Chapter 6

Systematic Liquidity Risk and Stock Price Reaction to Large One-Day Price Changes

6.1. Introduction

The efficient market hypothesis is challenged by numerous price anomalies. Investors' overreactions and underreactions are perhaps the most important anomalies that have received attention in the last twenty years. The overreaction hypothesis assumes a tendency of the investor to overweigh new information, resulting in a price reversal when the market corrects itself. However, the underreaction hypothesis is based on assuming a tendency of the investor to underweigh the new information signals, causing significant return continuation. Under both hypotheses, investors can make use of past historical returns to predict future prices and achieve abnormal returns.

DeBondt and Thaler (1985) are the first to propose the overreaction hypothesis. They argue that investors tend to overweight recent information, causing security prices to deviate from their fundamental values. Specifically, DeBondt and Thaler (1985) find that stocks that performed badly over the past three to five-year period (losers) tend to outperform prior period winners over the following three to five years. Succeeding studies that have followed the core study of DeBondt and Thaler (1985) confirm the evidence of the overreaction hypothesis (see, for example, Howe, 1986; Chopra et al., 1992). Lehman (1990) finds consistent evidence of price reversal over the short-run, specifically, one week after the portfolio formation. Another set of studies uncover opposite patterns of stock returns. Jegadeesh and

Titman (1993, 2001), Rouwenhorst (1998a, b), Liu et al. (1999), Griffin et al. (2003) and others find significant return continuation over short and medium terms (up to one year).

While most of the previously mentioned studies investigate the abnormal returns of losers and winners following DeBondt and Thaler's (1985) methodology, another cluster of studies use an event analysis. Indeed, Bremer and Sweeney (1991), Lasfer et al. (2003) and Spyrou et al. (2007) use a methodology based on calculating the cumulative abnormal returns of stocks after large one-day price shocks. Whilst Bremer and Sweeney (1991) find significant price reversals up to two days after large negative shocks, Lasfer et al. (2003) and Spyrou et al. (2007) find significant return continuations of stock market indices in the days following both negative and positive shocks.

Researchers raise many explanations to rationalise the observed price reversals and return continuations. Zarowin (1990) argue that overreaction is a demonstration of the size anomaly[1]. Chan (1988), Ball and Kothari (1989), Wu (2002) and Wang (2003) argue that markets are efficient and the observed abnormal returns are due to the failure to adjust for time-varying risk. A number of studies find that the abnormal returns are not large enough to cover the transaction cost of trading (see, for example, Atkins and Dyi, 1990; Cox and Peterson, 1994; Li et al., 2008). Moskowitz and Grinblatt (1999) demonstrate that industry effects[2] explain the

[1] Banz (1981) is the first to recognise the size anomaly. He finds that small firms yield higher risk-adjusted returns, on average, than large firms.
[2] Moskowitz and Grinblatt (1999) explain that investors may herd towards (away from) hot (cold) industries, causing price pressure that could create return continuation.

individual stock momentum (return continuation). Daniel et al. (1998), Barberis et al. (1998) and Hong and Stein (1999) employ psychological concepts such as overconfidence, biased self-attribution, conservatism and representativeness to validate the investor behaviour in response to new information signals.

This study suggests another plausible explanation for the observed abnormal returns following large one-day price shocks. Systematic liquidity risk is the new factor that we propose as a competing rationalisation of the overreaction and underreaction hypotheses. Our proposition is motivated by the recent evidence of the significant role of systematic liquidity risk in asset pricing. Pastor and Stambaugh (2003), Martinaiz et al. (2005) and Liu (2006) argue that the covariation between stock return and overall market liquidity represents a systematic risk found to be priced in financial markets. We argue that the different price reaction to large one-day price shocks between stocks may be explained by the variations in their systematic liquidity risk level. In particular, we expect the stocks with high sensitivity to the fluctuations in aggregate market liquidity to be more affected by price shocks. Liu (2006) finds that a liquidity augmented CAPM explains the cross-section of asset returns relatively well. In particular, the liquidity augmented CAPM is reported to be able to explain liquidity risk premium and other anomalies related to size, book to market ratio, cash flow to price ratio, dividend yield and long-term contrarian investment strategy. Sadka (2006) decomposes the liquidity risk, which is measured by the price impact of trades, into variable and fixed components. He finds that the systematic variations in the variable component are important for asset pricing. Specifically, Sadka (2006) argues that a substantial part of momentum returns can be viewed as compensation for unexpected variations in the aggregate ratio of informed traders to noise traders and the quality of information possessed by the informed traders. Lasfer et al. (2003) and Mazouz et al. (2009) have implicitly examined the role of liquidity measured by market capitalisation in explaining abnormal returns following large one-day price shocks. Lasfer et al. (2003) find that smaller capitalisation markets take longer to absorb price shocks. Consequently, the post-shock cumulative abnormal returns are more manifest in those markets. Mazouz et al. (2009) find that large capitalisation stocks react efficiently to both positive and negative shocks. Finally, Atkins and Dyi (1990), Cox and Peterson (1994) and Park (1995) link the short-term stock price reaction to the bid-ask spread bounce. They find that the abnormal returns following large one-day price changes do not cover the transaction price movement between the bid- and ask- prices. The findings of all those researchers which indicate the importance of liquidity in asset pricing have motivated us to examine explicitly the role of systematic liquidity risk in explaining the stock price reaction to large one-day price changes.

Our methodology is based on comparing the reaction of stocks with different levels of systematic liquidity risk to large one-day price changes. Specifically, we sort stocks according to their historical liquidity betas and assign them to ten portfolios ranging from the most liquid to the least liquid. We examine the abnormal returns of the stocks in these portfolios after large price shocks. The abnormal returns are defined as the residuals from the four-factor model consisting of the three Fama and French (1993) common risk factors and the momentum factor of Carhart (1997). We define positive price shocks for each stock as the abnormal returns of 5%, 10% and 20% or more, while negative price shocks are defined as the abnormal returns of -5%, -10% and -20% or less.

Our sample consists of 642 stocks of the FTSEALL share index constituents' list of February 2008. The analysis covers the period 1st July 1992 to 29th June 2007. We apply three liquidity measures reflecting three different aspects of liquidity. These measures are the proportional quoted bid-ask spread, the illiquidity ratio of Amihud (2002) and the turnover rate. The proportional quoted bid-ask spread is a proxy of the transaction cost, the illiquidity ratio measures the price impact of order flow and the turnover rate represents a proxy for the trading activity.

We uncover evidence in favour of the uncertain information hypothesis of Brown et al. (1988) in FTSEALL share index stocks. Specifically, positive one-day price shocks of different trigger values are followed by significant return continuations in the next few days. In contrast, negative one-day price shocks are followed by delayed price reversals that exist up to 10 days after the shock. This evidence opposes the findings of Lasfer et al. (2003) and Spyrou et al. (2007) who document significant return continuations following both positive and negative shocks in the short run.

Most importantly, strong evidence of the role of the systematic liquidity risk in explaining the price reaction to extreme events is detected. We find that the stocks with the highest systematic liquidity beta, the least liquid stocks, lead the abnormal reaction to both negative and positive shocks. Thus, in most cases, the most liquid stocks react efficiently to positive and negative shocks of different trigger values. This suggests that the price anomalies following large one-day price changes can be explained, at least partially, by the systematic liquidity risk. Thus, the variations in systematic liquidity risk level between stocks explain their different price reactions to shocks. The evidence is stronger when the proportional bid-ask spread and Amihud's (2002) illiquidity ratio are used as liquidity proxies than when liquidity is measured by the turnover rate. A five-factor model, which includes the three factors of Fama and French (1993), the momentum factor of Carhart (1997) and a systematic liquidity risk factor, does not explain away the abnormal returns following shocks. Specifically, the anomalous behaviour of the least liquid stocks following large price shocks continues to exist even after adjusting their returns to the systematic liquidity risk. This finding may be explained in two possible ways: (i) systematic liquidity risk can partially but not fully explain the abnormal reaction of stocks to large price shocks, or (ii) the way we account for the systematic liquidity risk may not be appropriate. Thus, the abnormal returns may be the result of the biases arising from using the static versions of the asset pricing models. Dynamic versions of the liquidity augmented asset pricing models may fix the pricing errors of the static models and clear the documented abnormal returns following large one-day price changes. We will return to this issue in the next chapter.

The sub-period analysis shows that the results are time-varying. This may be expected since market liquidity tends to improve over time as a result of developing new trading systems and increasing the numbers of companies and investors. However, the most liquid stocks react differently from the least liquid to the large one-day price changes in most of the sub-periods. This reflects the ability of the most liquid stocks to absorb the price shocks efficiently. On the other hand, the least liquid stocks take several days to absorb these shocks, resulting in significant abnormal returns.

The rest of this chapter is organised as follows. Section 6.2 describes our methodology, Section 6.3 reports our empirical findings and we conclude in Section 6.4.

6.2. Methodology

The methodology of this chapter is presented in three sections. Section 6.2.1 describes the estimation of the average cumulative abnormal returns (CAARs) following large one-day price changes. Section 6.2.2 explains the estimation of the CAARs of stocks in the liquidity-sorted portfolios. Finally, Section 6.2.3 shows the way we adjust the CAARs for systematic liquidity risk.

6.2.1. Average cumulative abnormal returns (CAARs)

We examine the short-run price reaction of all FTSEALL share index stocks following large one-day price change over the period 1st July 1992-29th June 2007. The excess returns of each stock are regressed on the three factors of Fama and French (1993) and the momentum factor of Carhart (1997). The regression is re-estimated annually and only stocks with continuing returns throughout the estimation period are considered. The total number of stocks that we have examined ranges between 270 stocks in 1992 and 520 in 2007. The Ordinary Least Squares (OLS) is used as an estimator with the Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity[1].

[1] The OLS-estimated Carhart (1997) four-factor model is found to be the best model in explaining the cross-section of stock returns in Chapter 5 of the thesis. Specifically, it is better than the CAPM and the three-factor model of Fama and French (1993) in terms of many criteria such as adjusted R squared and Akaike information criteria. Additionally, the OLS is found to yield better results than the GARCH models.

$$(R_{i,t} - R_{f,t}) = \alpha_i + \beta_{mkt,i} MKT_t + \beta_{hml,i} HML_t + \beta_{smb,i} SMB_t + \beta_{mom,i} MOM_t + \varepsilon_{i,t} \tag{6.1}$$

where $R_{i,t}$ is the return on stock i on day t. $R_{f,t}$ is the risk free rate of return on day t. MKT_t is the excess market rate of return. HML_t is the High Minus Low factor of Fama and French (1993), defined as the difference in returns between value and growth stocks. SMB_t is the Small Minus Big factor of Fama and French (1993), defined as the difference in returns between small- and large-sized stocks. MOM_t is the momentum factor of Carhart (1997), constructed as the difference in returns between stocks with high prior returns and stocks with low prior returns. $\varepsilon_{i,t}$ is the residual (error term) of stock i on day t. Details of constructing these variables are found in Chapter 5, Section 5.3.3.1.

