estimated return premia for an array of illiquidity measures in CRSP monthly return data. Finally, Chan, Faff and Gharghori state that liquidity factor only adds marginal explanatory power to contemporary asset pricing models.

The use of time series model allows for an investigation of whether mimicking portfolios for risk factors capture shared variations in stock returns and indentifies whether the model is well specified as indicated by intercepts indistinguishable from zero.

We employ the same methodology as Keene and Peterson (2007). Instead of creating a trisect for liquidity portfolios, we employed the methodology suggested by Martinez, Nieto, Rubio and Tapia (2005). Hence, we created 10 liquidity portfolios. Furthermore, we examine four liquidity proxies used in most recent studies: Amihud Illiquidity ratio, spread, volume and turnover. None of the above mentioned papers employs all four liquidity measures.

DATA AND METHOD:

Liquidity Risk is examined for all traded companies on the Berlin stock exchange by using return data from July 2000 to June 2012. We form the returns used in the time series regressions in size, book-to market equity, liquidity and momentum portfolios like those in Fama and French (1993), using the momentum factor from Carhart (1997).

Returns

At the end of June of each year all stocks are independently shorted by size, book-to market equity, liquidity and momentum. In the size groups market equity is measured at the end of June and in the book-to market groups market equity is measured at the end of December of the current year. The momentum groups are formed at the end of June. We calculated the 11-month returns, in contrast to that used in Carhart, beginning in July of the current year and ending in June of the following year. We use these measures to sort all stocks into two size bisects[1], three book-to

[1] Two size groups: small containing 50% of the sorted sample and big containing 50% of the sorted sample. The stocks are sorted from low to high market cap.

market trisects[2] and three momentum trisects[3], yielding 18 portfolios from the matrix of size, book to market and momentum .

The return series for each portfolio is calculated as the logarithmic price change: $R_t = \log\left(\frac{P_t}{P_{t-1}}\right)$ where R_t is the monthly return and Pt is the stock price at time t. All data were obtained from Bloomberg. Excess returns were used both for depended and independent variables in the time series regressions. For the market excess returns, we used the DAX index and the one year German government bond as Rm and Rf respectively.

Liquidity Measures

For the liquidity groups our methodology is different from that used in Keene and Peterson (2007). For each liquidity measure we formed ten liquidity portfolios (Martinez, Nieto, Rubio & Tapia, 2005). In order to sort and form the above mentioned portfolios, we calculated the yearly average liquidity ratio beginning in July of the current year and ending in June of the following year. Portfolios one to five are illiquid and portfolios six to ten are liquid.

We use four liquidity measures. All have precedence in the literature. The first is the dollar volume of trading, calculated by multiplying the number of shares traded by the concurrent stock price. The second is the share turnover, formed by dividing the number of shares traded by the number of shares outstanding. The third is the relative bid/ask spread and the fourth is Amihud Liquidity Ratio calculated as ILRi,t = $1/D_T \sum_{i=1}^{T} |R_{i,t}| / VOL_{i,t}$ where D_T is the number of trading days within a time window T, $|R_{i,t}|$ is the absolute return on day t and $VOL_{i,t}$ is the trading volume in monetary values on day t.

In order to form the portfolios for each liquidity measure, we sort the sample based on the yearly average liquidity ratio. Based on spread and Amihud Liquidity ratio, the sample was sorted from large values to small values. High values of both

[2] Three BE/ME groups: High containing 30% of the sorted sample Medium containing 40% of the sorted sample and Low containing 30% of the sorted sample. The stocks are sorted from high to low BE/ME.

[3] Three MOM groups: Winners containing 30% of the sorted sample Medium containing 40% of the sorted sample and Losers containing 30% of the sorted sample. The stocks are sorted from high to low MOM.

measures indicate an illiquid market with low depth. Based on volume and turnover, the sample was sorted from small values to large values. Each portfolio contains 10% of the sorted sample and as mentioned above, portfolios one to five are the illiquid and six to ten are the liquid ones.

Thus, the liquidity portfolios are formed four different times, once for each measure of liquidity. The difference between the simple average of excess returns from the five illiquid portfolios and the simple average of excess returns from the five liquid portfolios is used as the liquidity factor mimicking portfolio.

Previous studies such as Keene and Peterson (2007) suggest that liquidity as an independent variable is likely to be highly correlated with other variables in the model. Hence, we also examine liquidity in its original form as well as a residual effect measured independent of other variables. We examine four regressions: the first one four times, once for each liquidity measure, and the other three regressions ten times once for each liquidity portfolio, yielding to 240 time series regressions.

At this point we have to mention that all liquidity measures' returns begin in July 2000, leading to 144 monthly observations. However, the turnover liquidity portfolios begin in July 2001 due to lack of data, leading to 132 monthly observations.

Empirical Method

The first regression is given by:

$$LIQ = n_0 + n_1 MKT + n_2 SMB + n_3 HML + n_4 WML + e_{LIQ} \quad (1)$$

Where LIQ is the factor mimicking portfolio for liquidity (excess returns of illiquid firms minus liquid firms), SMB is the factor mimicking portfolio for size (excess returns of small firms minus big firms), HML is the factor mimicking portfolio for book-to market equity (excess returns of high-book-to market firms minus low-book-to market firms) and WML is the factor mimicking portfolio for momentum (excess returns of winner stocks minus losers stocks). MKT is the value weighted market excess return. We use this regression in order to obtain the residualse_{LIQ}, which will form an alternative liquidity factor mimicking portfolio free of any influence. We estimate this equation (1) four times.

The second regression is given as:

$$L_i = A + L\left(e_{LIQ,m}\right) + e_m \qquad (2)$$

Where L_i is the monthly excess return of each one of the ten liquidity portfolios and $e_{LIQ,m}$ is the monthly residual liquidity factor from equation (1). We estimate equation (2) ten times, once for each liquidity portfolio. We estimate the same equation four different times, once of each liquidity measure, yielding to 40 estimations. Each liquidity portfolio is regressed against its respective residual liquidity factor e.g. Spread portfolios (S1-S10) are regressed against the residuals of spread from the eq. (1).

The estimation of equation (2) will provide us with the coefficient's sign of each liquidity measure under different portfolios conditions. As mentioned in Keene and Peterson the natural relation between returns of low liquidity stocks and liquidity as a variable is positive. In contrast, the returns of high liquidity stocks and the liquidity variables may have a negative relation.

The third equation captures the effect of liquidity on returns under the condition of factors known to affect returns. The regression is:

$$L_i = A + L(LIQ)_m + B(MKT)_m + S(SMB)_m + H(HML)_m + M(WML)_m + e_m \qquad (3)$$

Where L_i is the month excess return of each one of the ten liquidity portfolios for month m. The equation is estimated again 40 times. The above mentioned regression includes liquidity in its original form and not as a residual. By using this form, we want to examine whether liquidity alters the effect of the other variables or their coefficients. The fourth time series regression will provide us with the results needed in order to compare and contrast. Furthermore, we will be able to examine if the new variable improves the model's specification. The equation is:

$$L_i = A + B(MKT)_m + S(SMB)_m + H(HML)_m + M(WML)_m + e_m \qquad (4)$$

EMPIRICAL RESULTS

Descriptive statistics

In Table 1 we report a summary of descriptive statistics of the variables used in the time series regressions.

