Chapter 1
Introduction

1.1. Rationale of thesis

Liquidity is one of the most dominant topics in the market microstructure literature. It represents the lifeblood of the financial markets. Regulators are concerned with liquidity because it is the cornerstone of financial stability and well functioning of any financial market. Firms and investors cannot get in and out of the financial markets safely (without a significant loss) if these markets are illiquid. Thus, liquid markets pledge the ease of trading large quantities of assets at low transaction costs. Because of its crucial impact on various topics in finance, including asset prices models and cost of capital, academics are also interested in research on liquidity.

Market efficiency and price anomalies are important and controversial issues in finance. Over the past three decades, several studies have tried to find out whether financial markets are efficient or not. Indeed, both academics and practitioners have paid great attention to market efficiency. Well-functioning financial markets are fundamental to a prosperous economy because these markets facilitate price discovery, risk hedging and efficient allocation of capital. Thus, the efficient market is the basis of a well-functioning financial and economic system.

This thesis relates between liquidity and stock market efficiency. It includes three empirical chapters, each addressing a particular question. The first empirical chapter finds out whether systematic liquidity risk is priced in the London Stock Exchange (LSE). The second empirical chapter investigates whether systematic liquidity risk

can explain the price anomalies following large one-day shocks. The third empirical chapter analyses the relative importance of time-varying systematic risk and systematic liquidity risk in explaining the return anomalies following large one-day price shocks. The three chapters are based on the constituents of the FTSALL share index on February 2008. This thesis covers the period 1st July 1992 to 29th June 2007.

Early studies have focused on the interrelation between single stock's liquidity and its rate of return (see, for example, Amihud and Mendelson, 1986; Eleswarapu, 1997; Chalmers and Kadlec, 1998; Datar et al., 1998). The general conclusion of those researchers is that illiquid stocks significantly outperform liquid stocks. However, a growing body of liquidity research concentrates mainly on the overall market liquidity (i.e., systematic liquidity). Chordia et al. (2000) have shifted the emphasis of the liquidity literature. They argue that, among many reasons, studying systematic liquidity risk is essential because it may represent a source of undiversifiable risk that needs to be reflected in the required rate of return. Pastor and Stambaugh (2003) argue that when the economy enters a recession, causing aggregate market liquidity to be low, investors will require a return premium to compensate them for bearing liquidity risk. Specifically, investors who employ some form of leverage and face solvency constraint will require higher expected returns for holding assets difficult to sell when aggregate liquidity is low. Pastor and Stambaugh (2003) find US evidence that stocks with high sensitivity to aggregate liquidity generate higher returns than low-sensitivity stocks. They conclude that market-wide liquidity is an important state variable for asset pricing. Amihud (2002) and Liu (2006) also provide evidence from the US market that systematic liquidity

risk is priced. This thesis checks whether the US evidence exists in other major capital markets such as LSE. It also links the systematic liquidity risk to the concepts of market efficiency and price anomalies.

Rational asset-pricing theories assume that the cross-section of expected stock returns can be explained by a single risk factor (see Sharpe, 1964; Lintner, 1965) or a set of common risk factors related to the state of the economy (see Merton, 1973; Ross, 1976; Breeden, 1979). Consistently, a series of studies by Fama and French (1993, 1995, 1996 and 1998) have assumed that stock returns can be explained in a rational multifactor framework. The assumptions of these rational asset-pricing models satisfy Fama's (1970) definition of market efficiency. Fama (1970) has formally defined the efficient market hypothesis by the notion that prices should fully reflect all available information. Thus, no investor can outperform the market using any past, public available or private information. However, the efficient market hypothesis has been challenged by numerous price anomalies. Overreaction and underreaction are amongst the well-known anomalies debated by researchers. Price overreaction is first proposed by DeBondt and Thaler (1985) while underreaction is first documented by Jegadeesh and Titman (1993). The overreaction hypothesis states that a stock price usually reverses itself after the stock experiences a sharp increase or decrease in price. The underreaction hypothesis states that investors underreact to good and bad news, resulting in a significant return continuation. These two phenomena have been the focus of extensive research over the last two decades. The extant literature has developed many explanations to rationalise the observed price reversals and return continuations. Chan (1988), Ball and Kothari (1989), Wu (2002) and Wang (2003) argue that these anomalies are