The residuals of each regression represent the daily abnormal returns of the underlying stock for that year. Lasfer et al. (2003) and Spyrou et al. (2007) define the abnormal return as the difference between the actual daily return and the average return of a 50-day window ending 10 trading days prior to the price shock. However, Mazouz et al. (2009) define abnormal returns as the residuals from three competing models, which are the capital asset pricing model (CAPM), the Fama and French (1993) model (F&F) and the four-factor model of Carhart (1997) (C-F&F). Following Mazouz et al. (2009), we compute abnormal returns for a stock i on day t (or $AR_{i,t}$) as follows:

$$AR_{i,t} = R_{i,t} - \left(\alpha_i + \beta_{mkt,i} MKT_t + \beta_{hml,i} HML_t + \beta_{smb,i} SMB_t + \beta_{mom,i} MOM_t\right) \tag{6.2}$$

We calculate the cumulative abnormal returns $CAR_{i,d}$ for stock i over a window of d days starting one day after a shock as:

$$CAR_{i,d} = \sum_{t=1}^{d} AR_{i,t} \tag{6.3}$$

The cumulative abnormal returns are computed for up to 10 days after a price shock. We follow previous studies in defining our price shocks. Howe (1986) defines the shock in any day as the rise or fall in stock price by more than 50%. Atkins and Dyi (1990) choose three stocks with largest one-day loss or gain in price on 300 trading days selected randomly. Bremer and Sweeny (1991) and Cox and Peterson (1994) define a shock as the one-day price decline of 10% or more. Park (1995) defines a shock day as the day in which market adjusted abnormal return rises or falls by 10% or more. Brown et al. (1998) consider the one-day change in (market model) residual returns in excess of 2.5%(in absolute value) as a price shock. Lasfer et al. (2003) and Spyrou et al. (2007) define the positive (negative) price shock as "the one where the return on a particular day is above (below) two standard deviations the average market daily return computed over [60 to 11] days relative to the day of the price shock". Mazouz et al. (2009) define shocks with trigger values of $\pm 5\%$, $\pm 10\%$ and $\pm 20\%$. Consistently, we define positive price shocks as the abnormal returns of 5%, 10% and 20% or more, while negative price shocks are defined as the abnormal returns of -5%, -10% and -20% or less. To avoid any confounding effects, we consider only one shock within a range of 10 days.

The average cumulative abnormal return associated with N stocks over a window of d days following a shock is calculated as:

$$CAAR_d = \frac{\sum_{i=1}^{N} CAR_{i,d}}{N} \tag{6.4}$$

The significance of the $CAAR_d$ is determined by using the t-test adjusted to serial correlation and heteroskedasticity by using Newey-West HAC Standard Errors & Covariance. According to the central limit theorem, if the number of CARs exceeds 30, then normality is assumed and the parametric t-test can be used. However, if the number of CARs is less than 30, then the non-parametric sign test is used to judge the significance of the average cumulative abnormal returns.

6.2.2. CAARs of stocks in liquidity sorted portfolios

We test whether systematic liquidity risk can explain the abnormal returns following a large one-day price shock. At 1st July each year starting from 1992, we use a liquidity augmented asset pricing model to estimate the historical liquidity beta of each stock in the sample, using the most recent five years' daily return data. The liquidity augmented asset pricing model consists of the three common risk factors of Fama and French (1993), the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). The Ordinary Least Squares (OLS) is used as an estimator with the Newey-West HAC Standard Errors & Covariance to account for serial correlation and heteroskedasticity. After the estimation is completed, we sort stocks according to their historical liquidity betas and assign them to decile portfolios. The process is repeated annually. We use three liquidity measures: the proportional bid-ask spread, the turnover rate and the Amihud (2002) illiquidity ratio. Thus, we do three different sorts according to each of the three liquidity measures. Next, we use equations (6.2) and (6.3) to calculate the abnormal returns $AR_{i,t}$ and the cumulative abnormal returns $CAR_{i,d}$ of each stock in each portfolio. In this case, we calculate the average cumulative abnormal return for each portfolio separately. Thus:

$$CAAR_d = \frac{\sum_{i=1}^{n} CAR_{i,d}}{n} \quad (6.5)$$

where n is the number of stocks in a certain portfolio and d is the number of days following a shock.

6.2.3. Liquidity-adjusted CAARs

As a further step, we investigate whether systematic liquidity risk can *fully* explain the abnormal returns following the one-day price shocks. We estimate the abnormal returns from three competing models as follows:

$$AR_{i,t} = R_{i,t} - (\alpha_i + \beta_{mkt,i} MKT_t + \beta_{hml,i} HML_t + \beta_{smb,i} SMB_t + \beta_{mom,i} MOM + \beta_{pspr,i} LIQ_t) \quad (6.6)$$

where LIQ_t is a mimicking market liquidity factor measured using three different proxies which are proportional quoted bid-ask spread ($PSPR_t$), turnover rate (TO_t) and Amihud's (2002) illiquidity ratio (AM_t).

Thereafter, we repeat the whole analysis in Section 6.2.2 using the new abnormal returns. If systematic liquidity risk can *fully* explain the abnormal returns following the one-day price shocks, then no significant abnormal returns should be found for all stocks in all portfolios after incorporating the liquidity factor in our analysis. Further, we test whether any significant statistical differences exist in the CAARs before and after incorporating the systematic liquidity factor, using Wilcoxon Signed Ranks test. This test is a non-parametric test of the differences between two related samples. The null hypothesis of the test assumes no significant differences between the CAARs before and after incorporating the mimicking liquidity factor[1].

[1] Details of the Wilcoxon Signed Ranks test are in Appendix D.2.

6.3. Empirical findings

6.3.1. Descriptive statistics

We analyse the reaction of FTSEALL share index stocks to one-day price shocks over the period 1st July 1992 to 29th June 2007. The analysis includes only the stocks with continuing returns on an annual basis. The total number of stocks examined ranges between 270 stocks in 1992 and 520 in 2007. Table 6.1 shows that the positive shocks are more common than negative. The total number of positive shocks at trigger values of 5%, 10% and 20% are 11140, 2036 and 249, respectively. However, the total number of negative shocks at trigger values of -5%, -10% and -20% are 8345, 1567 and 311, respectively.

6.3.2. Stock price reaction to large one-day price changes

Table 6.1 presents the CAARs for all sample stocks over the entire study period. Our evidence supports the uncertain information hypothesis of Brown et al. (1988). There is an asymmetric price reaction to positive and negative shocks. Positive price shocks are followed by significant return continuations that extend to several days, depending on the size of the shock. Specifically, the continuations persist up to 10 days subsequent to shocks of 5% or more, 3 days subsequent to shocks of 10% or more and 2 days after shocks of 20% or more. On the other hand, negative price shocks are followed by significant price reversals that start from the 2nd day following shocks of -5% and -10% or less and from the 3rd day following shocks of -20% or less and extend to 10 days. Thus, investors underreact to good news and overreact to the bad news. These results contradict the findings of Lasfer et al. (2003), Spyrou et al. (2007) and Mazouz et al. (2009) who find that investors underreact to both positive and negative shocks in the short run. Specifically, Lasfer et al. (2003) find that investors in both developed and emerging markets realise significant positive (negative) CAARs up to 10 days following positive (negative) price shocks. The observed CAARs are found to be larger in emerging markets. Spyrou et al. (2007) provide evidence consistent with the efficient market hypothesis for the large capitalisation stocks included in FT30 and FTSE100 and consistent with the underreaction hypothesis for the small and medium capitalisation stocks of FTSE250 and FTSE SmallCap, respectively. Mazouz et al. (2009) examine the price reaction of 424 UK stocks following shocks of different trigger values. They find that, regardless of the estimation model and method, shocks of 5% or more are followed by a significant one-day CAAR of 1%, whilst shocks of -5% or less are followed by a significant one-day CAAR of -0.43% for the Single Index and around -0.34% for the other two models, F&F and C-F&F. Thus, Mazouz et al. (2009) argue that investors underreact to positive shocks of all magnitudes and negative shocks of -5% or less. The larger negative shocks are found to be absorbed immediately.

Table 6.1

CAARs of FTSEALL share index stocks

This table presents average cumulative abnormal returns of 642 constituents of the FTSEALL share index from 1st July 1992 to 29th June 2007. Excess returns of each stock are regressed on the three factors of Fama and French (1993) and the momentum factor of Carhart (1997). The regression is re-estimated annually and only stocks with continuing returns throughout estimation period are considered. OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Positive shocks are defined as abnormal returns equal to or above 5%, 10% and 20%. Negative shocks are defined as abnormal returns equal to or under -5%, -10% and -20%. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_t$ is average cumulative abnormal return on a certain day (t) averaged over entire study period. Level of significance of CAARs is estimated using Newey-West t-statistic. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level.

Shocks	**#shocks**	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Shock (5%)	11140	0.0758[a]	0.0065[a]	0.0067[a]	0.0070[a]	0.0063[a]	0.0065[a]	0.0062[a]	0.0054[a]	0.0054[a]	0.0054[a]	0.0054[a]
Shock (-5%)	8345	-0.0785[a]	-0.0001	0.0015[b]	0.0030[a]	0.0038[a]	0.0045[a]	0.0058[a]	0.0063[a]	0.0072[a]	0.0075[a]	0.0077[a]
Shock (10%)	2036	0.1437[a]	0.0097[a]	0.0083[a]	0.0059[a]	0.0032	0.0031	0.0021	0.0005	-0.0002	-0.0007	0.0002
Shock (-10%)	1567	-0.1633[a]	0.0002	0.0055[b]	0.0091[a]	0.0115[a]	0.0138[a]	0.0150[a]	0.0146[a]	0.0162[a]	0.0187[a]	0.0200[a]
Shock (20%)	249	0.2784[a]	0.0182[a]	0.0172[b]	0.0047	-0.0037	-0.0075	-0.0112	-0.0155	-0.0151	-0.0118	-0.0070
Shock (-20%)	311	-0.3193[a]	0.0042	0.0137	0.0263[a]	0.0273[a]	0.0315[a]	0.0358[a]	0.0366[a]	0.0390[a]	0.0394[a]	0.0410[a]

6.3.3. Systematic liquidity risk and price anomalies

This section tests whether systematic liquidity risk explains the documented evidence of the overreaction and underreaction in the FTSEALL share index stocks. The important role of systematic liquidity risk in asset pricing (see, for example, Pastor and Stambaugh, 2003; Liu, 2006) and the asymmetric price reaction to shocks in high liquidity and low liquidity markets (Lasfer et al., 2003) have motivated us to think of a possible role of the systematic liquidity risk in explaining the stock price reaction to large one-day price changes. We start by sorting the sample stocks according to their historical liquidity betas to 10 decile portfolios and examine their reaction to large one-day price change. We do three sorts according to three different liquidity measures: the proportional bid-ask spread, the turnover rate and the Amihud (2002) illiquidity ratio.

Table 6.2 reports the numbers of shocks of liquidity beta sorted portfolios. Specifically, it shows the number of shocks for Port 1, the most liquid, and Port 10, the least liquid (results of remaining Ports 2 to 9 are reported in Appendix B.1). Panel A of Table 6.2 presents the total number of shocks for stocks in the proportional spread portfolios. Over the full period of the study, the numbers of positive and negative shocks are increasing as we move from most liquid to least liquid portfolios. For instance, Port 1 exhibits 856 shocks of 5% or more, while Port 10 displays 2696 analogous shocks. This is the first insight into the role of systematic liquidity in explaining the price reaction to extreme shocks. Smaller shocks of 5% or more are more frequent than larger shocks of 20% or more. One more interesting notice is that positive shocks are more common than negative shocks in LSE. Thus, the number of shocks of 20% or more for Port 10 is 135, whereas the number of shocks of -20% or less for the same portfolio is 98.

Panel B of Table 6.2 shows the total numbers of shocks for stocks in the turnover rate portfolios. Interestingly, over the full period of the study, Ports 1 and 10 show the highest number of shocks at all trigger values. For example, the number of negative shocks of -10% or less for Ports 1 and 10 are 335 and 327, respectively. However, the number of the equivalent shocks for Port 5 is 82. The reason is that Port 1 includes the stocks with the highest negative liquidity betas, while Port 10 consists of the stocks with the highest positive liquidity betas. Thus, when the overall market turnover rate changes, both portfolios will react in a strong manner but in an opposite direction. The strong reaction of these two extreme portfolios may make their number of shocks higher than the portfolios in the middle.

