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### **Diplomová práce**

## **New challenges in managing liquidity risk – Liquidity Black Holes**

**Autor diplomové práce: Martin Holovka**

**Vedoucí diplomové práce: RNDr. Jiří Witzany, Ph.D**

## **Prohlášení**

Prohlašuji, že jsem diplomovou práci zpracoval samostatně a že jsem uvedl všechny použité prameny a literaturu, ze kterých jsem čerpal.

V Praze, dne

.....  
podpis

### **Poděkování**

Na tomto místě bych rád poděkoval vedoucímu své diplomové práce panu RNDr. Jiří Witzanymu, Ph.D, který si vždy našel čas trpělivě se mi věnovat a poskytl mi mnoho cenných rad. Dále bych rád poděkoval panu Ing. Janu Kubíkovi a panu Mgr. Tomáši Vlkovi za pomoc při získávání klíčových dat pro tuto diplomovou práci.

### Annotation:

Following the financial turmoil in 2007/2008 liquidity black holes (LBH) has become arising topic often discussed among academics as well as portfolio managers all around the world. More recent view on liquidity risk covers those liquidity black holes which occur when the liquidity completely dries up in a particular market and the market becomes one-sided. There are basically 2 channels through which liquidity can be affected - Demand and Supply. In first case, the portfolios of investors lose the value and consequently the investors lose confidence in financial system. In the second case, banks hit their capital constraints, they tighten the terms of providing credits and loans to reduce the credit risk exposure and hence it becomes more difficult for firms to raise the funds. At this point dangerous spiral arises and the liquidity of financial system evaporates rapidly. The crucial point of this master thesis is to find the main determinants of Liquidity Black holes and find possible solutions to avoid their appearance.

### Anotace:

V návaznosti na finanční krizi v letech 2007/2008 se pojem „Liquidity Black Holes“ stal často diskutovaným tématem v akademických kruzích, stejně tak jako mezi portfolio manažeri po celém světě. Novější pohled na likviditní riziko bere v potaz „Liquidity Black Holes“, které se objevují, když likvidita zcela zmizí z určitého trhu a ten se tak stává jednostranný. V zásadě existují 2 kanály, přes které může být ovlivněna likvidita – kanál poptávky a nabídky. V prvním případě, portfolia investorů ztrácí hodnotu a v důsledku toho investoři ztrácí důvěru ve finanční systém. V druhém případě je postižen kapitál bank, a tyto instituce poté zpřísní podmínky poskytování úvěrů a půjček, tak aby snížily úvěrovou expozici, což nakonec vede k obtížnějšímu přístupu jednotlivých korporací ke zdroji finančních prostředků. V tomto momentě vzniká nebezpečná spirála a likvidita celého finančního systému se může zcela vytratit. Cílem této diplomové práce je zjistit hlavní faktory „Liquidity Black Holes“ a hledat možná řešení, aby se zabránilo jejich vzniku.

*“When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you’ve got to get up and dance. We’re still dancing,”*

[Chuck Prince, CEO of CityGroup, 2007]

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# Introduction

Following the financial turmoil in 2007/2009 liquidity black holes has become arising topic often discussed among academics as well as portfolio managers all around the world. More recent view on liquidity risk covers those liquidity black holes which occur when the liquidity completely dries up in a particular market and the market becomes one-sided. It means that the majority of market participants want to undergo the same type of transaction (e.g., selling or buying) but there is almost no counterparty for this contract. Since majority of traders want to close the position as soon as possible they are willing to sell the assets at fire-sale prices which are below the average price. The fair value of the asset is then hard to assess. These findings are in contrast with the theory that the development of modern technologies and worldwide networks implemented in financial markets should provide better liquidity for all assets. In well-functioning financial markets the decreases in asset prices should attract new prospective investors and the equilibrium should be restored. However, sometimes is the decrease big enough and leads to further selling which generates greater discounts in asset prices till the point the asset is untradeable.

There are basically 2 channels through which liquidity can be affected - Demand and Supply. In first case, the portfolios of investors lose the value and consequently the investors lose confidence in financial system. In the second case, banks hit their capital constraints, they tighten the terms of providing credits and loans to reduce the credit risk exposure and hence it becomes more difficult for firms to raise the funds. At this point dangerous spiral arises and the liquidity of financial system evaporates rapidly.

The main problem of Liquidity black holes is that it is very difficult to predict their appearance and determine their duration. Often cited examples of Liquidity black holes are Asian crisis in 1987, Russian debt crisis (connected with LTCM in USA) and more recently 2007 American subprime mortgage crises. However, there is one major difference - the role liquidity played in the meltdown of the global financial system in 2008. The causal relation as pointed out by Alan Greenspan in a speech in 1999 was reversed<sup>1</sup>. Not the crisis affected the liquidity of financial markets but drops in the liquidity of a range of assets lead directly into the crisis of 2008.