Since we use time series analysis the average values of the explanatory variables are the average risk premiums for the underlying factors. The results could be weighed against prior studies such as Keene and Peterson. However, the results are not directly comparable for the following reasons:

1. The period examined is different. Keene and Peterson analyze data from July 1963 to December 2002, whereas we use data from July 2000 to June 2012.
2. Keene and Peterson analyze stocks traded in U.S., whereas we analyze stocks in Germany.
3. Keene and Peterson form three liquidity groups, whereas we formed ten liquidity portfolios.
4. They used six liquidity measures: volume, turnover, standard deviations of trading volume and turnover and coefficients of variations of trading volume and turnover. We used four liquidity measures: volume, turnover, spread and Amihud Liquidity Ratio.

The average value of the market excess return (MKT) is -0,233% per month. Keene and Peterson reported 0, 41%. The average monthly premium for the book-to equity factor (HML) is 0, 19%, whereas Keene and Peterson reported 0, 43%. The average value of the size factor (SMB) is 0, 047%. Keene and Peterson reported 0,21%. The average value for the momentum factor (WML) is 0, 186% whereas Keen and Peterson reported 0, 91%. MKT and SMB in Keene and Peterson analysis is in most cases statistically insignificant (t= 1, 98 and t=1, 39 respectively). Our analysis suggest that all variables are statistically significant in most cases with the exception of HML (t=-0,594).

For the liquidity measures the excess return differences are the differences between the illiquid and liquid portfolios. The average value for dollar volume is 0,66% per month (t=-3,662). Turnover has an average of 0,442% per month (t=-3,88).

Spread has an average of -0, 374% per month (t=2, 61). Amihud liquidity ratio has an average value of -0,095% (t=0,999).

TABLE 1. Summary Statistics for the Monthly Explanatory Returns

Variables	Mean	St.Dev.	t(Mean)	min	max
MKT	-0,00233	0,069463	5,246741	-0,29583	0,191819
SMB	0,000473	0,008946	5,246741	-0,02277	0,032137
HML	0,001901	0,005908	-0,5946	-0,01098	0,030766
WML	0,001863	0,007261	-3,2608	-0,01421	0,029447
LIQs	-0,00374	0,025076	2,610053	-0,08189	0,06976
LIQv	0,00663	0,039187	-3,66238	-0,09369	0,142184
LIQt	0,004427	0,025797	-3,88064	-0,07439	0,082985
LIQil	-0,00095	0,028986	0,999586	-0,06246	0,064572
e_LIQs	0,00081	0,015436	1,579792	-0,04532	0,039476
e_LIQt	0,002097	0,020438	-1,65175	-0,05128	0,053639
e_LIQv	0,000638	0,019439	-2,48927	-0,06635	0,057509
e_LIQil	-0,00035	0,015707	0,633337	-0,04654	0,050561

In Table 2 we report the correlation matrix for the explanatory returns.

TABLE 2. Correlation Matrix for the Monthly Explanatory Returns

	MKT	SMB	HML	WML	LIQs	LIQv	LIQt	LIQil	e_LIQs	e_LIQt	e_LIQv	e_LIQil
MKT	1,00	-0,56	-0,21	-0,43	-0,41	-0,75	-0,49	-0,49	-0,06	0,00	0,05	0,01
SMB	-0,56	1,00	0,68	0,19	0,77	0,77	0,18	0,81	0,14	0,00	-0,11	0,00
HML	-0,21	0,68	1,00	0,11	0,49	0,40	-0,05	0,53	0,38	-0,03	-0,38	0,04
WML	-0,43	0,19	0,11	1,00	-0,21	0,47	0,50	0,04	-0,10	-0,03	0,06	0,01
LIQs	-0,41	0,77	0,49	-0,21	1,00	0,53	0,10	0,78	0,61	0,12	-0,06	0,18
LIQv	-0,75	0,77	0,40	0,47	0,53	1,00	0,54	0,61	0,09	0,17	0,39	-0,01
LIQt	-0,49	0,18	-0,05	0,50	0,10	0,54	1,00	0,20	0,06	0,78	0,34	0,13
LIQil	-0,49	0,81	0,53	0,04	0,78	0,61	0,20	1,00	0,31	0,10	-0,10	0,56
e_LIQs	-0,06	0,14	0,38	-0,10	0,61	0,09	0,06	0,31	1,00	0,18	-0,12	0,35
e_LIQt	0,00	0,00	-0,03	-0,03	0,12	0,17	0,78	0,10	0,18	1,00	0,35	0,17
e_LIQv	0,05	-0,11	-0,38	0,06	-0,06	0,39	0,34	-0,10	-0,12	0,35	1,00	-0,03
e_LIQil	0,01	0,00	0,04	0,01	0,18	-0,01	0,13	0,56	0,35	0,17	-0,03	1,00

In the table above all liquidity measures both in their original and residual form are provided. Highly correlated are considered the variables with a correlation coefficient equal or greater than |0, 7|. Several correlations are noteworthy. The MKT factor is highly negatively correlated with volume liquidity measure. The SMB factor is highly positively correlated with all liquidity measures except turnover. Spread liquidity measure is also highly positively correlated with Amihud Iliquidity ratio. Turnover liquidity measure is the only factor highly correlated with its residual in a positive manner.

Belsley collinearity diagnostic:

In order to assess the strength of collinearity among variables, we used Belsley collinearity test. Singular values of the scaled independent variable matrix are converted to condition indices, which identify the number and strength of any near dependencies in the designed matrix. The variance of the ordinary least squares (OLS) estimates of the regression coefficients is decomposed in terms of the singular values to indentify variables involved in each near dependency, and the extent to which the dependencies degrade the regression.

The number of large condition indexes indentifies the number of near dependencies among the columns of the design matrix. Large variance decomposition proportions identify covariates that are involved in the corresponding near dependency, and the magnitude of these proportions, in conjunction with the condition index, provides a measure of the degree to which the corresponding regression estimate has been degraded by the presence of collinearity. What is meant by “large” is not statistically precise, although numerical experiments by Belsley et al. indicate that the following ranges are useful:

Condition Index	Degree of collinearity
5<CI<10	Weak
30<CI<100	Moderate to strong
CI>100	severe

Below, we present the results of Belsley collinearity test on the independent variables used in our time series regressions. All indexes are below five, hence we can say that there is no apparent collinearity.

Independent Variables					collinearity test
MKT	SMB	HML	WML	LIQs	1
					1,373135702
					1,697554597
					2,500951982
					4,605978393
					collinearity test
MKT	SMB	HML	WML	LIQv	1
					1,593002916
					2,263596117
					3,612082121
					4,124247778
					collinearity test
MKT	SMB	HML	WML	LIQt	1
					1,329169825
					1,90142432
					2,406258882
					3,410643457
					collinearity test
MKT	SMB	HML	WML	LIQil	1
					1,514864323
					2,101109069
					2,861845509
					4,58010776
					collinearity test
MKT	SMB	HML	WML		1
					1,349561332
					1,916535179
					3,055363175
					collinearity test[4]
MKT	SMB	HML	WML		1
					1,459326601
					1,804834362
					3,229703555

Descriptive Characteristics

In our analysis we have included some descriptive characteristics for the ten portfolios of each liquidity measure. We want to see the relation between liquidity and characteristics such as leverage, Market Cap., BE/ME, ROE and Momentum.

[4] For the last sub-table, we have minus one year of observations.