The situation is somehow similar when we look to Panel C of Table 6.2 in which portfolios are sorted according to Amihud's (2002) illiquidity ratio historical liquidity beta. Ports 1 and 10 exhibit the highest numbers of shocks. Port 10 shows a greater numbers of shocks than Port 1 at all trigger values. For instance, Port 1 displays 31 shocks of 20% or more, whereas Port 10 shows 102 equivalent shocks.

Table 6.2

Numbers of shocks of stocks in liquidity beta sorted portfolios

This table presents total number of one-day price shocks of the FTSEALL share index stocks which in turn are assigned to 10 decile portfolios according to historical liquidity beta. Analysis covers 1st July 1992 to 29th June 2007. Positive shocks include price change equal to or above 5%, 10% and 20%. Negative shocks include price change equal to or under -5%, -10% and -20%. Port denotes portfolio. Panel A presents results of portfolios sorted according to historical liquidity beta when liquidity is measured by proportional bid-ask spread. Panel B reports results of portfolios sorted according to historical liquidity beta when liquidity is measured by turnover rate. Panel C shows results of portfolios sorted according to historical liquidity beta when liquidity is measured by Amihud's (2002) illiquidity ratio.

Panel A: Results of proportional spread portfolios						
Port	**5%**	**-5%**	**10%**	**-10%**	**20%**	**-20%**
Port 1	856	673	125	119	14	24
Port 10	2696	2193	767	539	135	98
Panel B: Results of turnover rate portfolios						
Port	**5%**	**-5%**	**10%**	**-10%**	**20%**	**-20%**
Port 1	2223	1782	482	335	52	68
Port 10	1699	1356	444	327	87	62
Panel C: Results of illiquidity ratio portfolios						
Port	**5%**	**-5%**	**10%**	**-10%**	**20%**	**-20%**
Port 1	1796	1420	321	269	31	50
Port 10	2065	1623	555	407	102	73

6.3.3.1. Proportional bid-ask spread portfolios

Panel A of Table 6.3 reports the CAARs of the stocks in the proportional spread Ports 1 and 10, following positive shocks (results of remaining proportional spread Ports 2 to 9 are reported in Appendix B.2). Starting with shocks of 5% or more, all the shocks on day 0 are highly significant, ranging from 6.9% for Port 3 to 8.5%for Port 10. Port 1 (most liquid portfolio) reacts efficiently subsequent to positive price shocks of 5% or more. Hence, no significant CAARs are found up to ten days following these shocks. However, Port 10 (least liquid portfolio) shows a highly significant return continuation up to 10 days following shocks of 5% or more. Thus, it seems that the least liquid portfolios drive the underreaction following positive shocks. Figure 6.1 shows the CAARs of the stocks of the proportional spread portfolios following shocks of 5% or more.

Shocks of 10% or more are highly significant, ranging from 12.9% for Port 2 to 15.4% for Port 10. Port 1 exhibits no significant CAARs subsequent to shocks of 10% or more, confirming the market efficiency hypothesis. However, Port 10 shows significant positive CAARs up to three days following these shocks. Once again, while liquid portfolios confirm the efficient market hypothesis, illiquid portfolios show an underreaction following positive price shocks.

Shocks of 20% or more are highly significant, ranging from 24.4% for Port 7 to 33.2% for Port 5. Since the number of shocks of 20% or more is less than 30 per portfolio for the most liquid portfolios, we depend on the non-parametric sign test when judging the statistical significance of the CAARs of these portfolios. Ports 1, 2, 3 and 4 react in an efficient manner to the shocks of 20% or more. On the other hand, the least liquid portfolio, Port 10, earns a significant positive CAAR of 2.99% two days after shocks of 20% or more.

Panel A of Table 6.4 reports CAARs of the stocks in the proportional spread Ports 1 and 10, following negative shocks (results of remaining proportional spread Ports 2 to 9 are reported in Appendix B.3). In looking at shocks of -5% or less, all the shocks are highly significant, ranging from -7.2% for Port 3 to -8.2% for Port 10. Noticeably, in most cases, Port 10 exhibits the largest shocks at all trigger values. Port 1 shows a significant price reversal in the two days following shocks of -5% or less. However, the least liquid portfolios, namely Ports 9 and 10, continue with a significant loss one day following these shocks and then they take five to six days to reverse their loss. The asymmetric response of liquid and illiquid portfolios to shocks confirms the role of systematic liquidity risk in explaining the price reaction.

Figure 6.4 shows the CAARs of the stocks of the proportional spread portfolios following shocks of -5% or less.

Shocks of -10% or less range from -14.8% for Port 3 to -18.2% for Port 6. The results still confirm the role of systematic liquidity risk in explaining the abnormal returns. The most liquid portfolios, Ports 1 to 4, react efficiently to shocks of -10% or less. Thus, liquid stocks absorb price shocks immediately. Conversely, the CAARs of the least liquid portfolio, Port 10, are significant in days 2 to 10 following shocks of -10% or less. These results are consistent with the prediction of the overreaction hypothesis.

Regarding shocks of -20% or less, the largest shock is -36.3% for Port 8 and the smallest is -24.7% for Port 3. Ports 1, 2, 3 and 4 display no significant CAARs according to the non-parametric sign test following shocks of -20% or less. However, according to the adjusted t-value, Port 10 displays a significant price reversal up to ten days subsequent to these shocks. This represents strong evidence of the asymmetric reaction to price shocks between the liquid and illiquid portfolios, confirming the importance of systematic liquidity in determining the price reaction to extreme shocks. Additionally, the results confirm the investor's overreaction to negative shocks and the underreaction to positive shocks. Indeed, the findings validate the fact that illiquid stocks drive the abnormal reaction to both the positive and negative shocks.

6.3.3.2. Turnover rate portfolios

Panel B of Table 6.3 reports the CAARs of the stocks in the turnover rate Ports 1 and 10, following positive shocks (results of remaining turnover rate Ports 2 to 9 are reported in Appendix B.4). Starting with shocks of 5% or more, the average value of the shocks is in between a low of 7.1% for Port 3 and a high of 8.5% for Port 10. All shocks on day 0 are highly significant. Both liquid and illiquid portfolios exhibit return continuation up to 10 days following shocks of 5% or more. Yet the abnormal returns for the illiquid portfolios are greater in magnitude and level of significance compared to those for the liquid portfolios. See, for example, the CAAR of Port 1 (the most liquid portfolio), one day following the large price increase, is 0.62% with an adjusted t-value of 6.860, while the equivalent CAAR of Port 10 (the least liquid portfolio) is 1.16% and its adjusted t-value is 8.229. This is consistent with the fact that systematic liquidity risk can, at least partially, explain the observed underreaction following positive price shocks.

All shocks of 10% or more are highly significant, ranging from 13.42% for Port 6 to 16.06% for Port 10. Once again, both liquid and illiquid portfolios exhibit return continuations following shocks of 10% or more. However, the abnormal returns continue up to three days following these shocks. The abnormal returns are more pronounced and more significant for the least liquid portfolio than for the most liquid. For example, Port 1 shows a significant CAAR of .93% on day 1 following shocks of 10% or more, while Port 10 shows a CAAR of 1.84% on day 1 following the same shocks. Figure 6.2 shows the CAARs of the stocks of the turnover rate portfolios following shocks of 10% or more.

Shocks of 20% or more are all significant. Port 10 exhibits the largest average shock of 29.5%, while Port 3 shows the lowest average shock of 23.6%. In addition to the adjusted t-test, we also use the non-parametric sign test to judge the significance of the CAARs when portfolios contain fewer than 30 shocks. There is obvious evidence of the difference in reaction between the liquid and the illiquid portfolios to large one-day price changes. Ports 1 and 2, the most liquid portfolios, show no significant CAARs following shocks of 20% or more, indicating an efficient reaction to the shock. However, Port 10, the least liquid portfolio, exhibits a significant return continuation up to two days following these shocks. The CAAR on day 2 is 4.26%. Thus, when liquidity is measured by turnover rate, illiquid portfolios seem to drive the return continuation following positive price shocks.

The situation is different when we look to the price reaction to negative shocks. Panel B of Table 6.4 reports the CAARs of the stocks in the turnover rate Ports 1 and 10, following negative shocks (results of remaining turnover rate Ports 2 to 9 are reported in Appendix B.5). Starting with shocks of -5% or less, the average value of these shocks is between -7.5% for Port 5 and -8.2% for Port 10. All of the shocks are highly significant. The most liquid portfolio reverses loss in 3 days following shocks of -5% or less and continues its price reversal until the tenth day. However, the least liquid portfolio exhibits a significant loss continuation in the first day following these shocks and shows a delayed price reversal starting from day 5 to day 10 after the shock. Thus, the reaction of liquid and illiquid portfolios is asymmetric.

Shocks of -10% or less are all highly significant, ranging from -15.3% for Port 3 to -17.7% for Port 6. All the portfolios show significant positive CAARs on days 3 or 4 to day 10 following shocks of -10% or less. However, the CAARs differ in magnitude and level of significance between the liquid and illiquid portfolios. For instance, the CAAR for the most liquid portfolio on day 4 is 1.54% with an adjusted t-value of 2.521, while it is 1.92% with an adjusted value of 2.882 for the least liquid portfolio. Figure 6.5 shows the CAARs of the stocks of the turnover rate portfolios following shocks of -10% or less.

Shocks of -20% or less are all significant. Surprisingly, Port 1 displays the largest average shock of -34.6%, while Port 10 displays the smallest average shock of -30.0%. The most liquid portfolios react clearly in a different manner from the least liquid portfolio. While Port 10, the least liquid portfolio, displays a significant price reversal from day 2 to day 10, Ports 1 and 2 react efficiently with no single significant CAAR following shocks of -20% or less.

To conclude, the results of the stocks sorted according to turnover rate betas confirm the different reaction between liquid and illiquid portfolios to the one-day price shocks. Positive shocks are followed by a return continuation, whereas negative shocks are mainly followed by a delayed price reversal. These results are more pronounced for illiquid portfolios, confirming the evidence that the price anomalies can be at least partially explained by the systematic liquidity risk.

6.3.3.3. Illiquidity ratio portfolios

Stocks in the Amihud (2002) illiquidity ratio portfolios show other clear evidence of the importance of systematic liquidity risk in explaining the price anomalies following large one-day price shocks. Panel C of Table 6.3 reports the CAARs of the stocks in the illiquidity ratio Ports 1 and 10, following positive shocks (results of remaining illiquidity ratio Ports 2 to 9 are reported in Appendix B.6). Starting with shocks of 5% or more, all these shocks on day 0 are highly significant. Port 10 (the least liquid portfolio) exhibits the largest average shock of 8.5%, whilst Port 3 shows the smallest average shock of 7.2%. Port 1 (the most liquid portfolio) exhibits no significant CAARs except for the first day after shocks of 5% or more. Port 10 displays large and highly significant positive CAARs up to 10 days following these shocks. This finding confirms the return continuation anomaly. For example, the value of the CAAR for Port 1 on the second day subsequent to the day of the shock is 0.10%, with an adjusted t-value of .788. However, the value of the comparable CAAR for Port 10 is 1.14%, with an adjusted t-value of 7.262.

The evidence is clearer when we look at the price reaction following shocks of 10% or more. While the CAARs of most liquid portfolios, Ports 1 and 2, are not significant, the least liquid portfolio, Port 10, demonstrates a highly significant momentum (return continuations) up to three days following shocks of 10% or more. Additionally, Port 10 displays the largest shock of 15.7%. Thus, our findings suggest that illiquid stocks drive the return continuations subsequent to positive shocks.

All shocks of 20% or more are highly significant and range from 23.5% for Port 4 to 31.8% for Port 6. Once more, Port 1 subsumes positive shocks immediately with no significant CAARs within 10 days, following shocks of 20% or more. In contrast, Port 10 exhibits a significant momentum on days 1 and 2 following these shocks. Thus, its CAAR accumulates to 4.45% on day 2. Figure 6.3 shows the CAARs of the stocks of the illiquidity ratio portfolios following shocks of 20% or more.