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<sup>1</sup> Greenspan A., (October 1999) , *Measuring Financial Risk in the Twenty-first century*, <http://www.federalreserve.gov/boarddocs/speeches/1999/19991014.htm>

It is clear, that frequency of liquidity black holes is increasing and this tendency will continue in near future. Even though this risk is less easy to quantify (in fact one cannot) this type of risk is more serious.

One of typical properties of liquidity black holes is that they are extremely rare (as the real physical phenomena) and hence, probability of occurring is extremely low. But on the other hand if they occur, enormous losses (including bankruptcies) that might result in system crises are incurred and cannot easily be avoided.

Forthcoming question is “What are the causes of those liquidity black holes?” Positive feed-back traders (such as Stop-loss rules, Dynamic Hedging, Margins, etc.) are often mentioned as the answer. Among other sources we can identify leveraging and deleveraging, impact of capital requirements and last but not least Irrational Exuberance –term used again by Alan Greenspan, former chairman of Federal Reserve in a speech in 1996.

Precise definition of liquidity black holes was provided by Morris, Shinn (2003) saying<sup>2</sup>:

*A liquidity black hole is the analogue of the run outcome model in a bank – run model. Short-horizon traders sell because others sell... liquidity black holes have the feature that they seem to gather momentum from the endogenous responses of the market participants themselves. Rather like a tropical storm, they appear to gather more energy as they develop.*

Another definition provides liquidity risk pioneer Avinash Persuad in his book devoted to liquidity Black Holes<sup>3</sup>:

*What we should be more concerned about however is an ill – functioning market where price declines (or rises) cause – through market mechanisms – more sellers to appear, not bargain – hunting buyers, initially pushing prices well – beyond the levels they will eventually settle at....Our theory of Liquidity Black Holes suggests that they would be more in markets that are homogenous and lacking in diversity in positions, views and risk management and less prevalent in markets that are more heterogeneous*

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<sup>2</sup> Morris S., Shin H. (2003/4) *Liquidity Black Holes*, Review of Finance, page 2

<sup>3</sup> Persuad, A.(2003) *Liquidity Black Holes Understanding, Quantifying and Managing Financial Liquidity Risk* management books, first edition, p. 101



In well-functioning market, large price changes entail the fact that news can be incorporated quickly with respect to the importance of new information. These markets might suffer from large price movements but within few moments the trading activity is restored at lower/higher price. On the opposite, liquidity black holes are accompanied by such a volatility that market is not well-functioning and one-way order flow destabilize market even more. Strategic interaction of traders is mutually reinforcing rather than offsetting.<sup>4</sup> Historically, there were basically 3 factors determining market liquidity – market depth (or breadth), tightness (trading costs) and resiliency. From modern point of view it is necessary to add one more factor – diversity. By the diversity we mean the diversity in opinions, i.e. if we want to sell there must be some counterparty who wants to buy.<sup>5</sup>

We are quite aware that liquidity risk was rather underestimated over a long period. In this master thesis we will discuss current concepts of liquidity risk and market liquidity, all the above mentioned causes of liquidity black holes and their appearance in history and we will examine the occurrence of liquidity black holes in Czech financial markets. We will devote particular attention to Czech Stock market, inter-bank market and foreign exchange market.

This master thesis is structured as follows: First section deals with concept of market liquidity and liquidity risk as a whole. Second section is devoted to the literature review of actual academic journals about liquidity black holes. Third section is represented by an overview of the biggest liquidity black holes in history and lessons learned. In section 4 we will learn about measures of liquidity black holes and we will also cover new liquidity risk measures as proposed by Basel committee for bank supervision. In section 5 we will test theoretical predictions by applying measures described in section 4 and last part of this master thesis is concerned with discussion of results, solutions conclusion and future steps in liquidity risk.

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<sup>4</sup> Persuad A. (2003) *Liquidity Black Holes – Understanding, Quantifying and Managing Financial Liquidity risk*, Risk Books, First edition

<sup>5</sup> Persuad A. (2003) *Liquidity Black Holes – Understanding, Quantifying and Managing Financial Liquidity risk*, Risk Books, First edition

# 1. Sources of liquidity risk – Market liquidity

There are several sources of Liquidity risk. Firstly, we must precisely define what liquidity means to identify and better understand the potential sources of liquidity risk. Basically, there are two types of liquidity - accounting and market liquidity. Accounting liquidity refers to the ability of a debtor to pay his debts as they become due. In contrast, market liquidity represents the opportunity to sell the asset without impact on price of the asset. Liquid asset can be sold anytime (within market hours) with minimum loss of value. However, these two types of liquidity are closely connected. The more liquid assets are in bank's portfolio the higher is the ability to repay the liabilities in time.