Volume Portfolios:

i. Leverage: The most illiquid and liquid portfolios appear to have the highest leverage[5]. According to previous studies illiquid firms tend to have higher level of leverage.
ii. Market Cap.: The most illiquid portfolio (portfolio 1) has the smallest market cap. And the most liquid portfolio (portfolio 10) has the highest market cap. For the rest portfolios there is not a clear trend.
iii. BE/ME: The illiquid portfolios tend to have higher BE/ME than the liquid portfolios. Portfolio 7 seems to be a breaking point since BE/ME turns negative and after that turns positive and increases again. However, the most liquid portfolio (portfolio 10) has significantly lower BE/ME than portfolio 1.
iv. ROE: The two most liquid portfolios have the largest ROE.
v. Momentum: All portfolios have a negative momentum sign. However, when we move from the illiquid portfolios to liquid ones the values of momentum become less negative.

Turnover Portfolios:

i. Leverage: The most illiquid portfolio (portfolio 1) and the most liquid portfolio (portfolio 10) appear to have the highest leverage level.
ii. Market Cap.: The first two illiquid portfolios as well as the three most liquid portfolios (portfolios 8-10) have the highest Market Cap.
iii. BE/ME: The highest BE/ME appears in the most liquid portfolio (portfolio 10). For the rest, there is no trend.
iv. ROE: All portfolios, with the exception of the first three illiquid portfolios, have a negative ROE. The highest one appears in portfolio 3 and then it turns negative. The lowest appears in portfolio 9.
v. Momentum: All portfolios, with the exception of the second portfolio have a negative momentum factor. Hence the higher momentum appears in portfolio 2 and the lowest in portfolio 10.

[5] Volume Portfolios 1 to 4 and 8 to 10.

Spread Portfolios:

i. Leverage: Portfolio 1 has the lowest leverage while portfolio 10 has the highest. For the rest, no trend can be distinguished.
ii. Market Cap.: The three most liquid portfolios (portfolios 8-10) have the highest Market Cap. Portfolio 1 has the lowest.
iii. BE/ME: The most illiquid portfolio has the highest BE/ME average value.
iv. ROE: All of the illiquid portfolios have a negative ROE while all the liquid have a positive one. The highest ROE appear in the most liquid portfolio.
v. Momentum: All portfolios have a negative Momentum. The lowest average value appears in the first portfolio. When we move from illiquid portfolios to liquid momentum becomes less negative.

Amihud Illiquidity Ratio Portfolios:

i. Leverage: The three most liquid portfolios have the highest leverage level.
ii. Market Cap.: Liquid portfolios appear to have the highest Market Cap. Market Cap increases when we move from portfolio 6 to portfolio 10.
iii. BE/ME: The highest BE/ME appears in the two most illiquid portfolios.
iv. ROE: All illiquid portfolios have a negative ROE, whereas all liquid have positive ROE.
v. Momentum: All portfolios have negative momentum.

Both spread and Amihud Illiquidity portfolios have the highest leverage in portfolios 9 and 10. Volume and turnover portfolios have the highest leverage in portfolios 1 and 10. Spread, Volume and Amihud Illiquidity portfolios have the lowest market cap in portfolio 1 and the highest in portfolios 8 to 10. Turnover portfolios have the highest market cap in portfolios 1, 2 and 8 to 10, whereas the lowest average market cap in portfolio 6. Spread, Volume and Amihud Illiquidity portfolios have the highest BEME in portfolio 1. The highest value in turnover portfolios is in portfolio 10. Spread, Volume and Amihud Illiquidity portfolios have negative ROE in illiquid portfolios and positive in liquid portfolios. Turnover portfolios have positive ROE only in the first three illiquid portfolios and the rest have a negative sign. Finally, Spread, Volume and Amihud Illiquidity portfolios have a negative momentum factor with no exceptions made. In turnover portfolios, portfolio 2 has a positive momentum factor.

Regression Analysis

We estimate time series regressions[6] given by equation (2) using four different measures of liquidity. Hence, there are four underlying liquidity proxies used in the calculation of the residual liquidity factor. We present the results in Table 3.

TABLE 3.A Regression of Excess Returns on the Residual Liquidity Factor Proxied by Spread

Variable	A	t(A)	L	t(L)	R^2
S1			1,426141	2,968657	0,057651135
S2	-0,0159	-2,99492	0,928158	2,69313	0,041894972
S3	-0,01694	-3,46913	0,918013	2,895892	0,04911481
S4			1,403439	2,758458	0,014739438
S5			1,365731	2,534496	0,0080633
S6			0,256725	0,547886	-0,062779512
S7			0,444354	0,958596	-0,060892825
S8			0,243578	0,559281	-0,049760314
S9			0,219648	0,473368	-0,036571273
S10	-0,00626	-1,12593	-0,21355	-0,59184	-0,004564231
IND.VAR.	**e(LIQs)**				

TABLE 3.B Regression of Excess Returns on the Residual Liquidity Factor Proxied by Volume

Variable	A	t(A)	L	t(L)	R^2
V1	-0,00519	-1,14803	0,148111	0,635563	-0,004185696
V2	-0,01033	-2,60964	-0,08629	-0,42269	-0,005776776
V3			-0,33512	-1,19286	-0,062750212
V4			-0,38426	-1,28629	-0,054509995
V5	-0,01369	-3,27211	-0,56457	-2,61488	0,039221288
V6	-0,0175	-3,53047	-1,33818	-5,23119	0,155671532
V7	-0,02092	-3,48798	-1,50996	-4,87883	0,137530432
V8	-0,01801	-2,84981	-1,30192	-3,99315	0,094622894
V9	-0,02073	-3,20766	-1,30723	-3,92035	0,091308389
V10	-0,01054	-1,62441	-0,66544	-1,98804	0,020227977
IND.VAR.	**e(LIQv)**				

[6] In cases where heteroskedasticity is detected, we used white's heteroskedasticity corrected regressions.

TABLE 3.C Regressions of Excess Returns on the Residual Liquidity Factor Proxied by Turnover

Variable	A	t(A)	L	t(L)	R^2
T1	-0,01562	-2,96024	0,369523	1,433001	0,007978
T2	-0,01622	-2,93935	-0,14823	-0,54985	-0,00535
T3	-0,01524	-2,50402	-0,1602	-0,53875	-0,00545
T4	-0,01624	-2,70615	-0,15116	-0,51565	-0,00564
T5	-0,0116	-1,83418	-0,29762	-0,96303	-0,00055
T6	-0,01561	-2,39377	-0,82162	-2,57909	0,041358
T7	-0,01563	-2,25092	-0,89673	-2,64334	0,043706
T8	-0,01255	-1,95249	-0,98367	-3,13355	0,063075
T9	-0,0196	-2,83969	-1,19437	-3,54238	0,081014
T10	-0,02332	-2,77185	-1,43234	-3,48489	0,078402
IND.VAR.	**e(LIQt)**				

TABLE 3.D Regressions of Excess Returns on the Residual Liquidity Factor Proxied by Amihud Liquidity Ratio

Variable	A	t(A)	L	t(L)	R^2
I1			0,743974	1,279507	-0,02664
I2	-0,01532	-2,70365	0,701933	1,939581	0,018949
I3			0,557429	1,422231	-0,05467
I4	-0,01605	-3,32422	0,775823	2,515852	0,03593
I5	-0,01742	-2,9729	0,930171	2,485924	0,034956
I6	-0,02066	-3,23168	-0,13608	-0,33324	-0,00626
I7	-0,01785	-2,72219	0,063414	0,151438	-0,00688
I8	-0,01651	-2,66873	-0,2605	-0,65944	-0,00397
I9	-0,01803	-2,67738	-0,41312	-0,9607	-0,00054
I10	-0,0071	-1,15971	-0,5895	-1,50778	0,008826
IND.VAR.	**e(LIQil)**				

We examined 18 portfolios based on sorts for size, book-to market and momentum and 10 portfolios based on sorts for liquidity. Table 3 is separated into four sub-tables one for each liquidity measure. We start the analysis by looking at the first liquidity measure presented above, spread. Because all regressions use the residuals obtained from equation (1), the results show the effect of liquidity independent of the other factors.