Similar to the proportional spread and turnover rate portfolios, the illiquidity ratio portfolios show evidence in favour of the overreaction hypothesis following negative shocks. Panel C of Table 6.4 reports the CAARs of the stocks in the illiquidity ratio Ports 1 and 10, following negative shocks (results of remaining illiquidity ratio Ports 2 to 9 are reported in Appendix B.7). All shocks of -5% or less are highly significant, with the least liquid portfolio, Port 10, exhibiting the largest average shock of -8.3%. The most liquid portfolio reverses its large loss one day following shocks of -5% or less and continues a significant price reversal up to day 10. In contrast, the least liquid portfolio continues to lose in the first day following these shocks and reverse late after five days. Thus, the asymmetric reaction between liquid and illiquid portfolios to negative shocks is noticeable.

The evidence following shocks of -10% or less confirms the efficient reaction of the most liquid stocks and the overreaction anomaly of the illiquid stocks. The most liquid portfolios, Ports 1 to 3, react efficiently to shocks of -10% or less. Port 10, however, exhibits a significant price reversal starting from the second day after these shocks and up to the tenth day.

The results following shocks of -20% or less are consistent with those of smaller shocks and also consistent with the other liquidity measures. The values of the shocks range from -28.6% for Port 7 to -40.8% for Port 4. They are all highly significant. While the most liquid portfolios, Ports 1 to 3, exhibit efficient reaction to shocks of -20% or less, Port 10, the least liquid portfolio, shows a significant price reversal up to 10 days following these shocks. Figure 6.6 shows the CAARs of the stocks of the illiquidity ratio portfolios following shocks of -20% or less.

Viewed collectively, positive one-day shocks are generally followed by significantly positive CAARs, consistent with the predictions of the underreaction hypothesis, whereas negative one-day shocks are mainly followed by significantly positive CAARs, confirming the overreaction hypothesis. The observed underreaction and overreaction seems to be driven by illiquid stocks. In most cases, high liquidity portfolios exhibit efficient reaction following price shocks, while the low liquidity portfolios earn significant abnormal returns. The main conclusion of the three previous sub-sections is that systematic liquidity risk, regardless of how liquidity is measured, can explain, at least partially, the observed price anomalies subsequent to one-day shocks in FTSEALL share index stocks.

Table 6.3

CAARs of stocks in liquidity beta sorted portfolios following positive shocks.

This table presents average cumulative abnormal returns of stocks of decile portfolios sorted according to historical liquidity beta following positive shocks of 5%, 10% and 20% or more. Liquidity is measured by the proportional bid-ask spread, the turnover rate and the illiquidity ratio of Amihud (2002). Sample consists of 642 stocks of FTSEALL share index constituents' list of February (2008). Analysis covers 1st July 1992 to 29th June 2007. At 1st July each year, we estimate historical liquidity beta of each stock based on daily data of previous 5 years. Only stocks with continuing returns through estimation period are considered. For estimation, we use the model consisting of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). After estimation, we sort stocks according to their historical liquidity betas and assign them to 10 decile portfolios, held for the following 12 months. The process is repeated annually. Each decile portfolio includes 27 to 52 stocks. Portfolio1 represents most liquid portfolio while portfolio10 is least liquid portfolio. Excess returns of each stock in each portfolio are regressed on the three factors of Fama and French (1993) and the momentum factor of Carhart (1997). OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Shocks are defined as abnormal returns of 5%, 10% and 20% or more. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_d$ is average cumulative abnormal return after (d) days following shock averaged over full period of the study and over all stocks in portfolio. *Port* denotes portfolio. Level of significance of CAARs is estimated using Newey-West t-statistic. For normality assumption, a non-parametric sign test of null hypothesis of a zero CAAR is used when the number of CAARs included in the average is less than 30. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level. Panel A presents CAARs of stocks in proportional spread portfolios. Panel B presents CAARs of stocks in turnover rate portfolios. Panel C presents CAARs of stocks in illiquidity ratio portfolios.

Panel A: CAARs of stocks in proportional spread portfolios											
CAARs following shocks of 5% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.0727[a]	0.0011	0.0016	0.0028	0.0027	0.0033	0.0025	0.0013	0.0028	0.0012	0.0026
Port 10	0.0851[a]	0.0126[a]	0.0128[a]	0.0122[a]	0.0104[a]	0.0101[a]	0.0101[a]	0.0089[a]	0.0082[a]	0.0081[a]	0.0079
CAARs following shocks of 10% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.1386[a]	0.0062	0.0066	0.0088	0.0012	0.0015	-0.0027	-0.0128	-0.0119	-0.0228	-0.0238
Port 10	0.1543[a]	0.0170[a]	0.0171[a]	0.0102[a]	0.0044	0.0023	0.0015	-0.0004	-0.0020	-0.0029	0.0010
CAARs following shocks of 20% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.2897[a]	0.0009	-0.0121	-0.0167	-0.0346	-0.0583	-0.0729	-0.0770	-0.0667	-0.0698	-0.0935
Port 10	0.2850[a]	0.0299[a]	0.0299[b]	0.0100	0.0035	-0.0003	-0.0021	-0.0120	-0.0160	-0.0159	-0.0103

Table 6.3 (Continued)

Panel B: CAARs of stocks in turnover rate portfolios											
CAARs following shocks of 5% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.0770[a]	0.0062[a]	0.0055[a]	0.0055[a]	0.0056[a]	0.0058[a]	0.0048[a]	0.0046[b]	0.0041[b]	0.0024	0.0026
Port 10	0.0850[a]	0.0116[a]	0.0114[a]	0.0113[a]	0.0091[a]	0.0094[a]	0.0092[a]	0.0075[a]	0.0064[b]	0.0074[a]	0.0077[a]
CAARs following shocks of 10% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.1403[a]	0.0093[a]	0.0083[b]	0.0076[c]	0.0039	0.0052	0.0044	0.0039	0.0026	-0.0028	-0.0019
Port 10	0.1606[a]	0.0184[a]	0.0173[a]	0.0119[b]	0.0060	0.0050	0.0046	0.0026	0.0002	-0.0010	0.0023
CAARs following shocks of 20% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.2767[a]	0.0109	0.0170	0.0155	0.0049	0.0031	-0.0085	-0.0134	-0.0169	-0.0148	-0.0227
Port 10	0.2947[a]	0.0392[a]	0.0426[b]	0.0222	0.0091	0.0063	0.0012	-0.0052	-0.0040	0.0040	0.0120
Panel C: CAARs of stocks in illiquidity ratio portfolios											
CAARs following shocks of 5% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.0742[a]	0.0016[c]	0.0010	0.0012	0.0006	0.0014	0.0004	-0.0007	-0.0009	-0.0019	-0.0016
Port 10	0.0849[a]	0.0116[a]	0.0114[a]	0.0108[a]	0.0088[a]	0.0083[a]	0.0091[a]	0.0074[a]	0.0076[a]	0.0079[a]	0.0073[a]
CAARs following shocks of 10% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.1373[a]	0.0019	0.0034	0.0048	-0.0001	0.0041	0.0021	-0.0012	-0.0030	-0.0074	-0.0077
Port 10	0.1570[a]	0.0211[a]	0.0220[a]	0.0139[a]	0.0073	0.0042	0.0043	0.0016	0.0019	-0.0002	0.0007
CAARs following shocks of 20% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.2831[a]	0.0025	0.0100	0.0113	-0.0167	-0.0238	-0.0452[b]	-0.0505[b]	-0.0419	-0.0386	-0.0497
Port 10	0.2905[a]	0.0338[a]	0.0445[a]	0.0251	0.0198	0.0176	0.0190	0.0110	0.0046	0.0036	0.0069

Table 6.4

CAARs of stocks in liquidity beta sorted portfolios following negative shocks

This table presents average cumulative abnormal returns of stocks of decile portfolios sorted according to historical liquidity beta following negative shocks of -5%, -10% and -20% or less. Liquidity is measured by the proportional bid-ask spread, the turnover rate and the illiquidity ratio of Amihud (2002). Sample consists of 642 stocks of FTSEALL share index constituents' list of February (2008). Analysis covers 1st July 1992 to 29th June 2007. At 1st July each year, we estimate historical liquidity beta of each stock based on daily data of previous 5 years. Only stocks with continuing returns through estimation period are considered. For estimation, we use the model consisting of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). After estimation, we sort stocks according to their historical liquidity betas and assign them to 10 decile portfolios, held for the following 12 months. The process is repeated annually. Each decile portfolio includes 27 to 52 stocks. Portfolio1 represents most liquid portfolio while portfolio10 is least liquid portfolio. Excess returns of each stock in each portfolio are regressed on the three factors of Fama and French (1993) and the momentum factor of Carhart (1997). OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Shocks are defined as abnormal returns of -5%, -10% and -20% or less. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_d$ is average cumulative abnormal return after (d) days following shock averaged over full period of the study and over all stocks in portfolio. *Port* denotes portfolio. Level of significance of CAARs is estimated using Newey-West t-statistic. For normality assumption, a non-parametric sign test of null hypothesis of a zero CAAR is used when the number of CAARs included in the average is less than 30. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level. Panel A presents CAARs of stocks in proportional spread portfolios. Panel B presents CAARs of stocks in turnover rate portfolios. Panel C presents CAARs of stocks in illiquidity ratio portfolios.

Panel A: CAARs of stocks in proportional spread portfolios											
CAARs following shocks of -5% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0749[a]	0.0027[c]	0.0049[b]	0.0041	0.0051	0.0051	0.0046	0.0062[c]	0.0077[b]	0.0089[b]	0.0098[b]
Port 10	-0.0824[a]	-0.0027[b]	-0.0014	0.0012	0.0017	0.0044[b]	0.0072[a]	0.0079[a]	0.0080[a]	0.0081[a]	0.0075[a]
CAARs following shocks of -10% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.1572[a]	0.0055	0.0105	0.0057	0.0075	0.0032	-0.0017	-0.0156	-0.0122	-0.0052	0.0033
Port 10	-0.1555[a]	0.0024	0.0074[c]	0.0150[a]	0.0184[a]	0.0240[a]	0.0289[a]	0.0304[a]	0.0303[a]	0.0324[a]	0.0325[a]
CAARs following shocks of -20% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.3394[a]	-0.0308	-0.0198	-0.0234	-0.0288	-0.0272[c]	-0.0375	-0.0613[c]	-0.0312	-0.0343	-0.0315
Port 10	-0.2953[a]	0.0237[c]	0.0413[b]	0.0593[a]	0.0589[a]	0.0615[a]	0.0700[a]	0.0727[a]	0.0675[a]	0.0745[a]	0.0787[a]

Table 6.4 (continued)