There are many definitions of liquidity and liquidity risk by various regulators and supervisors. To pick some of them, we choose for instance the definition by Bank for international settlement (BIS) which is: "*A liquid market is market where participants can rapidly execute large volume transactions with a small impact on prices*"<sup>6</sup>. Financial markets provide this type of liquidity in three main forms – central bank money (bank notes issued by central banks), commercial bank money or deposits (available through ATM machines) and securities traded in financial markets. Liquidity goes hand in hand with solvency which stands for inability of company to operate in its activities over a long-term period. Lack of liquidity might affect solvency and vice versa.

It is impossible to measure liquidity directly but there exist some certain ratios to capture the effect of liquidity indirectly. The precondition of liquid market is that there are always potential buyers and sellers willing to enter into the transaction.

However, there are more characteristics which determine the liquidity - market depth, resiliency and trading costs. Market depth is the market's ability to sustain relatively large market orders without impacting the price of security.<sup>7</sup> In other words, if the market is deep the large order needs to be made to have some impact on the price of the asset. There exists direct link between liquidity and the market depth – Deep market equals liquid market. In contrast, market breadth is the opposite concept of market depth. The concept of resiliency assumes that trading of financial instruments (especially in large block sales) leads to short-term misvaluations and errors in asset pricing. The speed at which these errors disappear and price of the instrument is reverted to the mean is so called resiliency.

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<sup>6</sup> *Market Liquidity: Research Findings and Selected Policy Implications Report*, (1999) Report of a Study Group established by the Committee on the Global Financial System, Basle 1999, CGFS publication no 11, page 6

<sup>7</sup> <http://www.investopedia.com/terms/m/marketdepth.asp>

Trading costs are often neglected but they can play very important role in case they are variable and related to the size of transaction.

The liquidity is connected through umbilical cord with risk and return. While the trade-off between risk and return is well-known and relatively easy to measure the relationship between liquidity and risk or liquidity and return is less popular. This is because liquidity is usually considered to be one source of risk apart from e.g. credit or market risk. Thus, the relationship among return, liquidity and risk is quite ambiguous. Henry Markowitz based his work on his modern portfolio theory (Don't put all the eggs in one basket) comparing the risk and return. Following the modern portfolio theory the famous CAPM model was invented by William Sharpe and then this model was extended and some new asset pricing models were added (Fama-French 3-factor model, APT, Carhart model, etc.) The problem is that these models usually don't take into account the liquidity. These models assume frictionless markets in which securities are traded costlessly but there is nothing about trading activity. Let me show this on the CAPM model which is based on several assumptions. According to CAPM, we assume that investors with homogenous expectations share the same information which means there is no information asymmetry or insider trading. Hence, all the investors hold the same, well-diversified portfolios to rule out the idiosyncratic risk. This fact results in a situation when investors have no incentives to trade and thus, the market is presumed to be illiquid. Obviously this is not true since billions of securities change its owners every day. This fact is explained by relaxing the assumption of homogenous expectations and giving the appropriate weight to private information. The effect of (i)liquidity was incorporated into CAPM model by Acharia, Pedersen (2003) and we will discuss it shortly in the next section.

To sum it up, liquidity is one of the key factors determining the price of the asset and its crucial importance arises in times of increased volatility over the financial markets.

We have already noted that the liquidity is hard to gauge. In general, the bid-ask spread is used. Dealers on the financial markets must hold large inventory of financial instruments. The willingness of holding particular asset is assessed just by this spread. If the dealer feels that some particular asset is more risky he widens the bid-ask spread (i.e. he lowers the bid and increases the ask) simply because his profit is the difference between those two characteristics. Thus, the bid-ask spread is the reward for supplying the liquidity for the dealer and the trading cost for the investor. This spread should reflect general forecast of market participants of unwinding the position in a particular financial instrument. General problem of the bid-ask spreads is that they are quoted only for small trades and actual spreads widen

substantially, the larger the size of the transaction (i.e. when market is under a stress). Paradoxically, bid–ask spreads are not good measures in situations when these measures are urgently needed.<sup>8</sup> Nowadays, electronic trading reduces the importance of the dealer who is replaced by the limit order book. Buy and sell orders are matched in accordance with “inside spread” that is the difference between the highest price the buyer is willing to pay and the lowest price at which another seller is willing to sell. Electronic trading diminishes the problems with inventory but the problem with information asymmetry remains and it escalates the classic *lemon problem*.

One might expect that according to recent market trends (globalization of financial markets, consolidation of stock exchanges, securitization, electronic trading) the market liquidity would strengthen. In fact, this is not the case. The fragility of financial markets has increased and numerous black holes at which liquidity vanished have occurred. The main reason for that is the lack of diversity, which is crucial for liquidity. The forthcoming consequences might be extremely negative and liquidity crises might change into insolvency crises. That’s why the market liquidity is monitored by Central Banks and partially managed by money market operations such as selling and repurchasing treasury bills. These operations are mainly settled between central and commercial banks and thus, these are the most important market participants. There are different types of markets such as government bond markets, foreign exchange markets, equity or stock markets which are more or less liquid. Either way all the above mentioned markets are sometimes hit by some liquidity black holes.