nothing other than pricing errors resulting from the use of static rather than dynamic asset pricing models. Zarowin (1990) argues that overreaction is a manifestation of the size anomaly. Several studies find that the transaction cost of trading exceeds the documented abnormal returns (see, for example, Atkins and Dyi, 1990; Cox and Peterson, 1994; Li et al., 2008). Moskowitz and Grinblatt (1999) show that industry effects explain the observed momentum in the individual stocks (return continuations). Barberis et al. (1998), Daniel et al. (1998) and Hong and Stein (1999) use psychological concepts such as overconfidence, biased self-attribution, conservatism and representativeness to explain the investor behaviour in response to new information. This thesis examines the stock price reaction following large one-day price change in LSE and investigates the relative importance of systematic liquidity risk and time-varying risk in explaining it.

The remainder of this chapter is organised as follows: Section 1.2 describes the contribution of each of our empirical chapters to the literature, Section 1.3 presents the structure of the thesis.

1.2. Contributions to literature

This thesis includes three empirical chapters. The contribution of each chapter to the literature is summarised as follows.

1.2.1. Systematic liquidity risk and asset pricing: UK evidence

The first empirical chapter, Chapter 5, examines whether systematic liquidity risk is priced in the LSE. Most of the studies concerning this issue examine the US market (see, for example, Pastor and Stambaugh, 2003; Amihud, 2002; Liu, 2006). Previous studies find that systematic liquidity risk represents an undiversfiable source of risk. Thus, investors require higher rates of return on stocks whose returns are more sensitive to the aggregate market liquidity.

Consistently, this chapter inspects whether a stock's expected return depends on the sensitivity of its return to the innovation in aggregate liquidity[1]. That sensitivity is represented for each stock by its liquidity beta. The liquidity beta is defined as the slope coefficient of the aggregate liquidity factor in a multi-variate regression, which includes Fama and French (1993) factors and the momentum factor of Carhart (1997) as independent variables. The analysis in this chapter follows an individual stock approach and a portfolio approach. The individual stock approach is based on estimating the percentage of the sample stocks that have significant systematic liquidity risk coefficients. The portfolio approach proceeds as follows. On 1st July of each year starting from 1992, stocks are sorted according to historical liquidity betas and decile portfolios are formed. The post-formation returns on these portfolios during the next 12 months are linked across years to form a single return series for each decile portfolio. The excess returns on those portfolios are then regressed on different combinations of common risk factors. To the extent that the regression intercepts, or alphas, differ from zero, the systematic liquidity factor explains a component of expected returns not captured by exposures to the other factors. The

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[1] The innovation in aggregate liquidity is a precise estimate of the changes in aggregate market liquidity and thus liquidity shocks.

systematic liquidity risk factor is constructed following Liu (2006) as the payoff from taking a long position in the highest liquid portfolio and a short position in the lowest liquid portfolio. Given the multi-dimensional nature of liquidity, we employ three different liquidity measures throughout the thesis. Each measure reflects a different aspect of liquidity. These measures are the proportional quoted bid-ask spread, the Amihud's (2002) illiquidity ratio 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.

This chapter makes a number of contributions to the literature. First, it is the first to examine the role of the systematic liquidity risk in asset pricing in the LSE, one of the major capital markets around the world. Second, it investigates three different aspects of liquidity and thus it tells which aspect of liquidity is most vital in asset pricing, if liquidity is at all priced. Third, it presents a model that best explains the variations of stock returns in the LSE among twelve estimated asset pricing models. Finally, in addition to the Ordinary Least Squares (OLS) used by previous studies, Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models are used in this chapter to account for conditional heteroskedasticity, volatility clustering, leptokurtosis and leverage effects in returns. The importance of adjusting for the heteroskedastic nature in the error term is confirmed in various studies, including Corhay and Rad (1996), Batchelor and Orakcioglu (2003), Gregoriou et al. (2004) and Hahn and Reyes (2004).