Panel B: CAARs of stocks in turnover rate portfolios											
CAARs following shocks of -5% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0779[a]	0.0010	0.0020	0.0040[b]	0.0057[a]	0.0062[a]	0.0072[a]	0.0083[a]	0.0101[a]	0.0115[a]	0.0115[a]
Port 10	-0.0824[a]	-0.0029[b]	-0.0012	0.0020	0.0022	0.0048[b]	0.0063[b]	0.0077[a]	0.0077[a]	0.0063[b]	0.0071[b]
CAARs following shocks of -10% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.1657[a]	0.0013	0.0040	0.0082	0.0154[b]	0.0188[a]	0.0195[a]	0.0165[c]	0.0211[b]	0.0243[a]	0.0267[a]
Port 10	-0.1558[a]	-0.0009	0.0070	0.0156[a]	0.0192[a]	0.0220[a]	0.0251[a]	0.0224[a]	0.0204[a]	0.0235[a]	0.0233
CAARs following shocks of -20% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.3462[a]	-0.0058	-0.0043	0.0065	0.0009	0.0072	0.0171	0.0111	0.0256	0.0226	0.0225
Port 10	-0.3001[a]	0.0186	0.0538[a]	0.0773[a]	0.0810[a]	0.0684[a]	0.0702[a]	0.0642[b]	0.0576[b]	0.0623[b]	0.0671[b]
Panel C: CAARs of stocks in illiquidity ratio portfolios											
CAARs following shocks of -5% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0772[a]	0.0041[a]	0.0042[b]	0.0042[b]	0.0049[b]	0.0054[b]	0.0068[a]	0.0074[a]	0.0082[a]	0.0091[a]	0.0093[a]
Port 10	-0.0825[a]	-0.0035[a]	-0.0017	0.0011	0.0007	0.0033	0.0050[b]	0.0062[b]	0.0057[b]	0.0056[b]	0.0049[c]
CAARs following shocks of -10% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.1602[a]	0.0039	0.0046	0.0062	0.0102[c]	0.0129[c]	0.0162[b]	0.0122	0.0171[c]	0.0202[b]	0.0227[b]
Port 10	-0.1549[a]	0.0056	0.0127[b]	0.0205[a]	0.0249[a]	0.0294[a]	0.0302[a]	0.0298[a]	0.0286[a]	0.0303[a]	0.0298[a]
CAARs following shocks of -20% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.3215[a]	-0.0118	-0.0093	-0.0036	-0.0094	-0.0070	-0.0058	-0.0142	0.0090	0.0066	0.0040
Port 10	-0.2950[a]	0.0257[c]	0.0417[b]	0.0590[a]	0.0623[a]	0.0555[a]	0.0602[a]	0.0582[b]	0.0520[b]	0.0569[b]	0.0609[b]

Figure 6.1
CAARs of proportional spread portfolios following shocks of 5% or more

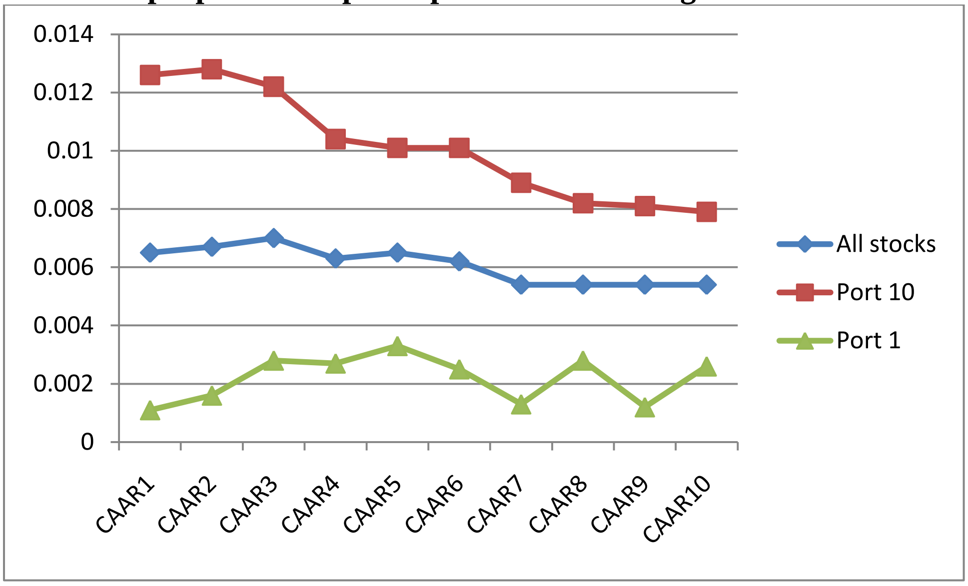


Figure 6.2
CAARs of turnover rate portfolios following shocks of 10% or more

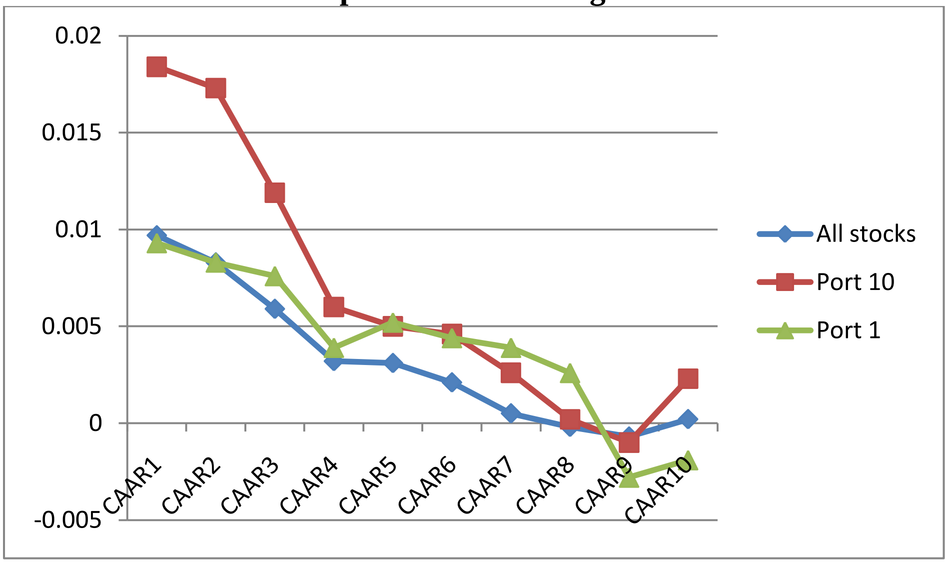


Figure 6.3
CAARs of illiquidity ratio portfolios following shocks of 20% or more

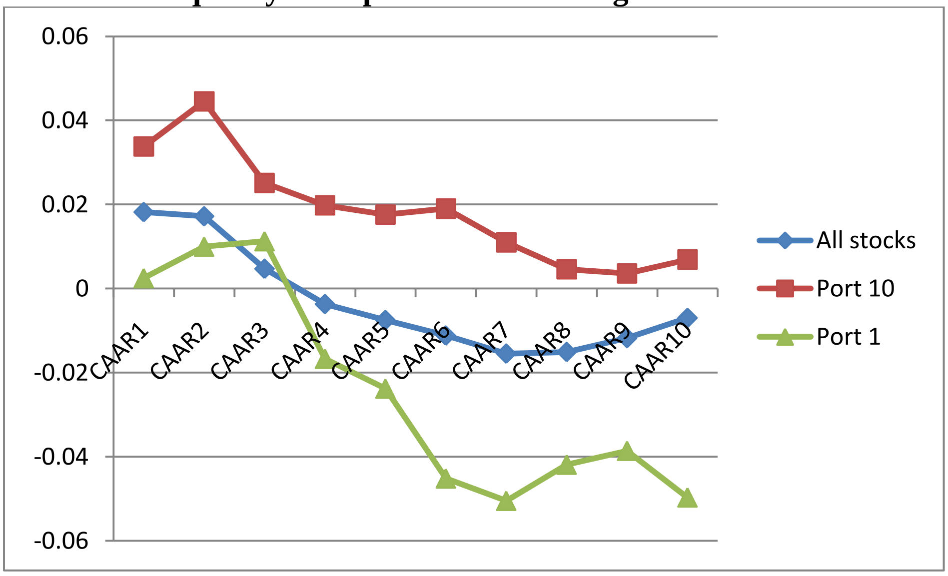


Figure 6.4
CAARs of proportional spread portfolios following shocks of -5% or less

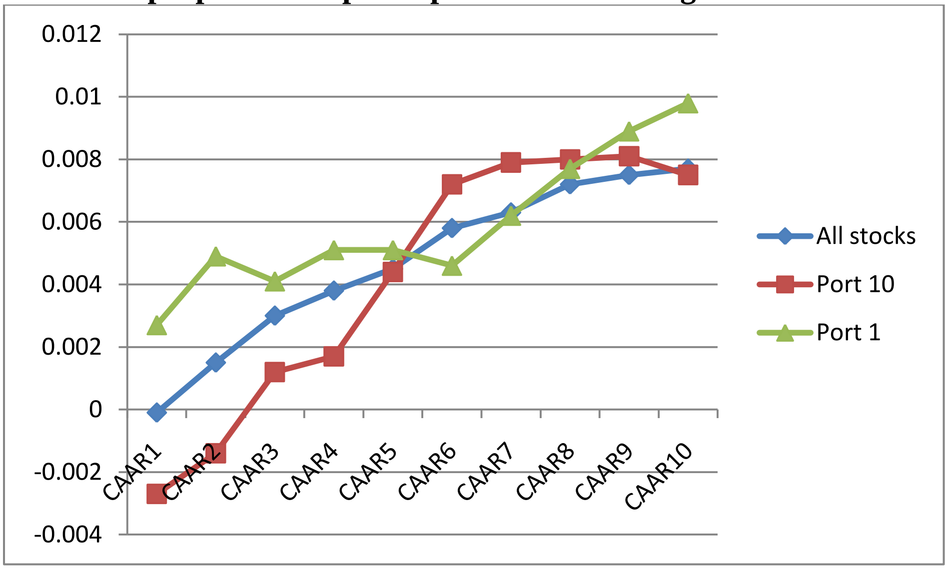


Figure 6.5
CAARs of turnover rate portfolios following shocks of -10% or less

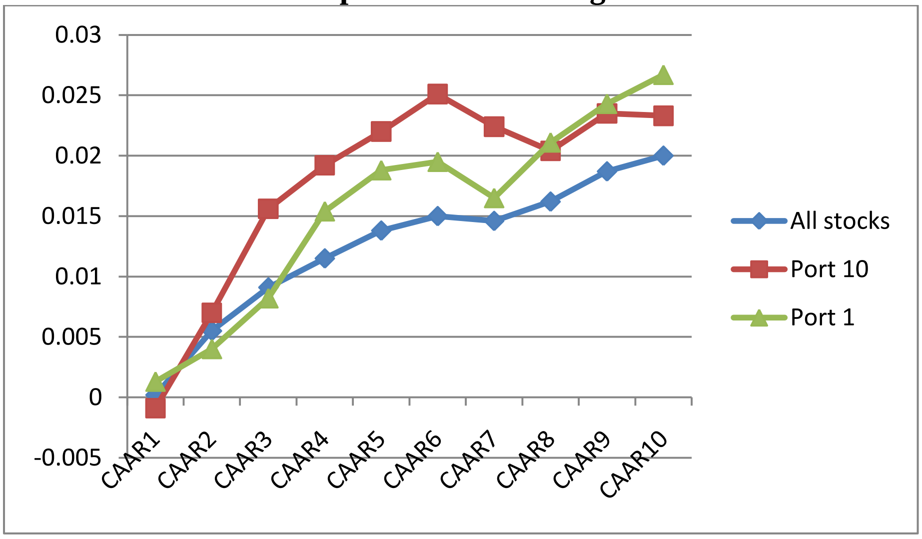
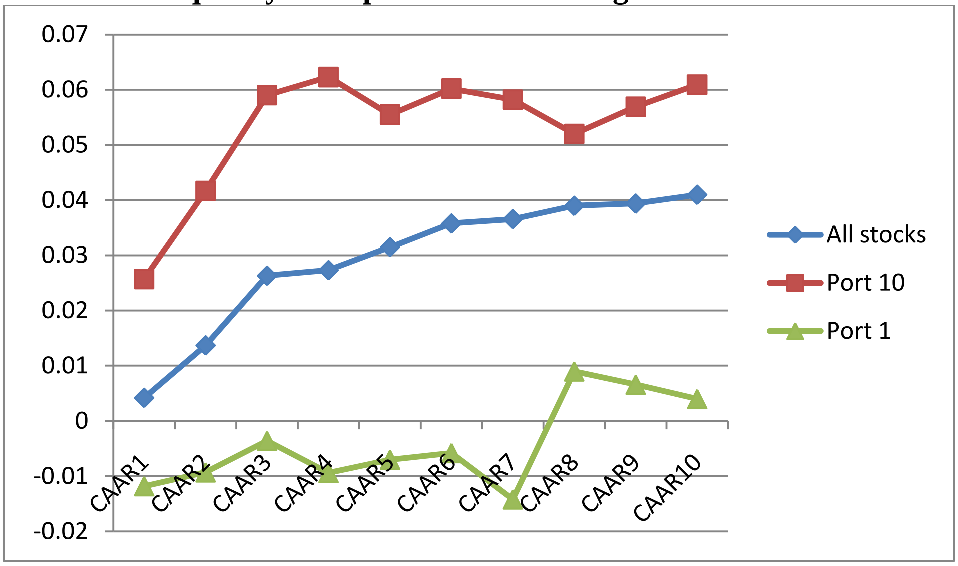


Figure 6.6
CAARs of illiquidity ratio portfolios following shocks of -20% or less



6.3.4. CAARs and liquidity augmented asset pricing

We redefine the abnormal returns as the residuals from a model that includes the three factors of Fama and French (1993), the momentum factor of Carhart (1987) and a mimicking liquidity factor constructed following Liu (2006). Hence, we repeat the whole analysis after incorporating the systematic liquidity factor in our four-factor model. We assume that if systematic liquidity risk can *fully* explain the price anomalies following large one-day shock, then incorporating its factor in the four-factor model should yield insignificant abnormal returns.