## **1.1. Liquidity risk management**

Liquidity risk is not well-covered in risk management books in which analysis of credit, market or commodity risks are predominant issues. To tackle the problem of liquidity risk management we have to emphasize the position of Basel committee on banking supervision, responsible for setting rules and recommendations in managing risk for financial institutions. One of the main goals of Basel Committee was to underpin the capital and liquidity adequacy.<sup>9</sup> While the capital adequacy ratio was successfully implemented the agreement on managing liquidity risk failed. We witnessed this situation during the recent financial crisis. Even though there were years of ample liquidity in history, it is clear that nowadays can liquidity disappear in a while. The widespread trend within this period was to

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<sup>8</sup> Persaud, A. (2002) *Liquidity Black Holes: And Why Modern Financial Regulation in Developed Countries is making Short-Term Capital Flows to Developing Countries Even More Volatile* ; UN discussion paper No. 2002/31

<sup>9</sup> C.A.E. Goodhart (2007)– *Liquidity Risk Management*, Special Paper 175, LSE Financial markets group

finance long-term assets by relatively short-term borrowing in wholesale market. In addition, banks were heavily using the off-balance sheets to hide some certain facts. When the financial crisis was in its peak central banks or governments started pumping liquidity through repo-operations to commercial banks and giving additional incentives to prevent them from bankruptcy. As a typical example of this happening might serve the TARP (Trouble asset relief program) that indirectly deliver the liquidity to the banks.

Liquidity risk depends on internal and external forces. In other words, some aspects of liquidity risk are firm-specific and can be assigned to a particular company (endogenous liquidity) while other aspects are common for many institutions or eventually for the entire market (exogenous liquidity). In next sub-chapters we will describe 2 main approaches in managing liquidity risk - liquidity funding risk and liquidity trading risk.

## **1.2. Liquidity Funding risk**

Liquidity funding risk corresponds to ability to meet cash needs that are necessary for covering the liabilities as they fall due. Many liquidity ratios have been developed to assess company's financial wealth such as working capital ratio, liquidity coverage ratio or capital expenditure ratio. The key factor is the sum of assets, which should be higher than sum of all obligations. However, this is not the solution of entire problem. We must take into account the maturity and the interest rate mismatch of assets and liabilities. To put it differently, the ample size of assets (overwhelming the size of liabilities) does not guarantee liquidity risk-free situation because if the maturity and interest rates of assets and liabilities differs then the company might become consequently illiquid. That is why the GAP analysis was established.

GAP analysis identifies the difference between assets and liabilities. If GAP is positive ( $GAP > 0$ ) then the company suffers from insufficient funds to finance its assets. On the other hand if GAP is negative ( $GAP < 0$ ) then the company owns an ample amount of funds regarding to its assets. Portfolio managers (especially those managing portfolio in pension funds) are used to immunize portfolio and to synchronize assets and liabilities according to the concept of duration, which primarily serves for managing interest rate risk. The duration is defined as the weighted average of the times until each payment is made, with weights proportional to present value of the payment. The process of immunization goes as follows: In first step, the duration of assets and liabilities is calculated. Having the assets and liabilities durations calculated it is necessary to find optimal asset mix such as both durations were equal. The result of this is some particular weight  $w$  that is assigned to assets and  $(1-w)$  assigned to liabilities. Finally, we can assess how to fully fund the obligations. Because of the

convexity of some instruments (e.g. bonds) we must recalculate durations every year (or even more frequently) and rebalance the asset mix to eliminate the interest rate risk. Thus, by diminishing the interest rate risk, we also mitigate the potential liquidity risk resulting from asset-liability mismatch.

In some cases trading/asset and funding risk goes together, similarly like the accounting and market liquidity, generating new type of risk joint asset/funding liquidity risk. This type of risk reflects the situations in which the potential loss lies in inability to access funding and assets cannot be converted into cash in order to meet obligations.<sup>10</sup> Simultaneous effects of liquidity funding and trading risk might cause liquidity spiral leading to liquidity black holes. This spiral is the mixture of the loss of investor's confidence and the inability of management to deal with the crisis ending with the company in financial distress.

The liquidity of an institution is strengthened by accessibility to cash and cash-equivalent instruments, securitization, the ability to liquidate trading book positions, to borrow money in the wholesale market, borrowing from the banks and central banks, or by less defaults by counterparties<sup>11</sup>. Obviously, some of these sources failed during the financial crisis in 2007-2009. Namely, we can mention the destruction of inter-bank market, the failure of the securitization process when even highly-rated CDOs have become untradeable. Recently, the liquidity funding risk increased due to complexity of some financial instruments with uncertain liquidity as well. The inevitability of subsequent defaults of companies is the result of other typical characteristic of liquidity – contagion. Secondly, we have to note that banks are running into liquidity problem as a consequence of losses incurred earlier due to credit, market or operational risk. Partially, it is fault of regulatory and supervisory institutions whose reports, recommendations and working papers usually omitted the liquidity risk. For instance, famous Basel II Accord considers this type of risk only in one tiny paragraph. At this point Basel committee for banking supervision (BCBS) released a set of 17 principles in reaction of previous events and perhaps in anticipation of subsequent events triggered by the fall of Lehman Brothers. By releasing this guidance BCBS emphasized poor quality of some of the liquidity risk frameworks used by international banks which were dramatically underestimating the severance of potential risk in times of normal market conditions when liquidity was plentiful. These 17 principles are organized in 5 sections and each section deals with fundamental principles for the management and supervision of