We find that liquidity is priced and has an explanatory power for the five illiquid portfolios. In these portfolios there is a tendency for positive coefficients, suggesting a positive relation with returns. For all liquid portfolios spread is statistically insignificant. On the opposite hand, turnover is statistically significant for the five liquid portfolios. The results above present a negative relation between turnover and returns.

When considering volume as a liquidity measure, the results are quite different. Volume has an explanatory power for portfolios 5 to 9. Similar to the results from turnover's regression, coefficients are negative suggesting a negative relation between liquidity, proxied by volume, and returns. Amihud Illiquidity ratio is statistically insignificant for all portfolios, except portfolios 4 and 5. We have to note that although this liquidity measure is mostly insignificant, as independent from all other factors, the sign of its coefficient changes from illiquid portfolios to liquid. Illiquid portfolios suggest a positive relation while liquid a negative one.

In Table 4 we present regression results from the estimation of equation (4). This model does not include liquidity as an explanatory variable. It only includes the other four factors that are already known to affect returns.

TABLE 4.A Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market and Momentum

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	R^2
S1			0,66	8,27	4,43	6,33	-1,50	-1,13	-3,08	-5,47	0,45
S2			0,65	9,83	3,30	5,74	-3,66	-5,32	-3,68	-8,82	0,66
S3	-0,01	-1,63	0,67	11,18	2,79	4,73	-3,69	-4,84	-1,71	-3,64	0,61
S4			0,53	7,77	2,07	3,08	-5,37	-5,17	-3,46	-6,40	0,61
S5			0,60	8,65	2,07	2,98	-5,49	-5,18	-3,24	-5,88	0,61
S6			0,62	11,29	1,47	2,70	-3,66	-4,87	-2,33	-5,09	0,65
S7			0,64	8,82	1,36	2,35	-3,80	-4,51	-2,14	-4,06	0,65
S8	-0,01	-1,66	0,60	10,65	0,19	0,35	-2,09	-2,95	-1,83	-4,19	0,68
S9			0,59	10,05	-0,65	-1,13	-1,40	-1,75	-2,36	-5,07	0,70
S10			0,73	10,70	-1,56	-3,45	1,51	3,09	-1,24	-2,77	0,82
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**							

TABLE 4.BRegression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market and Momentum

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	R^2
V1			0,49	7,79	2,76	5,05	0,12	0,13	-1,88	-4,64	0,42
V2	0,00	-1,19	0,50	9,69	2,69	5,35	-1,77	-2,71	-1,91	-4,77	0,54
V3			0,49	6,85	2,77	4,43	-3,44	-4,32	-1,93	-3,93	0,50
V4			0,55	10,29	2,14	4,21	-2,60	-3,95	-2,73	-6,06	0,59

V5			0,51	10,47	1,55	3,27	-2,40	-3,74	-1,93	-4,68	0,55
V6			0,60	9,87	2,38	3,62	-4,68	-4,94	-2,84	-4,59	0,58
V7			0,73	8,80	1,72	2,49	-4,98	-4,64	-3,45	-6,43	0,67
V8			0,77	9,32	1,42	1,73	-4,32	-4,45	-3,20	-5,64	0,68
V9			0,68	10,16	-0,40	-0,59	-4,19	-3,72	-3,15	-5,91	0,71
V10			0,84	11,62	-1,24	-2,38	-0,92	-1,28	-1,69	-3,46	0,82
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**							

TABLE 4.C Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market and Momentum

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	R^2
T1	0,00	-0,96	0,47	6,97	1,30	1,87	-1,89	-1,63	-3,55	-6,38	0,57
T2	-0,01	-1,89	0,54	7,11	1,29	1,67	-0,90	-0,70	-2,82	-4,57	0,50
T3	-0,01	-1,42	0,63	7,71	1,65	1,98	-0,91	-0,66	-3,04	-4,57	0,53
T4	-0,01	-2,32	0,74	10,00	1,82	2,41	-0,72	-0,57	-2,11	-3,48	0,60
T5	0,00	-0,84	0,76	9,54	2,46	3,02	-1,03	-0,76	-2,66	-4,07	0,58
T6	-0,01	-1,46	0,68	7,78	2,00	2,25	-0,25	-0,17	-3,81	-5,36	0,55
T7	-0,01	-1,36	0,74	8,57	1,59	1,80	-0,09	-0,06	-4,17	-5,90	0,61
T8	-0,01	-1,20	0,72	8,73	1,62	1,91	-0,04	-0,03	-3,42	-5,05	0,59
T9	-0,01	-2,91	0,82	10,01	1,22	1,45	0,94	0,67	-3,66	-5,45	0,66
T10	-0,01	-1,96	0,79	7,40	1,00	0,91	0,43	0,24	-5,92	-6,73	0,60
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**							

TABLE 4.D Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market and Momentum

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	R^2
I1			0,73	7,29	3,46	4,00	-2,90	-2,51	-5,38	-7,82	0,60
I2			0,72	11,59	3,08	4,70	-3,45	-3,78	-3,13	-6,40	0,62
I3			0,56	7,99	1,98	3,00	-2,47	-3,05	-3,05	-6,55	0,52
I4			0,64	13,78	2,15	3,81	-2,79	-3,53	-2,12	-4,18	0,58
I5	-0,01	-1,23	0,69	9,16	1,78	2,42	-3,80	-4,00	-2,35	-4,02	0,58
I6			0,69	11,46	1,72	2,67	-5,93	-5,20	-2,56	-4,30	0,63
I7			0,69	8,92	1,06	1,35	-4,55	-4,55	-3,66	-7,17	0,70
I8			0,65	9,50	-0,54	-0,85	-2,62	-2,92	-2,48	-4,49	0,68
I9			0,69	12,23	-1,91	-3,35	-1,34	-1,50	-2,88	-5,59	0,74
I10			0,85	11,13	-1,02	-2,03	0,60	1,14	-1,44	-3,09	0,84
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**							

As shown above MKT factor is significant for all 40 portfolios presented. It is positively related with returns. In spread portfolios, size is almost always statistically significant. As we move from illiquid to liquid portfolios size coefficient decreases and in the last two most liquid portfolios turns negative. For portfolios 8 and 9 size appears to be insignificant. HML factor's coefficient decreases when we move from highly illiquid portfolios to less illiquid and increases when we move from less liquid portfolios to highly liquid. All coefficients are negative with the exception of portfolio 10, when it turns positive. HML is statistically insignificant for portfolios 1 and 9. Momentum factor does not seem to have a trend and it has a negative relation with returns. R^2 increases when we move from illiquid portfolios to liquid.