The main findings of this chapter can be summarised as follows. The individual stock approach shows that approximately 50% to 90% of the sample stocks have significant liquidity betas, depending on the liquidity measure and the estimation method. The systematic liquidity factor outperforms the momentum factor of Carhart (1997) in explaining the stock returns. The best model that describes the variations of stock returns consists of the three Fama and French (1993) common risk factors, the momentum factor of Carhart (1997) and a mimicking liquidity factor (regardless of which liquidity measure is used). These results are robust to different estimation methods and regression error distributions. On the other hand, the portfolio approach provides evidence that systematic liquidity risk is priced only when liquidity is measured by the Amihud (2002) illiquidity ratio. This is consistent with the findings of Martinaiz et al. (2005) for the Spanish stock market. The results of this chapter seem to vary across different sub-periods. Specifically, the evidence that the illiquidity ratio of Amihud (2002) is priced exists in our earliest sub-period, but disappears in the two following sub-periods. This may be due to the introduction of new trading systems of the FTSEALL share index stocks, which in turn has improved the aggregate liquidity of the market and thus reduces investors' concerns with the liquidity risk.[2]

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[2]During the period 1986-1997, the trading of FTSEALL share index stocks was happening through SEAQ (stock exchange automated quotation system), that is, a dealership market. On 20th October 1997, the trading mechanism of FTSEALL share index stocks had been changed to an order-driven market where SETS (Stock Exchange Trading System) had been introduced. Since 4th November 2003, a hybrid market prevails, thus a new trading system has been introduced, which is SETSmm (Stock Exchange Trading System with Market Makers).

1.2.2. Systematic liquidity risk and stock price reaction to large one-day price changes

The second empirical chapter of this thesis, Chapter 6, examines the role of systematic liquidity risk in explaining the stock price reaction to large one-day price change in the LSE. A broad body of recent finance literature reports evidence that past historical prices can be used to predict stock returns. This evidence runs against the prediction of the efficient market hypothesis. DeBondt and Thaler (1985) find that stocks with bad performance in the past three years (loser portfolio) outperform stocks with good performance during the equivalent period (winner portfolio) three years subsequent to the date the portfolios have been formed. Howe (1986), Chopra et al. (1992) and Lehman (1990) confirm this price reversal evidence. In contrast, Jegadeesh and Titman (1993, 2001) find that stocks considered as loser or winner based on their returns over the last three to twelve months exhibit significant return continuation over the next same periods of time. Lasfer et al. (2003) and Spyrou et al. (2007) document significant returns continuation following large one-day price shocks. Researchers have suggested risk, investors' behavior and transaction cost as possible explanations for the observed price anomalies. The main contribution of this chapter is that it suggests a new possible rationalisation of the price anomalies documented following large one-day price shocks. Specifically, this chapter adds systematic liquidity risk to the growing list of candidates that may give a justification for this anomalous price behaviour.

The evidence of the critical role of the systematic liquidity risk in asset pricing is the motivation of this chapter. Pastor and Stambaugh (2003) find that systematic liquidity risk is indeed priced. We argue that the variations in this risk level between

stocks may explain their different price reactions to large one-day price shocks. Specifically, we expect that stocks with high sensitivity to the fluctuations in aggregate market liquidity are more likely to be affected by price shocks. Lasfer et al. (2003) find that less liquid markets, when liquidity is measured by market capitalisation, take longer time to absorb price shocks. As a result, the post-shock cumulative abnormal returns are more pronounced in these markets. Liu (2006) develops a liquidity augmented asset pricing model that consists of two factors, the market excess return and a mimicking market liquidity factor. Liu (2006) finds that the two-factor model well explains the variations of asset returns. Specifically, it can explain liquidity risk premium in addition to documented anomalies related to size, book to market ratio, cash flow to price ratio, dividend yield and long-term contrarian investment strategy. Finally, Sadka (2006) decomposes liquidity risk, when liquidity is measured by the price impact of trades, into variable and fixed components. He finds 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. It is the importance of systematic liquidity risk, documented in the extant literature, that motivates us to examine the role of this risk in explaining the stock price reaction to large one-day price shocks.