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<sup>10</sup> Banks E. (2005), *Liquidity risk: Managing asset and funding risk*, 2005, 1<sup>st</sup> edition, Palgrave Macmillan, chapter 1

<sup>11</sup> Hull J. (2009) *Risk Management and Financial Institutions*, Second edition, Pearson Education, Inc

liquidity risk, governance of liquidity risk management, measurement and management of liquidity risk, public disclosure and the role of supervisors. In our humble opinion these rules are too much general and less specific. It suggests only the implementation of basic unspecified strategies, the importance of proper governance structure, the importance of regular disclosure but not much more. For example, in principle 1 - A bank is responsible for the sound management of liquidity risk (abbreviated form) is in the description below this principle stated: " *a bank should hold an adequate liquidity cushion comprised of readily marketable assets to be in a position to survive such periods of liquidity stress*"<sup>12</sup>. But there is nothing about how to calculate this liquidity cushion or what is supposed to be the marketable assets. Even in the section devoted to the measuring liquidity risk we could not find any concrete solution. It is true, that different banks follow different strategies and therefore their cash needs might vary. Moreover, the risks they face are different - for instance while commercial banks probably deal with liquidity funding risk more, for investment banks is liquidity trading risk more severe. And here is another problem - Should there be different set of rules for investment banks and commercial banks? Yet, there are universal banks which cover both – commercial banking as well as investment banking. Notwithstanding, usually one of those characteristics prevails. Things might change due to new proposal of president of the United States Barrack Obama, who strives for separation of investment and commercial banks. The split of universal banks and its impact on regulation might be interesting for further research but it is not the goal of our thesis.

To be fair, there are lots of useful recommendations in the set of principles which involve large part of liquidity risk. We find the problem that these are just recommendations and not the rules and in some cases the word *should* might be replaced by word *must*

It is clear that even these principles did not avert following financial crisis but the question is whether the strengthened regulation and supervision deepened or mitigated whole financial crisis. Definitely, the subsequent financial crisis inflated new revised set of papers dealing with the liquidity risk in 2009. We will try to answer the question to which extent these papers contributed to improvements in this area and whether reflect the current phenomenon – the liquidity black holes.

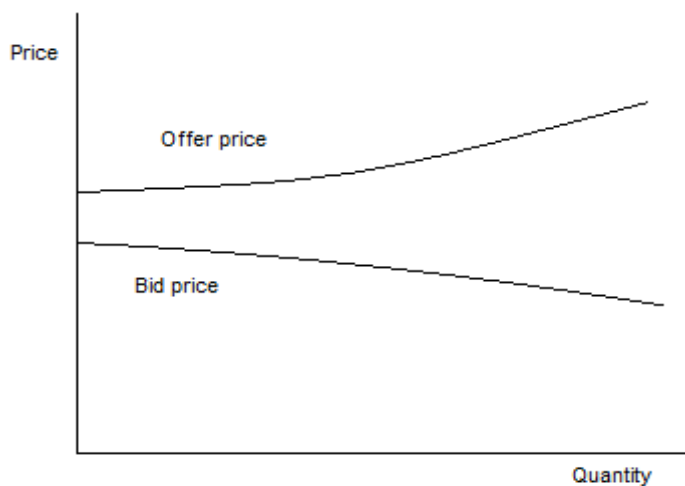
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<sup>12</sup> BCBS(2008) *Principles for Sound Liquidity Risk Management and Supervision*, September 2008, page 6

### 1.3. Liquidity trading risk

This type of risk (also called asset risk) stems from the size of transaction and its impact on price of the asset traded. It is clear that if we are trading only few securities (e.g. shares) the price impact will be close to zero. However, the large size of one particular trade might convey signal to the market and establish additional demand causing changes in price of the instrument. As stated above, the bid-ask spread is then widened as depicted on the graph below:

Figure 1: Bid and Offer prices as a function of quantity transacted



Source: Hull J. (2009)– Risk management and Financial institutions 2<sup>nd</sup> edition