In volume portfolios market factor does not have a trend. Size is statistically significant for all portfolios except portfolios 8 and 9. Its coefficient decreases when we move from highly illiquid portfolios to less illiquid. Portfolio 6 seems to be a breaking point since size coefficient increases and then decreases again when we move towards portfolio 10. In portfolio 10 there is a negative relation between size and returns. HML factor is statistically insignificant for portfolios 1 and 10, whereas in spread it was for portfolios 1 and 9. Coefficients are negative. From portfolio 8 to portfolio 10 coefficients increase as well as from portfolio 3 to 5. Momentum factor is in all portfolios statistically significant and negative. Similar to spread portfolios, R^2 increases as we move from illiquid to liquid portfolios.

In turnover portfolios the only factors always statistically significant are MKT and momentum. HML has no explanatory power for none of the turnover portfolios and size is mainly insignificant. Only portfolios 4 to 6 have a statistically significant size factor. Momentum factor increases in illiquid portfolios and decreases in liquid. No apparent trend for R^2.

In Amihud Illiquidity portfolios MKT remain the same for portfolios 5 to 7 and for portfolio 9. All illiquid portfolios and the first liquid one (portfolio 6) are affected by size factor. Size has a positive relation with returns, in cases where it is statistically significant. HML has an explanatory power for all the portfolios except the two most liquid portfolios. However, it does not appear to have a trend. Momentum factor affects all of the above mentioned portfolios. Its coefficient increases throughout illiquid portfolios. All coefficients are negative. R^2 increases from portfolio 1 to 2, 3 to 7 and 8 to 10.

Using the four factor model, the R^2s are roughly 45% to 80%. The highest R^2s belong to portfolio 10, regardless the liquidity measure. However, our results do not present an extreme increase or decrease throughout the portfolios. In comparison to

Keene and Peterson we have lower R^2s. This different may be attributed to our method of creating liquidity portfolios. They created a trisect of liquidity portfolios, whereas we created 10 portfolios. Despite this reduction, the R^2 measure still reaches 80% similar to their results.

In Table 5 we report regression results from equation (3). Liquidity is included in its original form and not as a residual liquidity factor. We want to examine the liquidity's effect both on the other factor and the model itself. Results are presented for all liquidity measures.

TABLE 5.A Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market, Momentum and Liquidity

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	L	t(L)	R^2
S1			0,68	9,01	0,48	0,44	1,44	1,03	-1,57	-2,07	1,43	4,04	0,55
S2			0,66	9,64	0,88	1,20	-1,86	-2,29	-2,76	-5,22	0,87	3,89	0,70
S3			0,68	11,57	0,59	0,91	-2,41	-3,08	-1,02	-1,82	0,86	3,85	0,65
S4			0,55	9,63	-1,82	-2,16	-2,48	-3,27	-1,98	-3,28	1,40	5,80	0,72
S5			0,62	9,61	-1,72	-1,99	-2,67	-3,10	-1,79	-2,63	1,37	4,84	0,70
S6			0,63	11,35	0,76	0,98	-3,13	-3,69	-2,05	-3,35	0,26	1,01	0,65
S7			0,65	9,40	0,13	0,17	-2,88	-3,39	-1,67	-2,58	0,44	1,77	0,66
S8			0,60	10,77	-0,31	-0,43	-2,05	-2,51	-1,77	-3,16	0,24	1,10	0,67
S9			0,59	9,96	-1,26	-1,78	-0,95	-1,20	-2,13	-3,65	0,22	0,99	0,70
S10			0,73	10,95	-0,91	-1,51	1,02	1,72	-1,49	-2,69	-0,23	-1,17	0,82
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**	**LIQ**								

TABLE 5.B Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market, Momentum and Liquidity

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	L	t(L)	R^2
V1			0,52	7,13	2,54	4,26	-0,12	-0,13	-1,99	-4,57	0,14	0,78	0,42
V2	0,00	-1,16	0,48	8,02	2,85	5,16	-1,60	-2,32	-1,84	-4,45	-0,10	-0,71	0,54
V3			0,42	5,41	3,32	4,66	-2,86	-3,33	-1,68	-3,03	-0,34	-2,00	0,51
V4			0,47	7,42	2,76	4,53	-1,94	-2,87	-2,44	-4,86	-0,38	-2,44	0,61
V5	-0,01	-2,13	0,39	6,57	2,27	4,10	-0,86	-1,23	-1,25	-3,01	-0,58	-4,18	0,61
V6	0,00	-1,28	0,31	5,18	4,47	8,09	-1,99	-2,88	-1,66	-4,01	-1,36	-9,90	0,76
V7	-0,01	-1,74	0,40	6,71	4,05	7,30	-1,87	-2,69	-2,08	-5,01	-1,54	-11,11	0,83
V8	0,00	-0,98	0,49	7,05	3,47	5,39	-1,72	-2,14	-2,06	-4,28	-1,33	-8,29	0,78
V9			0,39	5,30	1,79	3,09	-1,85	-2,46	-2,13	-4,48	-1,34	-7,57	0,82
V10			0,69	8,70	-0,12	-0,20	0,27	0,39	-1,17	-2,33	-0,68	-4,64	0,85
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**	**LIQ**								

TABLE 5.C Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market, Momentum and Liquidity

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	L	t(L)	R^2
T1	0,00	-1,18	0,51	7,27	1,23	1,79	-1,48	-1,27	-3,98	-6,66	0,31	1,86	0,58
T2	-0,01	-1,76	0,51	6,49	1,33	1,72	-1,14	-0,87	-2,56	-3,83	-0,19	-1,01	0,50
T3	-0,01	-1,29	0,60	7,07	1,69	2,03	-1,18	-0,83	-2,76	-3,82	-0,21	-1,01	0,53
T4	-0,01	-2,19	0,72	9,26	1,86	2,46	-0,96	-0,75	-1,85	-2,82	-0,19	-1,00	0,60
T5	0,00	-0,64	0,72	8,67	2,53	3,13	-1,47	-1,07	-2,19	-3,12	-0,34	-1,72	0,59
T6	0,00	-1,05	0,57	6,65	2,19	2,62	-1,38	-0,97	-2,62	-3,62	-0,87	-4,27	0,60
T7	0,00	-0,92	0,62	7,44	1,80	2,20	-1,32	-0,95	-2,87	-4,05	-0,95	-4,76	0,67
T8	0,00	-0,68	0,59	7,62	1,84	2,41	-1,37	-1,06	-2,02	-3,05	-1,03	-5,51	0,67
T9	-0,01	-2,59	0,67	9,16	1,48	2,09	-0,66	-0,54	-1,97	-3,18	-1,24	-7,10	0,75
T10	-0,01	-1,49	0,61	6,20	1,33	1,39	-1,51	-0,93	-3,87	-4,65	-1,51	-6,41	0,70
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**	**LIQ**								

TABLE 5.D Regression of Excess Market Returns and the Mimicking Excess Returns for Size, Book-to Market, Momentum and Liquidity