6.3.4.1. Proportional bid-ask spread portfolios

Panel A of Table 6.5 reports the liquidity-adjusted CAARs of the stocks in the proportional spread Ports 1 and 10, following positive shocks of different magnitude (results of remaining proportional spread Ports 2 to 9 are reported in Appendix B.8). The overall picture is the same before and after incorporating the systematic liquidity risk factor. Port 1 (the most liquid portfolio) reacts efficiently in most cases to positive shocks, whereas Port 10 (the least liquid portfolio) exhibits a significant return continuation extending to several days. Indeed, the Wilcoxon Signed Rank test (WSRT) shows that none of the CAARs differs significantly before and after incorporating the systematic liquidity risk factor.

The results are also consistent before and after incorporating the systematic liquidity risk in the case of negative liquidity shocks. Panel A of Table 6.6 reports the liquidity-adjusted CAARs of the stocks in the proportional spread Ports 1 and 10, following negative shocks of different magnitude (results of remaining proportional spread Ports 2 to 9 are reported in Appendix B.9). In most cases, the most liquid portfolios react efficiently to negative shocks, whilst the least liquid portfolio exhibits a significant price reversal extending to several days. Once again, the WSRT shows that differences between the CAARs before and after incorporating the systematic liquidity risk are not statistically significant.

The explanation of these results holds two possibilities. One is that systematic liquidity risk can partially but not fully explain the abnormal reaction of stocks to large one-day shocks. The other possibility is that, given the strong evidence that we have detected from the analysis in section 6.3.3 of the role of this factor in explaining the price anomalies, the way we account for it may not be appropriate. We will examine this issue in the next chapter.

6.3.4.2. Turnover rate portfolios

Panel B of Table 6.5 reports the liquidity-adjusted CAARs of the stocks in the turnover rate Ports 1 and 10, following positive shocks of different magnitude (results of remaining turnover rate Ports 2 to 9 are reported in Appendix B.10). Again, the main conclusions are the same before and after incorporating the systematic liquidity risk factor into the asset pricing model. Most of the portfolios exhibit significant return continuations following positive shocks of different magnitude. However, the magnitude of the CAARs of the least liquid portfolio (Port 10) is higher than that of the most liquid portfolios. The WSRT suggests the absence of any significant differences in the CAARs before and after accounting for the systematic liquidity risk.

Panel B of Table 6.6 reports the liquidity-adjusted CAARs of the stocks in the turnover rate Ports 1 and 10, following negative shocks of different magnitude (results of remaining turnover rate Ports 2 to 9 are reported in Appendix B.11). Most of the portfolios show delayed price reversals following the negative shocks. The WSRT shows that the CAARs of the portfolios do not differ significantly before and after adjusting them for the systematic liquidity risk.

6.3.4.3. Illiquidity ratio portfolios

Panel C of Table 6.5 reports the liquidity-adjusted CAARs of the stocks in the illiquidity ratio Ports 1 and 10, following positive shocks of different magnitude (results of remaining illiquidity ratio Ports 2 to 9 are reported in Appendix B.12). The asymmetric reaction of the most liquid and least liquid portfolios to positive shocks is still there. Indeed, the least liquid portfolios exhibit highly significant return continuations for several days after the shock. On the other hand, the most liquid portfolios react efficiently to positive shocks in most cases. The WSRT also suggests no significant differences in the CAARs before and after adjusting them for the systematic liquidity risk.

Panel C of Table 6.6 reports the liquidity-adjusted CAARs of the stocks in the illiquidity ratio Ports 1 and 10, following negative shocks of different magnitude (results of remaining illiquidity ratio Ports 2 to 9 are reported in Appendix B.13). While the least liquid portfolio, Port 10, exhibits significant price reversals following the negative shocks of -10% and -20% or less, Port 1, the most liquid portfolio, reacts efficiently to these shocks. Thus, the results are consistent before and after incorporating the mimicking liquidity factor. The differences in the

CAARs before and after incorporating the systematic liquidity factor according to the WSRT are also insignificant in the case of the negative shocks.

Overall, incorporating the systematic liquidity factor in the four-factor model used to calculate the abnormal returns of the stocks does not make any difference. Thus, regardless of which liquidity proxy is used, the CAARs do not differ significantly before and after adding the systematic liquidity risk factor to the model. In other words, the general picture remains the same before and after adjusting CAARs to the systematic liquidity risk. More specifically, the illiquid stocks seem to drive the price anomalies following both positive and negative shocks.

Table 6.5

Liquidity-adjusted CAARs of stocks in liquidity beta sorted portfolios following positive shocks.

This table presents average cumulative abnormal returns of stocks of decile portfolios sorted according to historical liquidity beta following positive shocks of 5%, 10% and 20% or more. Liquidity is measured by the proportional bid-ask spread, the turnover rate and the illiquidity ratio of Amihud (2002). Sample consists of 642 stocks of FTSEALL share index constituents' list of February (2008). Analysis covers 1st July 1992 to 29th June 2007. At 1st July each year, we estimate historical liquidity beta of each stock based on daily data of previous 5 years. Only stocks with continuing returns through estimation period are considered. For estimation, we use the model consisting of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). After estimation, we sort stocks according to their historical liquidity betas and assign them to 10 decile portfolios, held for the following 12 months. The process is repeated annually. Each decile portfolio includes 27 to 52 stocks. Portfolio1 represents most liquid portfolio while portfolio10 is least liquid portfolio. Excess returns of each stock in each portfolio are regressed on the three factors of Fama and French (1993), the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Shocks are defined as abnormal returns of 5%, 10% and 20% or more. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_d$ is average cumulative abnormal return after (d) days following shock averaged over full period of the study and over all stocks in portfolio. *Port* denotes portfolio. Level of significance of CAARs is estimated using Newey-West t-statistic. For normality assumption, a non-parametric sign test of null hypothesis of a zero CAAR is used when the number of CAARs included in the average is less than 30. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level. Panel A presents CAARs of stocks in proportional spread portfolios. Panel B presents CAARs of stocks in turnover rate portfolios. Panel C presents CAARs of stocks in illiquidity ratio portfolios.

Panel A: CAARs of stocks in proportional spread portfolios											
CAARs following shocks of 5% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.0727[a]	0.0012	0.0031[c]	0.0045[b]	0.0048[b]	0.0048[c]	0.0045	0.0032	0.0049	0.0037	0.0042
Port 10	0.0847[a]	0.0126[a]	0.0136[a]	0.0124[a]	0.0110[a]	0.0098[a]	0.0099[a]	0.0092[a]	0.0085[a]	0.0071[a]	0.0070[a]
CAARs following shocks of 10% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.1375[a]	**0.0034**	0.0037	0.0051	-0.0017	-0.0007	-0.0021	-0.0140[c]	-0.0142	-0.0242	-0.0240
Port 10	0.1513[a]	0.0162[a]	0.0155[a]	0.0088[b]	0.0029	0.0008	0.0000	-0.0018	-0.0025	-0.0035	0.0001
CAARs following shocks of 20% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	**0.2819[a]**	-0.0045	-0.0211[c]	-0.0242[c]	-0.0422	-0.0601[b]	-0.0740	-0.0872	-0.0783	-0.0879	-0.1101
Port 10	0.2836[a]	0.0243[b]	0.0206	0.0008	-0.0059	-0.0088	-0.0105	-0.0197	-0.0246	-0.0253	-0.0200

Table 6.5 (continued)

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Panel B: CAARs of stocks in turnover rate portfolios											
CAARs following shocks of 5% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.0769[a]	0.0072[a]	0.0063[a]	0.0068[a]	0.0072[a]	0.0075[a]	0.0061[a]	0.0061[a]	0.0050[a]	0.0040[b]	0.0040[c]
Port 10	0.0839[a]	0.0109[a]	0.0110[a]	0.0099[a]	0.0086[a]	0.0088[a]	0.0087[a]	0.0073[a]	0.0064[a]	0.0073[a]	0.0078[a]
CAARs following shocks of 10% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.1392[a]	0.0082[a]	0.0076[b]	0.0083[b]	0.0058	0.0060	0.0050	0.0040	0.0019	0.0002	0.0018
Port 10	0.1587[a]	0.0154[a]	0.0123[b]	0.0090[c]	0.0030	0.0026	0.0038	0.0027	0.0007	0.0016	0.0040
CAARs following shocks of 20% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	**0.2717[a]**	0.0117	0.0209	0.0219	0.0120	0.0098	-0.0037	-0.0081	-0.0082	-0.0080	-0.0161
Port 10	0.2912[a]	0.0341[b]	0.0292[c]	0.0017	-0.0114	-0.0141	-0.0123	-0.0144	-0.0113	-0.0063	-0.0009
Panel C: CAARs of stocks in illiquidity ratio portfolios											
CAARs following shocks of 5% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.0739[a]	0.0023[b]	0.0015	0.0019	0.0016	0.0028	0.0020	0.0015	0.0013	0.0003	0.0006
Port 10	0.0843[a]	0.0111[a]	0.0109[a]	0.0101[a]	0.0088[a]	0.0082[a]	0.0095[a]	0.0089[a]	0.0088[a]	0.0080[a]	0.0073[a]
CAARs following shocks of 10% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.1371[a]	0.0025	0.0029	0.0048	0.0007	0.0043	0.0015	-0.0001	-0.0013	-0.0050	-0.0053
Port 10	0.1560[a]	0.0202[a]	0.0211[a]	0.0136[a]	0.0066	0.0045	0.0054	0.0013	0.0024	0.0013	0.0008
CAARs following shocks of 20% or more											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	0.2785[a]	0.0017	0.0037	0.0068	-0.0185	-0.0214	-0.0433	-0.0505[c]	-0.0479	-0.0463	-0.0525[c]
Port 10	0.2856[a]	0.0267[b]	0.0284[c]	0.0033	0.0027	0.0021	0.0038	-0.0063	-0.0134	**-0.0161**	**-0.0153**

Table 6.6

Liquidity-adjusted CAARs of stocks in liquidity beta sorted portfolios following negative shocks.