It is important to note that this relationship as shown in Figure 1 doesn't hold in all markets. Consider, retail foreign exchange market where individual persons want to exchange one currency for another for whatever reason. As the size of the transaction grows up the individual customer gets better or even prime rate or eventually the contract is closed for mid-price. In this paper we will omit these specific markets and we will focus on the markets which comply with situations presented in Figure 1. Yet, it is clear how liquidity affects the pricing of the assets. It gives rise to the extended CAPM called liquidity adjusted Capital asset pricing model invented by Acharya V. and Pedersen L. in 2003. In their paper, they find empirical evidence that expected return of any particular asset increases with its illiquidity (including trading costs) and the “net Beta”- the net beta can be decomposed into the sensitivity of the security's return and tradability to market downturns as well as to liquidity



crises.<sup>13</sup> In other words, they include the expected level of liquidity of asset as well as unanticipated changes in market liquidity. Thus, the adjusted model of CAPM contains besides systemic beta the firm-specific component. Acharya, Pedersen (2003) came up with the alternative for the criticized CAPM. However, “classic” CAPM model is still predominant in financial world. In our opinion, the unpopularity of liquidity adjusted CAPM consist in the complexity of its calculation. While CAPM is easy to compute and widely accepted, it is preferred from the less known and more difficult to understand liquidity-adjusted CAPM. On the other hand, the velocity of the recent financial crisis showed up the importance of managing liquidity risk.

The severity of liquidity risk depends on whether is the trader unwinding his position optimally. The trader has to solve classic trade-off between size and the speed of the transaction. If he decides to leave the position quickly he is exposed to increases in bid-offer spreads but he faces lower potential losses from adverse movements in stock prices and thus lower market risk. Oppositely, Unwinding position slowly leads to lower changes in bid-offer spreads but the market risk increases. To gauge the cost of liquidation and then using following risk measures we must firstly define proportional bid – offer spread:

$$s = \frac{\text{Offer price} - \text{Bid price}}{\text{Mid-market price}} \quad (1.1)$$

At this point we can express Cost of liquidation under normal market condition as:

$$\sum_{i=1}^n \frac{1}{2} S_i \alpha_i \quad (1.2)$$

Where  $S$  stands for proportional bid – offer spread for the  $i$ -th financial instrument  $\alpha_i$  represents the dollar (mid-market) value of the position in the instrument and  $n$  is the number of positions. More interestingly we can express cost of liquidation under stress market condition as:

$$\sum_{i=1}^n \frac{1}{2} (\mu_i + \lambda_i \sigma_i) \alpha_i \quad (1.3)$$

Where  $\mu_i$  is the mean and  $\sigma_i$  is the standard deviation of the proportional spread and  $\lambda_i$  represents the confidence level – “the worst  $X\%$  scenario”. This equation assumes perfect correlation of spreads in all instruments. At first glance, it looks like too conservative but when liquidity is tight it is usually the same for all the instruments.

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<sup>13</sup> Acharya , Pedersen L., (2003)*Asset Pricing with Liquidity Risk* Department of Finance, NYU Stern

Having those two characteristics of liquidity we can finally measure the overall liquidity risk by applying adjusted measure of Value at Risk (VaR). VaR refers to the value that can be lost on a certain portfolio V, over a given period N with certain confidence level X:

$$VaR = Pr \left[ (P_{t+n} - P_t) < -V \right] = 1 - X \quad (1.4)$$

Where  $P_t$  is the value of the portfolio at time t. In other words, we are X% sure that we will not lose more than V unit of currency over a given period N. Standard VaR assumes that one can sell the entire portfolio in the respective markets within the investment horizon (usually a day) without generating price effects in the market. Thus, the standard VaR understate the real Value at Risk. Therefore, in case of measuring liquidity risk, we have to modify the previous equation by implementing the previous measures as follows:

$$Liquidity - adjusted \quad VaR_{norm} = VaR + \sum_{i=1}^n \frac{1}{2} S_i \alpha_i \quad (1.5)$$

Which is regular VaR extended by cost of liquidity of unwinding positions in a normal market. The adjustments for the liquidity VaR under stress market conditions is then quite straightforward:

$$Liquidity - adjusted \quad VaR_{stress} = VaR + \sum_{i=1}^n \frac{1}{2} (\mu_i + \lambda_i \sigma_i) \alpha_i^{14} \quad (1.6)$$

The main advantage of this measure is the simplicity of its calculation and easy interpretation. VaR is widely used measure and accepted by the regulators and supervision bodies. It gives us the answer for the question “How bad can things get?” However, it does not tell us anything about what is the expected loss in case “things get bad.” In this case it is useful to introduce new measure – the expected shortfall which is often referred as conditional VaR. Expected shortfall tell us something about what’s going on in the “tales” of probability distribution (i.e. in extreme situations) In contrast, expected shortfall is more difficult to calculate and less easy to interpret and back-test than simple VaR. Moreover, the calculation gets much complicated if the probability distribution is different from normal distribution. The same thing holds for the calculation of VaR as well. Assuming non-normal distribution we can use the historical VaR or Monte-Carlo simulation. Both concepts bring pros and cons. The main advantage of historical concept is the general validity for all financial instruments