Variable	A	t(A)	B	t(B)	S	t(S)	H	t(H)	M	t(M)	L	t(L)	R^2
I1			0,77	6,84	1,48	1,30	-2,60	-2,25	-4,91	-6,65	0,74	2,38	0,62
I2			0,76	12,79	1,15	1,36	-3,16	-3,52	-2,66	-5,39	0,72	3,34	0,65
I3			0,59	7,79	0,49	0,64	-2,24	-2,68	-2,69	-4,86	0,56	2,36	0,54
I4			0,68	14,33	0,02	0,03	-2,46	-3,21	-1,61	-2,99	0,80	4,12	0,63
I5			0,73	8,74	-0,59	-0,63	-3,87	-3,59	-1,94	-3,14	0,96	3,81	0,62
I6			0,68	11,31	2,00	2,27	-5,97	-5,19	-2,63	-4,12	-0,11	-0,44	0,63
I7			0,70	8,72	0,82	0,94	-4,51	-4,49	-3,60	-6,53	0,09	0,39	0,70
I8			0,64	9,40	0,09	0,11	-2,72	-3,03	-2,64	-5,05	-0,24	-0,99	0,68
I9			0,67	11,68	-0,88	-1,22	-1,50	-1,67	-3,13	-5,99	-0,39	-1,87	0,75
I10			0,83	12,14	0,52	1,07	0,37	0,70	-1,81	-3,57	-0,58	-3,11	0,85
IND.VAR.	**MKT**	**SMB**	**HML**	**WML**	**LIQ**								

LIQs, both in eq. 2 and 3, is statistically significant in portfolios 1 to 5. Returns and LIQs are positively related. Spread coefficients remain the same or with small changes, as in S2 and S3. Size is affected by spread. In most cases, where LIQs is statistically significant, size becomes insignificant. The only exception is S4, where size has an explanatory power and turns negative. MKT factor does not present large changes. However, there is a small increase so it is strengthened under the presence of LIQs. HML coefficients become less negative and remain statistically significant almost in all cases. S10 is the only portfolio where HML becomes statistically insignificant even with spread having no explanatory power. WML factor is affected and becomes less negative, even when spread is not a statistically significant factor.

The only exceptions are portfolios S9 and S10, where WML coefficients become more negative. The R^2s increase, when LIQs is added in eq.3. In portfolios 1 to 5, where spread has an explanatory power, this increase reaches 4% to 9%. In portfolios 6 to 10, there is still a small increase with the exception of S8. The R^2s are roughly from 54% to 81%.

LIQil shows different results in eq.2 and 3. In eq.2 where we examine LIQil as a free of any influence variable, Amihud Illiquidity ratio is statistically significant only in I4 and I5. In eq. 3, LIQil is statistically significant for portfolios 1 to 5 and for portfolio 10. Hence, LIQil affects, while it is affected by the other factors. However, its positive relation with returns suggested in eq. 2 remains the same for the illiquid portfolios. In I10 Amihud Illiquidity ratio is negatively related with returns. MKT factor under the presence of LIQil is strengthened for all illiquid portfolios. For liquid portfolios, where LIQil has no explanatory power, again except I10, market factor is either weakened (I8-I10) or strengthened (I6-I7). Similar with the results of spread, wherever LIQil is statistically significant size becomes statistically insignificant. No exceptions made. An interesting case, are portfolios 6 and 9. In I6 where Amihud Illiquidity ratio has no explanatory power, size factor strengthens. In I9 even though again Amihud Illiquidity ratio is of no significance, size becomes statistically significant. HML factor still has an explanatory power in portfolios 1 to 5, where LIQil is statistically significant. Its coefficients become less negative, with the exception of portfolio 5 where the results suggested are the opposite. The same case appeals in I6, which is the first liquid portfolio and LIQil is statistically significant, and I8. WML factor is affected and for portfolios 1 to 5 its coefficients become less negative. For the rest, even for I10, WML coefficients become more negative. The R^2s have a clear pattern, when Amihud Illiquidity ratio has an explanatory power. They show an increase of 1% to 4%. For the rest, there is no clear pattern except portfolio I10, where LIQil is statistically significant, and presents an increase of roughly 2%. The R^2s are roughly from 53% to 85%.

Volume liquidity measure has the same performance as Amihud Illiquidity ratio under the influence of the other four factors. In eq. 2, LIQv has an explanatory power for V5 to V10. In eq.3, LIQv is statistically significant for V3 to V10. However, volume in both cases is negatively related with returns. MKT factor in all portfolios show significant changes. All coefficients are smaller and hence MKT factor is weakened by the presence of LIQv. In contrast with our previous results, size factor remains or even becomes statistically significant, when volume has an explanatory power. The same appeals for V1 and V2, where volume is statistically significant. The only exception is the most liquid portfolio. The main result is that size strengthens when volume is statistically significant. The most illiquid portfolio and the most liquid have the opposite results. In V1 size weakens while in V10 it becomes statistically insignificant. We have to note that V10 is the only portfolio where size is negatively related with returns (eq. 4). HML factor, almost in all cases, remains statistically significant. In V5, HML factor is the only case where it becomes statistically insignificant. Its coefficients show great changes. They are still negative but they appear to have a weaker negative effect on returns. WML coefficients, under the presence of LIQv, have a weaker negative impact on returns. The same result appeals for V2, whereas in V1 the opposite case exists. The R^2s increase for V3 to V10 from 1% to 10%. Without volume having an explanatory power, there is a small decrease of max. 0,2%. The R^2s are roughly from 42% to 85%.

Similar to spread results, turnover is statistically significant in T6 to T10 both in eq.2 and 3. LIQt is negatively related with returns. In most cases, with the exception of the most illiquid portfolio (T1), MKT factor gets weaker. Its coefficients' changes are larger than in any other liquidity measure. In T7 to T10 size factor becomes statistically significant, whereas in eq. 4 it appears to have no explanatory power. In portfolios where size is statistically significant, its effects get stronger even in cases where LIQt has no explanatory power. HML has no explanatory power in any of the eq. 3 and 4. WML factor has less negative coefficients in T2 to T10. In T1, WML appears to have a more negative impact on returns. The R^2s either remain unchanged or increase from roughly 1% to 10%. They are roughly from 50% to 75%.

Comparing liquidity measures results

Spread and turnover are both statistically significant in the same portfolios suggested by their respective eq. 2. Amihud Illiquidity ratio and volume seem to be affected by the other four factors, since in eq. 3 new portfolios are added when we examine their statistical significance. All liquidity measures provide us with R^2s of 85%, whereas turnover is the only liquidity proxy for which R^2 is roughly 75%. Amihud Illiquidity ratio is the only measure with a sign change. Mainly, spread and

Amihud Illiquidity ratio are positively related with returns, while volume and turnover are negatively related with returns. Model's performance (eq.3) is in all cases increased from 1% to 10%. Hence, we could note that adding either one of the four liquidity measures improves the overall explanatory power of the model itself.

For turnover's portfolios the only factors that seem to explain returns, beside liquidity, are MKT and WML factors. For all the other portfolios, more or less, size and book-to market equity appear to have some explanatory power. Size is the factor mostly affected by liquidity. In most cases under the presence of liquidity, size becomes statistically insignificant.

Spread and Amihud Illiquidity ratio are both statistically significant for portfolios 1 to 5, portfolios of illiquidity. Turnover is statistically significant for liquid portfolios, portfolios 6 to 10. Volume affects returns in both illiquid and liquid portfolios, portfolios 3 to 10. MKT factor weakens when turnover and volume are statistically significant. On the opposite hand, it strengthens when spread and Amihud Illiquidity ratio affect returns.