The methodology of this chapter is mainly based on comparing the cumulative abnormal returns following large one-day price shocks between high liquidity beta and low liquidity beta stocks. In particular, we start with sorting stocks according to their historical liquidity betas and assigning them to decile portfolios. Then, we calculate the average cumulative abnormal returns (CAARs) up to 10 days following

the shock day for each stock in each decile portfolio. The abnormal returns represent the residuals from the four-factor model consisting of the three Fama and French common risk factors and the momentum factor of Carhart (1997) (C-F&F hereafter). Positive price shocks are defined as the abnormal returns of 5%, 10% and 20% or more, while the negative price shocks are defined as the abnormal returns of -5%, -10% and -20% or less.

The main findings of this chapter can be summarised as follows. The reaction of the FTSEALL share index stocks to large one-day shocks follows the uncertain information hypothesis of Brown et al. (1988). Specifically, there is a significant underreaction (return continuation) that lasts up to several days following shocks of 5%, 10% and 20% or more. Alternatively, there is evidence of a delayed overreaction (price reversal) following shocks of -5%, -10% and -20% or less that lasts up to 10 days after the shock. These findings are different from the findings of Lasfer et al. (2003) and Spyrou et al. (2007) who document significant return continuation following both positive and negative shocks in the short-run. There is an important role of the systematic liquidity risk in explaining the price reaction to large shocks. Thus, while stocks with the highest systematic liquidity beta, the least liquid stocks, show anomalous behaviour following large one-day shocks, the most liquid stocks in most cases react efficiently to them. This evidence is stronger when proportional bid-ask spread and Amihud's (2002) illiquidity ratio are used as liquidity measures than when the turnover rate is used. However, a liquidity augmented C-F&F does not explain the abnormal returns following large one-day price changes. We argue that the way we adjust for the systematic liquidity risk may not be appropriate. Specifically, we expect that the abnormal returns may result from

the use of static versions of the asset pricing models. In other words, a conditional version of the liquidity augmented C-F&F may perform better than the static C-F&F in explaining the return anomalies following large one-day price changes. We will examine this issue further in the next chapter. The sub-period analysis shows that the results of this chapter are varying over time. This is expected because market liquidity tends to improve over time as a result of developing new trading systems and increasing the numbers of companies and investors. However, most liquid and least liquid stocks still react differently to large one-day price changes in most sub-periods.

1.2.3. Time-varying risk and stock price reaction to large one-day price changes

The third empirical chapter of this thesis, Chapter 7, investigates whether time-varying risks can explain the price anomalies following large one-day price changes in LSE. Our motivation in this chapter is that, in a dynamic world, risk exposures as well as prices of risk are likely to vary over time. The extant literature confirms the time-varying nature of both risk and return (see, for example, Fabozzi and Francis, 1978; Bollerslev et al., 1988; Wang, 2003; Ferson et al., 2006; Ammann and Verhofen, 2008). Chan (1988), Ball and Kothari (1989), Wu (2002) and Chordia and Shivakumar (2002) are among the studies that relate overreaction and underreaction of winner and loser portfolios to the poor performance of the static asset pricing models. In fact, those researchers argue that time-varying risk is the primary source of momentum and reversal profits documented by Jegadeesh and Titman (1993) and DeBondt and Thaler (1985), respectively. Brown et al. (1988) argue that major informational surprises increase both the risk and the expected return of the affected

companies in a systematic manner. Motivated by the findings of those researchers, this chapter is the first to show whether the dynamic versions of the asset pricing models can explain the documented abnormal returns following large one-day price shocks. Specifically, we expect that time-varying risk may explain the abnormal returns following large one-day price changes.