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<sup>14</sup> Equations 1.1 - 1.6 (except 1.4) taken from Hull J. (2009)– Risk management and Financial institutions 2<sup>nd</sup> edition

(including linear and non-linear instruments) and no additional assumptions are required. Contrary, the accuracy is affected by the number of observations (the more observations the more precise result) and of course by the fact that historical observations do not consider the current events and possible future scenarios (e.g. Black Swan problem). Monte Carlo simulation is generally valid and its accuracy does not depend on number of observations. However, success of applying Monte Carlo simulation depends on the underlying assumptions with respect to the distribution of risk factors. Yet, we know that bid-offer spreads are not normally distributed<sup>15</sup> and that liquidity risk exposure is characterized by infrequent but severe losses. Hence, the essential stress tests are hardly applicable. Overall, the function of the VaR is only informative. It gives us some idea about how large is our exposure to the liquidity risk but there is no hint of how to manage it.

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<sup>15</sup> Banks E., Liquidity risk: Managing asset and funding risk, 2005, 1<sup>st</sup> edition, Palgrave Macmillan

## **2. Liquidity Black Holes – literature review, understanding, causes of liquidity black holes**

### **2.1. Literature review**

The issue of liquidity black holes has been even more discussed since the financial turmoil (2007-2009). Obviously, the financial crisis has made this topic more attractive which induced the further research in this area. However, this issue is not only product of the recent crisis but appeared in the world of finance much earlier. Schnabel, Shin (revised 2004) dug deep into the history and found that there is some sort of resemblance in the most recent crises with the crisis of 1763 in Northern Europe. Specific contractual arrangements at that time, high leverage, these all aspects caused severe liquidity crisis. In addition, interlocking credit relationships contributed to the widespread contagion. It seems that all the financial innovations, risk management strategies and other tools in financial world are bringing more problems than solutions. To be fair, it is necessary to mention that the core business of banks in 18th century lied in managing the payment system in trading goods. Accepting the retail deposits and providing the loans was uncommon in that period. Despite the different conditions this is the evidence that liquidity and credit issues are historical problems. The cohesion of these types of risk is centerpiece of the Anastasia Nesvetailova's working paper from 2008. She demonstrates that recent credit crunch and subsequent crash of financial system is the result of previous liquidity illusion. Basel Committee on the Global financial system defines the liquidity illusion as a situation "*in which markets underprice liquidity and financial institutions underestimate the liquidity risk.*"<sup>16</sup> Nesvetailova and Ben Bernanke (the chairman of Federal Reserve of USA) similarly noticed that (in period between 2003 and 2007) there was a glut of large capital inflows into the well-developed economies (including US) from emerging economies (mostly Asian countries) and thus the emerging economies became net lenders. Bernanke thought that these vast inflows together with low interest rates accelerated the creation of excess liquidity while contrary the low interest rates gave incentives to U.S. citizens to take so called NINJA mortgages.<sup>17</sup> In fact, low inflation, capital inflows and savings from emerging markets in US reduced risk spreads laid the ground for the forthcoming crunch. The illusion of excess liquidity was endorsed by IMF warning against

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<sup>16</sup> BIS Committee on the Global Financial System (2001), *Structural Aspects of Market Liquidity from a Financial Stability Perspective* A discussion note prepared by the CGFS for the June 2001 meeting of the Financial Stability Forum (FSF), page 2

<sup>17</sup> In this case the word NINJA is the abbreviation for No Income, No Job, Asset (Asset equals the subject of mortgage – house or other type of building)

the increasing risk factors stemming from this *overly* of liquidity. In Nesvetailova's opinion, the credit boom in housing and structured financial products only disguised the fact that financial markets in well-developed countries became illiquid. Nesvetailova argue that albeit discrepancy in savings between U.S. and the emerging countries this is still not the proof of greater liquidity. She blame so called Ponzi Finance, collective thinking by the investors and the credibility of credit rating agencies for being the sources of liquidity illusion. We will now describe those 3 sources of artificial liquidity: Ponzi finance (or scheme) refers to the situation when the debtor is able to repay his debts only by taking a new debt. It is also sometimes called as the pyramid scheme and typical example of Ponzi finance is Bernard Madoff case. Financial innovations represented by subprime lending and transition to originate and distribute model focusing on maximization of fees income and securitization process (CDO, ABS) triggered by credit rating agencies was a solid base for consequent liquidity illusion. In addition, Nesvetailova criticize the common perception of liquidity according to which volume of trades play the major role. Of course, that if the trade volume is very low we can say the market is illiquid but the opposite situation (i.e. high trade volumes) does not guarantee that market is highly liquid. This misbelieve is well-described by the statement of one risk manager saying: *"The possibility that liquidity could suddenly dry up was always a topic on our list but we could only see more liquidity coming into the market –not going out of it"*<sup>18</sup> Nesvetailova's published in 2008 one more paper dedicated to liquidity where she identified 3 facets of this crunch –macroeconomic, market-centred and international. She claims that following the end of the Bretton Woods regime liquidity management has become minor part of monetary and financial authorities' interest. Consequently, the liquidity management faded into the background and stopped reflecting the current market trends. The first facet assumes the illusion of Macro-liquidity, more concretely national economy and the payment mechanism. The main characteristic of this aspect involves the quantity of liquid assets in hands of households and firms representing their savings. The second aspect of liquidity illusion is related to another function – the previously well-described quality of liquidity - the speed at which asset can be bought or sold. The author tackles here "the liquidity paradox" defined by John M. Keynes and then raised by Hyman Minsky. This problem concerns the trade-off between systemic and individual liquidity. Minsky argued that deregulation of credit environment leads financial institutions to exploiting new profit opportunities. Financial innovations cause the increase in velocity of money. Enhanced