If we were to rank the liquidity measures chosen, based on their respective R^2s levels, the first measure that best improves the model's explanatory performance would be Amihud Illiquidity ratio. In Goyenko, Holden and Trzcinka (2009), the Amihud (2002) measure is found to be among the best price impact measures. It appears to have the highest levels of R^2s. the second one would be spread proxy. It starts with a R^2 of 54,6% and its highest value is 81,6%. Volume has a maximum R^2 of 85,07% in V10. However, it appears to have quite lower R^2 in illiquid portfolios, than those in spread. Hence, we believe that spread's overall performance is better than volume's. We have to note that, Amihud Illiquidity ratio and spread are the most commonly used proxies in recent literature.

Hansen's Stability Test:

In order to assess whether there is a structural break in our estimates, we used Hansen's stability test. The test is of the null hypothesis of constant parameters against the alternative that parameters follow a martingale. The analysis includes both static and dynamic regressions for no serial treatment of lagged dependent variables is required. It excludes non stationary regressors. The test is not designed for determining the timing of a structural break. Note that, if a large number of parameters are estimated, it should not be surprising to find a small number of significant test statistics for individual instability. The joint significance test is more reliable guide in this context. In case of instability, there might be omitted variables that induce parameter variation. The coefficients provided by the test are the same obtained by our initial regressions. The results for the third and fourth equations are presented below.

The third equation has LIQ as an independent variable. Based on the critical values given by Bruce E. Hansen the Joint LC has a critical value of 1,68 (n = 6)[7]. For the individual LCs the critical value is 0, 47 (n = 1). We have excluded from the table below all the individual LCs that do not exceed its critical value.

	Joint LC		MKT	SMB	HML	WML	LIQ
S1	2,71	**not stable**				1,28	
S2	1,93	**not stable**					0,61
S3	1,79	**not stable**				0,59	
S4	2,60	**not stable**				0,67	0,77
S5	2,24	**not stable**				0,49	0,52
S6	1,88	**not stable**					
S7	1,56	**stable**			0,52	0,53	
S8	1,93	**not stable**				0,78	0,50
S9	2,39	**not stable**				1,07	0,50
S10	2,04	**not stable**				1,03	
	Joint LC		**MKT**	**SMB**	**HML**	**WML**	**LIQ**
V1	3,19	**not stable**		0,48	0,77	0,21	
V2	1,26	**stable**					
V3	1,34	**stable**				0,56	
V4	2,05	**not stable**					
V5	2,08	**not stable**				1,05	
V6	1,37	**stable**					
V7	1,30	**stable**					
V8	1,66	**stable**				0,48	
V9	2,26	**not stable**				1,32	
V10	2,89	**not stable**				1,55	
	Joint LC		**MKT**	**SMB**	**HML**	**WML**	**LIQ**
T1	1,02	**stable**					
T2	1,99	**not stable**				0,69	0,86
T3	1,75	**not stable**				0,61	0,69
T4	1,72	**not stable**				0,69	

[7] N = m+1, level of confidence a=5%

T5	2,39	**not stable**			0,55		
T6	1,68	**stable**			0,55		
T7	1,12	**stable**					
T8	1,30	**stable**			0,54		
T9	2,54	**not stable**	0,55			0,67	
T10	2,09	**not stable**	0,66			1,18	1,38
	Joint LC		**MKT**	**SMB**	**HML**	**WML**	**LIQ**
I1	2,60	**not stable**		0,79	0,52		
I2	2,82	**not stable**			0,66		
I3	2,45	**not stable**					
I4	1,87	**not stable**				0,59	
I5	3,17	**not stable**	0,56		0,92		
I6	2,59	**not stable**			0,73		
I7	3,39	**not stable**			0,91		
I8	2,40	**not stable**				0,82	
I9	2,46	**not stable**				0,68	
I10	2,35	**not stable**				0,90	

The fourth equation is the four factor model, without LIQ. Based on the critical values given by Bruce E. Hansen the Joint LC has a critical value of 1,47 (n = 5). For the individual LCs the critical value is 0, 47 (n = 1). We have excluded from the table below all the individual LCs that do not exceed its critical value.

	Joint LC		**MKT**	**SMB**	**HML**	**WML**
S1	2,21	**not stable**			0,90	0,90
S2	1,95	**not stable**				
S3	1,59	**not stable**				
S4	3,62	**not stable**			0,74	
S5	3,23	**not stable**			0,87	
S6	1,61	**not stable**				
S7	1,69	**not stable**			0,75	0,51
S8	1,83	**not stable**				0,74
S9	2,31	**not stable**				1,06
S10	1,96	**not stable**				1,04
	Joint LC		**MKT**	**SMB**	**HML**	**WML**
V1	3,08	**not stable**		0,49	0,72	2,07
V2	1,24	**stable**				
V3	1,16	**stable**				0,55
V4	1,84	**not stable**				
V5	2,36	**not stable**				0,83
V6	2,80	**not stable**			0,52	
V7	2,44	**not stable**			0,64	
V8	3,03	**not stable**			0,71	

V9	2,23	**not stable**			0,74	0,79
V10	2,55	**not stable**				1,32
	Joint LC		**MKT**	**SMB**	**HML**	**WML**
T1	0,58	**stable**				
T2	1,62	**not stable**				0,66
T3	1,50	**not stable**				0,60
T4	1,73	**not stable**				0,66
T5	2,26	**not stable**			0,61	
T6	1,74	**not stable**			0,60	
T7	0,91	**stable**				
T8	1,18	**stable**			0,54	
T9	2,31	**not stable**	0,61			
T10	1,55	**not stable**	0,48			0,85
	Joint LC		**MKT**	**SMB**	**HML**	**WML**
I1	2,11	**not stable**	0,49	0,68	0,52	
I2	2,53	**not stable**			0,49	
I3	2,73	**not stable**				
I4	1,89	**not stable**				
I5	3,20	**not stable**			0,87	
I6	2,32	**not stable**			0,73	
I7	3,25	**not stable**			0,91	
I8	1,79	**not stable**				0,86
I9	2,24	**not stable**				0,77
I10	2,22	**not stable**				1,12

If we compare the two tables, one could see the following main changes:

- When LIQ (proxied by Spread) is a variable we have one portfolio stable, otherwise none.
- When LIQ (proxied by Volume) is a variable we have 5 portfolios stable, otherwise two.
- When LIQ (proxied by Turnover) is a variable we have 4 portfolios stable, otherwise three.
- When LIQ (proxied by Amihud Illiquidity Ratio) none portfolio in both equations is stable.

Chow Test

The presence of LIQ factor seems to stabilize the whole model. Since none of the Amihud Illiquidity portfolios is stable we performed a Chow test8 to see whether there is a structural break. The date we assume to have this structural change is September 2008. For the third equation all portfolios seem to have a structural break except portfolios I4 and I3. However, for the fourth regression the only portfolio with no structural break is I4. This change in I3 portfolio could be based on LIQ factor. In equation (4) LIQ is not included, hence any explanatory power or impact is included in the regression's residuals. By adding LIQ factor in equation (3), its explanatory power is now apparent in its coefficient and not in the residuals.

Quantile Regressions

Finally, we performed quantile regressions for equations (3) and (4) in order to see which variables have an explanatory power in the quantiles examined. We choose three quantiles 0.05, 0.5 and 0.9.