This table presents average cumulative abnormal returns of stocks of decile portfolios sorted according to historical liquidity beta following negative shocks of -5%, -10% and -20% or less. Liquidity is measured by the proportional bid-ask spread, the turnover rate and the illiquidity ratio of Amihud (2002). Sample consists of 642 stocks of FTSEALL share index constituents' list of February (2008). Analysis covers 1st July 1992 to 29th June 2007. At 1st July each year, we estimate historical liquidity beta of each stock based on daily data of previous 5 years. Only stocks with continuing returns through estimation period are considered. For estimation, we use the model consisting of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). After estimation, we sort stocks according to their historical liquidity betas and assign them to 10 decile portfolios, held for the following 12 months. The process is repeated annually. Each decile portfolio includes 27 to 52 stocks. Portfolio1 represents most liquid portfolio while portfolio10 is least liquid portfolio. Excess returns of each stock in each portfolio are regressed on the three factors of Fama and French (1993), the momentum factor of Carhart (1997) and a mimicking liquidity factor constructed following Liu (2006). OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Shocks are defined as abnormal returns of -5%, -10% and -20% or less. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_d$ is average cumulative abnormal return after (d) days following shock averaged over full period of the study and over all stocks in portfolio. *Port* denotes portfolio. Level of significance of CAARs is estimated using Newey-West t-statistic. For normality assumption, a non-parametric sign test of null hypothesis of a zero CAAR is used when the number of CAARs included in the average is less than 30. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level. Panel A presents CAARs of stocks in proportional spread portfolios. Panel B presents CAARs of stocks in turnover rate portfolios. Panel C presents CAARs of stocks in illiquidity ratio portfolios.

Panel A: CAARs of stocks in proportional spread portfolios

CAARs following shocks of -5% or less

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	-0.0754[a]	0.0025	0.0047[b]	0.0047[c]	0.0040	0.0036	0.0045	0.0052	0.0073[b]	0.0077[c]	0.0091[b]
Port 10	-0.0817[a]	-0.0013	-0.0001	0.0019	0.0024	0.0049[b]	0.0077[a]	0.0093[a]	0.0090[a]	0.0085[a]	0.0084[a]

CAARs following shocks of -10% or less

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	-0.1601[a]	0.0017	0.0027	-0.0007	0.0002	-0.0039	-0.0103	-0.0236	-0.0194	-0.0130	-0.0039
Port 10	-0.1548[a]	0.0049	0.0095[b]	0.0168[a]	0.0176[a]	0.0231[a]	0.0276[a]	0.0293[a]	0.0284[a]	0.0292[a]	0.0292[a]

CAARs following shocks of -20% or less

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	-0.3353[a]	-0.0309	-0.0221	-0.0259	-0.0321	-0.0297	-0.0401	-0.0626[b]	-0.0364	-0.0415	-0.0405
Port 10	-0.2897[a]	0.0258[c]	0.0436[b]	0.0625[a]	0.0615[a]	0.0646[a]	0.0714[a]	0.0739[a]	0.0688[a]	0.0747[a]	0.0771[a]

Table 6.6 (continued)

Panel B: CAARs of stocks in turnover rate portfolios											
CAARs following shocks of -5% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0781[a]	0.0014	0.0024	0.0043[b]	0.0052[b]	0.0063[a]	0.0069[a]	0.0071[a]	0.0084[a]	0.0097[a]	0.0103[a]
Port 10	-0.0829[a]	-0.0016	0.0001	0.0029	0.0029	0.0050[b]	0.0070[a]	0.0081[a]	0.0091[a]	0.0078[b]	0.0079[b]
CAARs following shocks of -10% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.1647[a]	-0.0003	0.0012	0.0067	0.0123[b]	0.0175[a]	0.0184[b]	0.0189[b]	0.0241[a]	0.0247[a]	0.0242[a]
Port 10	-0.1374[a]	-0.0002	0.0060	0.0156[a]	0.0187[a]	0.0193[a]	0.0217[a]	0.0207[a]	0.0199[a]	0.0206[a]	0.0212[b]
CAARs following shocks of -20% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.3425[a]	-0.0042	-0.0070	0.0056	0.0035	0.0121	0.0217	0.0158	0.0272	0.0189	0.0189
Port 10	-0.2976[a]	0.0193	0.0511[a]	0.0701[a]	0.0701[a]	0.0594[a]	0.0629[a]	0.0535[b]	0.0577[b]	0.0672[b]	0.0735[a]
Panel C: CAARs of stocks in illiquidity ratio portfolios											
CAARs following shocks of -5% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0774[a]	0.0045[a]	0.0045[b]	0.0047[b]	0.0068[a]	0.0077[a]	0.0090[a]	0.0088[a]	0.0096[a]	0.0094[a]	0.0089[a]
Port 10	-0.0820[a]	-0.0020[c]	-0.0005	0.0018	0.0012	0.0036[c]	0.0060[a]	0.0063[a]	0.0064[a]	0.0055[b]	0.0051[c]
CAARs following shocks of -10% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.1588[a]	0.0059	0.0064	0.0071	0.0085	0.0117[c]	0.0115	0.0100	0.0153[c]	0.0164[c]	0.0155
Port 10	-0.1552[a]	0.0099[b]	0.0163[a]	0.0223[a]	0.0243[a]	0.0292[a]	0.0308[a]	0.0296[a]	0.0297[a]	0.0306[a]	0.0296[a]
CAARs following shocks of -20% or less											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	**-0.3149[a]**	-0.0105	-0.0114	-0.0059	-0.0101	-0.0091	-0.0134	-0.0214	-0.0026	-0.0069	-0.0096
Port 10	-0.2891[a]	0.0213	0.0376[b]	0.0492[b]	0.0538[a]	0.0508[a]	0.0551[b]	0.0510[b]	0.0477[c]	0.0507[b]	0.0522[b]

6.3.5. Sub-period analysis

As a robustness check, we perform a sub-period analysis. We divide the entire study period to three equal sub-periods. Next, we repeat the analysis of the positive and negative 5% or more shocks over the three sub-periods. Table 6.7 presents the sub-period CAARs of the stocks in liquidity beta sorted Ports 1 and 10, following shocks of 5% or more (results of remaining proportional spread, turnover rate and illiquidity ratio portfolios are reported in Appendices B.14, B.16 and B.18, respectively). Starting with the proportional spread portfolios, the different reaction of liquid and illiquid portfolios is getting much clearer over time. Across the three sub-periods, Port 10, the least liquid portfolio, exhibits significant return continuation up to ten days following shocks of 5% or more. Port 1, the most liquid portfolio, displays a significant return continuation for two days after these shocks in the first sub-period. However, the reaction of this portfolio is efficient during the ten days following shocks of 5% or more in the two later sub-periods. The results of the turnover portfolios are consistent over the three sub-periods of analysis. Both the liquid and illiquid portfolios exhibit significant return continuation following shocks of 5% or more. Yet the CAARs of Port 10, the least liquid portfolio, are greater in magnitude and level of significance than the CAARs of Port 1, the most liquid portfolio. Regarding the Amihud (2002) illiquidity ratio portfolios, in the first sub-period, Port 1 earns significantly positive CAARs up to four days following shocks of 5% or more. Port 10 does so for up to five days. The magnitude and the level of significance of CAARs of Port 10 are higher than those of the CAARs of Port 1. Port 1 reacts efficiently to the 5% (or more) shock in the last two sub-periods, while Port 10 exhibits a significant return continuation. The asymmetric reaction of liquid and illiquid portfolios is clear throughout the three sub-periods.

Table 6.8 presents the sub-period CAARs of the stocks in liquidity beta sorted Ports 1 and 10, following shocks of -5% or less (results of remaining proportional spread, turnover rate and illiquidity ratio portfolios are reported in Appendices B.15, B.17 and B.19, respectively). Starting with the proportional spread portfolios, in the first sub-period, Port 1 reacts efficiently to shocks of -5% or less while Port 10 continues its loss up to three days subsequent to these shocks. In the second sub-period, Port 1 reverses its loss on day 2, whereas Port 10 shows a delayed reversal starting from day 6 to day 10. Port 1 shows a significant price reversal only one day after shocks of -5% or less in the last sub-period, while Port 10 starts its reversal from day 1 to day 10. In spite of the fact that results are changing over time, there is strong evidence of the role of the systematic liquidity risk in explaining the price reaction to extreme events in all sub-periods. Regarding the turnover rate portfolios, in the first sub-period, Port 1 continues its loss up to three days subsequent to shocks of -5% or less and Port 10 does so up to four days subsequent to these shocks. However, the negative CAARs are higher and more significant for Port 10. In the second sub-period, Port 1 reverses its loss on day 3, whereas Port 10 continues to lose one day after shocks of -5% or less and does not exhibit any reversal. Both Ports 1 and 10 display significant price reversals following these shocks in the third sub-period. However, the price reversals of Port 10 are higher in magnitude and more significant than Port 1. Once more, although results are changing over time, they all support the role of systematic liquidity in explaining the price reaction to large price changes in all sub-periods. Finally, the results of the illiquidity ratio portfolios show the following. In the first sub-period, all the portfolios react efficiently to shocks of -5% or less, except Port 10 which shows significant underreaction in the two days following these shocks. However, in the last two sub-periods the evidence is mixed.

Thus, while Port 10 earns no significant abnormal returns following shocks of -5% or less, Port 1 exhibits a significant price reversal.

Table 6.7

Sub-period CAARs of stocks in liquidity beta sorted portfolios following shocks of 5% or more

This table presents average cumulative abnormal returns of stocks of decile portfolios sorted according to historical liquidity beta following shocks of 5% or more. Liquidity is measured by the proportional bid-ask spread, the turnover rate and the illiquidity ratio of Amihud (2002). Analysis covers three equal sub-periods. Panel A reports results for first sub-period from 1st July 1992 to 30th June 1997. Panel B present results for second sub-period from 1st July 1997 to 28th June 2002. Panel C shows results of third sub-period from 1st July 2002 to 29th June 2007. Sample consists of 642 stocks of FTSEALL share index constituents' list of February (2008). At 1st July each year, we estimate historical liquidity beta of each stock based on daily data of previous 5 years. Only stocks with continuing returns through estimation period are considered. For estimation, we use the model consisting of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor of the proportional bid-ask spread constructed following Liu (2006). After estimation, we sort stocks according to their historical liquidity betas and assign them to 10 decile portfolios, held for the following 12 months. The process is repeated annually. Each decile portfolio includes 27 to 52 stocks. Portfolio1 represents most liquid portfolio while portfolio10 is least liquid portfolio. Excess returns of each stock in each portfolio are regressed on the three factors of Fama and French (1993) and the momentum factor of Carhart (1997). OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Shocks are defined as abnormal returns of 5% or more. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_d$ is average cumulative abnormal return after (d) days following shock averaged over full period of the study and over all stocks in portfolio. *Port* denotes portfolio. Level of significance of CAARs is estimated using Newey-West t-statistic. For normality assumption, a non-parametric sign test of null hypothesis of a zero CAAR is used when the number of CAARs included in the average is less than 30. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level.