The chapter uses a unique methodology to estimate time-varying coefficients of common risk factors for each stock. Previous studies have mainly focused on two approaches: the Kalman filter approach and the multivariate GARCH models[3]. These approaches suffer from the problem of complexity and difficulty to use and in some cases they become problematic when more dynamics are added to the estimation process (Harris et al., 2007).

Harris et al. (2007) develop a simple, easy to use, flexible and at the same time efficient approach to estimate conditional covariances. In particular, a simplified GARCH model (S-GARCH) based on the estimation of only univariate GARCH models, both for the individual return series and for the sum and difference of each pair of series. The covariance between each pair is then imputed from these variance estimates. This chapter uses the Harris et al. (2007) approach to estimate the time-varying coefficients of the common risk factors for each stock. After adjusting the returns of the sample stocks to time-varying risks, the behaviour of the conditional returns is examined following large one-day price changes of different magnitudes.

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[3] Examples of the papers using GARCH models are Bollerslev et al. (1988), Engle and Rodrigues (1989), Ng (1991), Bodurtha and Mark (1991), Koutmos et al. (1994), Giannopoulos (1995), Braun et al. (1995), Gonzalez-Rivera (1996), Yun (2002) and Bali (2008). Similarly, many authors use the Kalman filter to estimate time-varying coefficients, such as Black et al. (1992), Well (1994), Huang and Hueng (2008) and Adrian and Franzoni (2008).

The methodology proceeds by analysing the relative importance of the time-varying and systematic liquidity risks in explaining the documented price anomalies following large one-day shocks. This is done by comparing the behaviour of the conditional returns between the stocks of decile portfolios sorted according to the historical liquidity beta.

The findings of this chapter can be summarised as follows. The evidence of stock price reaction to large one-day price shocks reported in Chapter 6 changes significantly after adjusting for time-varying risk. Particularly, the FTSEALL share index stocks react efficiently to shocks of 10% and 20% or more and to shocks of -5%, -10% and -20% or less. Only one-day price reversal is found following shocks of 5% or more. Hence, time-varying risk plays a very important role in explaining the observed overreaction and underreaction following large one-day price changes. In fact, it explains nearly all of these anomalies. Time-varying risk is more important than systematic liquidity risk in explaining the price reaction of the stocks of different liquidity beta sorted portfolios. Regardless of the liquidity measure, most stocks in both liquid and illiquid portfolios show insignificant S-GARCH-based average cumulative abnormal returns (CAARs) following both positive and negative shocks. A few portfolios exhibit significant overreaction following positive shocks. The smallest liquidity beta stocks underreact to the negative large one-day price changes. Overall, the conditional four-factor model of Carhart (1997) (C-F&F) and the conditional version of the liquidity augmented C-F&F are superior in explaining the return variations of FTSEALL stocks than their static versions. These findings are robust to different sub-periods and different versions of GARCH models.

1.3. Structure of thesis

The rest of the thesis is structured as follows. Chapter 2 provides some background on the liquidity phenomenon from the market microstructure perspective. Chapter 3 defines liquidity, discusses its dimensions, explains its measures and reviews its empirical effects on assets pricing. Chapter 4 reviews the efficient market hypothesis and the two well-known price anomalies, momentum and price reversal. Chapter 5 examines whether systematic liquidity risk is priced in LSE. Chapter 6 focuses on the role of systematic liquidity risk in explaining the price anomalies following large one-day price changes. Chapter 7 highlights the importance of the time-varying nature of the systematic risk in explaining the underreaction and the overreaction phenomena observed subsequent to large one-day price changes. Chapter 8 is a conclusion of the main results.