Quantile regression 0.05 for eq.(3) and (4)					
	MKT	**SMB**	**HML**	**WML**	**LIQ**
Si portfolios	100%	10%	40%	20%	10%
Ti portfolios	90%	40%	30%	40%	40%
Vi portfolios	80%	70%	30%	60%	70%
Ii portfolios	100%	40%	50%	50%	30%
	MKT	**SMB**	**HML**	**WML**	
Si portfolios	100%	40%	60%	30%	
Ti portfolios	100%	30%	30%	80%	
Vi portfolios	90%	40%	30%	60%	
Ii portfolios	100%	50%	60%	50%	

The table above presents the results from quantile regression 0.05 for equations (3) and (4). We expressed the times each independent variable is statistically significant in percentages (e.g. MKT factor is statistically significant in all ten Spread portfolios).

S4 is the only portfolio that has a statistically significant LIQ factor. The same portfolio has a statistically insignificant SMB and WML factor in eq. (3), whereas in

[8] We use a confidence level of 5%. Chow test null hypothesis: no breaks at specified breakpoints.

eq. (4) these factors are statistically significant. It seems like LIQs absorbs explanatory power from these factors, mainly from SMB factor which has a correlation coefficient with LIQS of |0,77|. In turnover portfolios the greater change is presented in WML factor. Its greater correlation is with LIQt factor |0.5|. In volume portfolios MKT appears to have the lowest percentage of all portfolios. LIQv on the other factor has the highest frequency of statistical significance. SMB factor is highly correlated with LIQv and as it is presented above LIQv follows SMB's significance. In Amihud Illiquidity ratio portfolios we do not see drastic frequency's changes. We have to note that LIQ is statistically significant mainly in Medium and High liquidity portfolios in quantile 0.05. With the exception of spread portfolios, LIQ is negatively related with excess returns.

Quantile regression 0.9 for eq.(3) and (4)					
	MKT	SMB	HML	WML	LIQ
Si portfolios	100%	0%	20%	70%	50%
Ti portfolios	100%	40%	0%	90%	50%
Vi portfolios	90%	80%	10%	80%	50%
Ii portfolios	100%	0%	10%	100%	40%
	MKT	**SMB**	**HML**	**WML**	
Si portfolios	100%	50%	60%	90%	
Ti portfolios	100%	30%	0%	90%	
Vi portfolios	100%	50%	20%	90%	
Ii portfolios	100%	40%	10%	90%	

The table above presents the results from quantile regression 0.9 for equations (3) and (4). LIQ factor is has a higher frequency of statistical significance with the exception of volume portfolios. Its frequency remains more or less at the same level throughout all liquidity measures. In spread portfolios LIQs absorbs explanatory power from all factors, especially from SMB factor which remains statistically insignificant in all spread portfolios. In turnover portfolios, we do not have drastic changes hence we could say that LIQ factor works as a complimentary factor and do not absorb any explanatory power from other variables. In volume portfolios LIQ appears to strengthen the presence of SMB. In Amihud Illiquidity ratio portfolios we can see again that LIQ factor absorbs all the explanatory power from the SMB factor with which it is strongly correlated. We have to note that LIQ seems to have a pattern in its statistical significance. In spread and Ammilud Illiquidity ratio portfolios, LIQ factor is statistically significant in Low and Medium liquidity portfolios. On the other hand, in turnover and volume portfolios LIQ factor is statistically significant in Medium and High liquidity portfolios. The same pattern appeals in LIQ's signs. It is positively related with excess returns in spread and Amihud portfolios, whereas it is negatively related with excess returns in turnover and volume portfolios.

Quantile regression 0.5 was mainly used to see whether it resembles[9] our initial estimations. In 35% of all 40 portfolios, quantile regression 0.5 resembles the initial estimation of equation (3). In 55% of all 40 portfolios, quantile regression 0.5 resembles the initial estimation of equation (4). All quantile regressions resemble the initial estimation of equation (4) in portfolios S2, T7, T9 and T10. In 53% of all 40 portfolios, none quantile regression resembles the initial estimation of eq. (3). In 23% of all 40 portfolios, none quantile regression resembles the initial estimation of eq. (4).

Another interesting case is that a constant term appears to be statistically significant in quantiles 0.05 and 0.9. In eq. (3) the only portfolios without this constant are portfolios S3, S4 and T4, while in eq. (4) the only portfolio without a constant is I4. Both in eq. (3) and (4) the constant term of 0.05 quantile regression is negative probably suggesting a panic attack. On the contrary, in 0.9 quantile regression the constant term is positive probably suggesting euphoria.

CONCLUSION:

We examine the role of liquidity in asset pricing four factor model, using time-series regressions. The role of liquidity is examined as a free of any influence variable, as well as in combination with other well-known risk factors: market, size, book-to market equity and momentum.

We employ four liquidity proxies in our analysis: Amihud Illiquidity ratio, spread, volume and turnover. The time-series regressions are estimated with monthly data from July 2000 to June 2012. For every regression, we from 18 portfolios sorted independently for size, book-to market equity and momentum. For the liquidity proxies, we formed 10 portfolios. We present all the relevant results for all liquidity measures.

[9] When we refer to resemblance we refer to the factors' statistical significance.

The main finding of our time-series regressions is that liquidity is priced and is related with returns, either in a positive or negative manner. In contrast to the results of Keene and Peterson (2007), we find that both liquid and illiquid stocks are affected in the same way. We have no proof of sign changes from illiquid to liquid portfolios. Liquidity seems to explain returns in minimum half of the portfolios created, regardless of the liquidity measure used.

An interesting case is that liquidity, when proxied by Amihud Illiquidity ratio or spread is affected by the other four risk factors. Similar to the results of Keene and Peterson (2007), size is correlated with almost all liquidity measures. In most cases, size becomes statistically insignificant when liquidity has an explanatory power. In contrast with previous studies (Chan & Faff, 2002), momentum factor is negatively related to stocks returns. However, liquidity makes momentum's effect less negative. A possible explanation for this is the construction of the WML factor. It is based on average returns and probably the majority, of these average returns, is negative. MKT factor has the largest t-stat values suggesting that its presence remains the most important one since it represents the market itself.

In order to assess the model's stability, we performed Hansen's stability test. Under the presence of LIQ factor, some cases of instability are eliminated. By performing the Chow test in Amihud Illiquidity portfolios, which were unstable in both eq. (3) and (4), we find a structural break in September 2008. Finally, our quantile regressions reveal some interesting results:

1. LIQ is statistically significant mainly in Medium and High liquidity portfolios in quantile 0.05. With the exception of spread portfolios, LIQ is negatively related with excess returns.

2. For quantile 0.9, in spread and Ammilud Illiquidity ratio portfolios, LIQ factor is statistically significant in Low and Medium liquidity portfolios. On the other hand, in turnover and volume portfolios LIQ factor is statistically significant in Medium and High liquidity portfolios. The same pattern appeals in LIQ's signs. It is positively related with excess returns in spread and Amihud portfolios, whereas it is negatively related with excess returns in turnover and volume portfolios.

3. Both in eq. (3) and (4) the constant term of 0.05 quantile regression is negative probably suggesting a panic attack.

4. On the contrary, in 0.9 quantile regression the constant term is positive probably suggesting euphoria.

The presence of liquidity in the model alters the effect of the other factors. We find evidence that it is also affected by them too. All R^2s are increased, when we add liquidity as an independent variable. Thus, we could state that liquidity might be a missing variable from the augmented four factor pricing model. However, as Kuan-Hui Lee (2006) states, results vary to the liquidity measures used, to the test methodology employed, to the test assets and to the weighting scheme.

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