Panel A: Results from 1st July 1992 to 30th June 1997

CAARs of stocks in proportional spread portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0769[a]	0.0116[a]	0.0126[b]	0.0109	0.0162[c]	0.0158	0.0130	0.0100	0.0133	0.0168	0.0203
Port 10	0.0928[a]	0.0192[a]	0.0205[a]	0.0215[a]	0.0182[a]	0.0150[a]	0.0132[a]	0.0112[b]	0.0109[b]	0.0119[b]	0.0119[b]

CAARs of stocks in turnover rate portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0794[a]	0.0117[a]	0.0114[a]	0.0122[a]	0.0139[a]	0.0109[b]	0.0132[b]	0.0110[c]	0.0096	0.0086	0.0107
Port 10	0.0935[a]	0.0212[a]	0.0215[a]	0.0239[a]	0.0207[a]	0.0200[a]	0.0171[a]	0.0128[b]	0.0116[c]	0.0137[b]	0.0145[b]

CAARs of stocks in illiquidity ratio portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0790[a]	0.0116[a]	0.0111[b]	0.0116[b]	0.0111[c]	0.0089	0.0100	0.0123	0.0112	0.0122	0.0122
Port 10	0.0909[a]	0.0165[a]	0.0161[a]	0.0171[a]	0.0135[a]	0.0102[b]	0.0078	0.0060	0.0061	0.0075	0.0071

Table 6.7 (continued)

Panel B: Results from 1st July 1997 to 28th June 2002

CAARs of stocks in proportional spread portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0676[a]	0.0021	0.0021	0.0005	-0.0010	0.0010	0.0002	-0.0019	0.0016	0.0022	0.0045
Port 10	0.0873[a]	0.0122[a]	0.0128[a]	0.0115[a]	0.0100[a]	0.0114[a]	0.0123[a]	0.0108[a]	0.0092[a]	0.0087[b]	0.0088[b]

CAARs of stocks in turnover rate portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0764[a]	0.0081[a]	0.0064[a]	0.0048[b]	0.0041[c]	0.0043[c]	0.0022	0.0020	0.0015	0.0000	-0.0005
Port 10	0.0887[a]	0.0105[a]	0.0098[a]	0.0089[a]	0.0062[c]	0.0078[b]	0.0079[b]	0.0071[b]	0.0067[c]	0.0074[c]	0.0087[b]

CAARS of stocks in illiquidity ratio portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0707[a]	0.0012	-0.0001	-0.0011	-0.0017	-0.0003	-0.0016	-0.0045[c]	-0.0036	-0.0037	-0.0036
Port 10	0.0880[a]	0.0124[a]	0.0124[a]	0.0112[a]	0.0102[a]	0.0110[a]	0.0122[a]	0.0109[a]	0.0104[a]	0.0099[b]	0.0087[b]

Panel C: Results from 1st July 2002 to 29th June 2007

CAARs of stocks in proportional spread portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0756[a]	-0.0021	-0.0013	0.0026	0.0024	0.0022	0.0018	0.0017	0.0013	-0.0032	-0.0030
Port 10	0.0777[a]	0.0087[a]	0.0077[a]	0.0066[a]	0.0054[b]	0.0055[b]	0.0059[b]	0.0054[b]	0.0053[b]	0.0049[c]	0.0044

CAARs of stocks in turnover rate portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0770[a]	0.0023[c]	0.0025	0.0042[b]	0.0047[b]	0.0059[b]	0.0050[b]	0.0054[b]	0.0052[c]	0.0031	0.0034
Port 10	0.0752[a]	0.0059[a]	0.0058[b]	0.0046[c]	0.0035	0.0034	0.0049	0.0040	0.0025	0.0029	0.0019

CAARs of stocks in illiquidity ratio portfolios

Port	CAAR0	CAAR1	CAAR2	CAAR3	CAAR4	CAAR5	CAAR6	CAAR7	CAAR8	CAAR9	CAAR10
Port 1	0.0772[a]	-0.0010	-0.0008	0.0007	0.0000	0.0010	-0.0002	-0.0001	-0.0013	-0.0040	-0.0034
Port 10	0.0782[a]	0.0079[a]	0.0077[a]	0.0065[a]	0.0046[c]	0.0045	0.0066[b]	0.0049	0.0056[c]	0.0061[c]	0.0059[c]

Table 6.8

Sub-period CAARs of stocks in liquidity beta sorted portfolios following shocks of -5% or less

This table presents average cumulative abnormal returns of stocks of decile portfolios sorted according to historical liquidity beta following shocks of -5% or less. Liquidity is measured by the proportional bid-ask spread, the turnover rate and the illiquidity ratio of Amihud (2002). Analysis covers three equal sub-periods. Panel A reports results for first sub-period from 1st July 1992 to 30th June 1997. Panel B present results for second sub-period from 1st July 1997 to 28th June 2002. Panel C shows results of third sub-period from 1st July 2002 to 29th June 2007. Sample consists of 642 stocks of FTSEALL share index constituents' list of February (2008). At 1st July each year, we estimate historical liquidity beta of each stock based on daily data of previous 5 years. Only stocks with continuing returns through estimation period are considered. For estimation, we use the model consisting of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor of the proportional bid-ask spread constructed following Liu (2006). After estimation, we sort stocks according to their historical liquidity betas and assign them to 10 decile portfolios, held for the following 12 months. The process is repeated annually. Each decile portfolio includes 27 to 52 stocks. Portfolio1 represents most liquid portfolio while portfolio10 is least liquid portfolio. Excess returns of each stock in each portfolio are regressed on the three factors of Fama and French (1993) and the momentum factor of Carhart (1997). OLS is used as estimator with Newey-West HAC Standard Errors & Covariance to adjust for serial correlation and heteroskedasticity. Residuals of each regression represent abnormal returns. Shocks are defined as abnormal returns of -5% or less. If two shocks happen within ten successive days, one of them is ignored to avoid confounding effects. $CAAR_d$ is average cumulative abnormal return after (d) days following shock averaged over full period of the study and over all stocks in portfolio. *Port* denotes portfolio. Level of significance of CAARs is estimated using Newey-West t-statistic. For normality assumption, a non-parametric sign test of null hypothesis of a zero CAAR is used when the number of CAARs included in the average is less than 30. [a] denotes statistical significance at 1% level, [b] at 5% level and [c] at 10% level.

Panel A: Results from 1st July 1992 to 30th June 1997											
CAARs of stocks in proportional spread portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0784[a]	0.0015	-0.0027	0.0001	0.0007	-0.0039	-0.0033	-0.0127	-0.0159	-0.0107	-0.0067
Port 10	-0.0875[a]	-0.0099[a]	-0.0106[a]	-0.0071[b]	-0.0068	-0.0005	0.0042	0.0068	0.0070	0.0075	0.0072
CAARs of stocks in turnover rate portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0832[a]	-0.0061[b]	-0.0108[b]	-0.0096[c]	-0.0056	-0.0023	-0.0012	-0.0029	-0.0039	-0.0027	-0.0016
Port 10	-0.0860[a]	-0.0093[a]	-0.0102[a]	-0.0081[b]	-0.0085[c]	-0.0026	0.0010	0.0038	0.0037	0.0030	0.0044
CAARs of stocks in illiquidity ratio portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0920[a]	-0.0038	-0.0129[b]	-0.0134[b]	-0.0117	-0.0085	-0.0038	-0.0084	-0.0109	-0.0117	-0.0110
Port 10	-0.0864[a]	-0.0111[a]	-0.0095[b]	-0.0050	-0.0047	0.0021	0.0054	0.0078	0.0056	0.0075	0.0077

Table 6.8 (continued)

Panel B: Results from 1st July 1997 to 28th June 2002											
CAARs of stocks in proportional spread portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0704[a]	0.0012	0.0074[b]	0.0085[b]	0.0098[b]	0.0124[a]	0.0144[a]	0.0162[a]	0.0177[a]	0.0202[a]	0.0180[a]
Port 10	-0.0827[a]	-0.0027[c]	-0.0022	0.0002	0.0023	0.0041	0.0078[b]	0.0075[b]	0.0079[b]	0.0083[b]	0.0083[b]
CAARs of stocks in turnover rate portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0762[a]	0.0007	0.0024	0.0051[b]	0.0071[a]	0.0097[a]	0.0124[a]	0.0143[a]	0.0161[a]	0.0186[a]	0.0189[a]
Port 10	-0.0839[a]	-0.0045[b]	-0.0030	0.0008	0.0025	0.0036	0.0052	0.0063	0.0076	0.0057	0.0067
CAARs of stocks in illiquidity ratio portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0725[a]	0.0051[a]	0.0071[a]	0.0081[a]	0.0092[a]	0.0100[a]	0.0123[a]	0.0132[a]	0.0139[a]	0.0157[a]	0.0144[a]
Port 10	-0.0835[a]	-0.0030	-0.0022	0.0000	0.0006	0.0019	0.0050	0.0055	0.0056	0.0054	0.0047
Panel C: Results from 1st July 2002 to 29th June 2007											
CAARs of stocks in proportional spread portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0779[a]	0.0042[b]	0.0047	0.0014	0.0023	0.0013	-0.0016	0.0026	0.0052	0.0043	0.0072
Port 10	-0.0780[a]	0.0030[b]	0.0070[a]	0.0090[a]	0.0077[a]	0.0086[a]	0.0088[a]	0.0092[a]	0.0088[a]	0.0083[b]	0.0065[c]
CAARs of stocks in turnover rate portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0782[a]	0.0037[b]	0.0060[a]	0.0074[a]	0.0079[b]	0.0049	0.0037	0.0049	0.0075[b]	0.0077[b]	0.0070[c]
Port 10	-0.0775[a]	0.0043[b]	0.0085[a]	0.0118[a]	0.0110[a]	0.0124[a]	0.0119[a]	0.0127[a]	0.0112[a]	0.0098[b]	0.0098[b]
CAARs of stocks of illiquidity ratio portfolios											
Port	**CAAR0**	**CAAR1**	**CAAR2**	**CAAR3**	**CAAR4**	**CAAR5**	**CAAR6**	**CAAR7**	**CAAR8**	**CAAR9**	**CAAR10**
Port 1	-0.0786[a]	0.0054[a]	0.0061[b]	0.0047[c]	0.0047	0.0040	0.0033	0.0051	0.0071[c]	0.0073[c]	0.0093[b]
Port 10	-0.0788[a]	0.0006	0.0036	0.0063[b]	0.0042	0.0057[c]	0.0049	0.0060	0.0060	0.0047	0.0035

6.4. Summary and conclusions

Extant research has found significant abnormal returns following large one-price changes (see, for example, Bremer and Sweeney, 1991; Lasfer et al., 2003; Spyrou et al., 2007; Mazouz et al., 2009). Atkins and Dyi (1990), Cox and Peterson (1994) and Park (1995) explain the CAARs following price shocks by the bid-ask spread bounce. Brown et al. (1989) argue that these CAARs result from the systematic variations of both the risk and return around price shocks. Lasfer et al. (2003) argue that the price anomalies following shocks are more pronounced in less liquid markets. These findings and the evidence concerning the important role of systematic liquidity risk in asset pricing (see, for example, Pastor and Stambaugh, 2003; Liu, 2006) have motivated us to examine the role of the systematic liquidity risk in explaining the stock price reaction to large one-day price changes. To the best of our knowledge, this study is the first to propose the systematic liquidity risk as an explanation of the price anomalies following price shocks. We argue that the different price reaction to large one-day price shocks between stocks may be explained by the variations in their systematic liquidity risk levels.

We examine the price reaction to one-day price shocks of FTSEALL shares index stocks over the period 1992-2007. Consistent with the uncertain information hypothesis of Brown et al. (1989), we find that investors undereact to positive shocks and overreact to negative shocks. This disagrees with Lasfer et al. (2003), Spyrou et al. (2007) and Mazouz et al. (2009), who document evidence in favour of the underreaction hypothesis following both positive and negative shocks. More importantly, we find that stocks with high return co-variation with the overall market liquidity drive the documented anomalies following price shocks. Thus, stocks with the least systematic liquidity risk react efficiently in most cases to positive and negative shocks of different trigger values. On the other hand, the least liquid stocks show significant CAARs following both positive and negative shocks. These findings suggest that systematic liquidity risk can explain, at least partially, the different price reaction to shocks. This evidence is robust to the use of proportional bid-ask spread, Amihud's (2002) illiquidity ratio and turnover rate as proxies of liquidity. With a few exceptions, the role of the systematic liquidity risk in leading the abnormal price behaviour is apparent across the different sub-periods.

A model that consists of the three factors of Fama and French (1993), the momentum factor of Carhart (1997) and the systematic liquidity risk factor cannot explain the abnormal returns following extreme events. This may be due to the potential biases associated with using a static asset pricing model. The next chapter tests whether conditional asset pricing models can perform better than the static models in explaining the abnormal returns following large one-day price changes.