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<sup>18</sup> Magazine The Economist, 9August 2008, page 68

availability of credit enables to increase debt capacity and the debt level is higher in general. At this point, Minsky warns that every new innovation developing a new substitute for cash or a new way to fund business activities brings decrease in liquidity. Thirdly, the facet of international financial system is taken into account. The author thinks about the concept of global liquidity as a whole. She concluded that the contribution of this concept is quite vague since there is a long discussion about what in fact global liquidity is and what the correct measures to gauge it are. This was clearly demonstrated by IMF in October 2007 when measuring global liquidity by narrow monetary aggregates with the conclusion that global liquidity had improved. Another remarkable paper deciphering the liquidity and credit crunch was published by Markus K. Brunnermeier. He completely describes the creation of liquidity black holes by illustrating the process of arising liquidity spirals. Firstly, the drops in price of assets deteriorate capital of financial institution and simultaneously the terms of lending tighten. This situation inflates further selling so that the assets are sold at even more depressed prices making the terms of providing credit even more severe. Secondly, as the financial institutions hit their constraints, the lending channel might dry up. Banks, in spite of not losing the access to capital markets start saving funds and withdrawing liquidity. As the bad news spread to the public it might evoke runs on banks as we witnessed at Lehman Brothers, Washington mutual fund or Bear Stearns. Last but not least the network effects might occur. Network effects happen when financial institutions are both lenders and borrowers. The process of netting transactions among particular counterparties might be destabilized and multiple trading partners fail to cancel out trading positions due to increased probability of default by counterparty. Nielsen, Feldhutter, Lando (2009) examine the onset of subprime crisis by looking at the fixed income securities market, especially on corporate bonds. Corporate bonds are widely perceived as illiquid (or less liquid) financial instruments. In their study, they find evidence that enormous yield spreads include the premium for liquidity. Regarding to Longstaff, Neis, Mithal (2005) who argues that “pure credit risk component” can be obtained by detracting CDS premium from the bond spread. Nielsen, Feldhutter, Lando (2009) proved that this residuum over a default risk premium is assigned to liquidity risk. Using several liquidity proxies and simultaneously controlling credit risk component they find (i) liquidity to be important factor during onset of subprime mortgage crisis, supporting our hypothesis of credit/liquidity crunch. Similarly, Chen, Cheng, Wu (2005) test the dynamic interactions between Credit, interest rate and liquidity risk. Their model is based on CDS spreads too and they try to find a reason why the liquidity differs across reference entities. Their results suggest that financial institutions have (on average) higher CDS spreads than

non-financial institutions. Furthermore, they divided these entities into low and high-liquidity groups according to the frequency of updating CDS quotes. The contracts are more liquid, the more frequently are CDS spreads updated and hence those contracts have higher spreads. The intriguing finding is that entities in the same industry and within the same credit rating class face higher credit risk the more frequent are their CDS transactions. Thus, the companies in low-liquidity groups have lower default risk. The credit/liquidity puzzle with ambiguous solutions still persists. Let's get back to the interactions of individual types of risk.

One of the pioneers in liquidity risk management and diligent writer who has been regularly contributing to the liquidity black holes literature since 2000 is Avinash Persaud. He was one of the first guys who pointed out to the importance of diversity in financial markets, reinforcing the market liquidity.<sup>19</sup> His famous discussion paper *Liquidity Black Holes* (2002) starts with definition of liquidity. According to his paper the key role in affecting the market liquidity plays central banks through the sales and repurchases of treasury bills. He stressed the fact that liquidity is still (in 2002) under-researched concept due to lack of detailed information about all trades. He offends utility of using bid-ask spreads as the adequate measure in the times of financial distress when the adequate measure or liquidity proxy is urgently needed. Nesvetailova (2008) accepts this notion and moreover she argues that conventional indicators are useful only in situations when markets are closed system – *“neither bid-ask spreads nor the volume of trades reflect the aggregate outcome of the deteriorating quality of portfolios of companies comprising the market, especially if it is tightly interconnected with other market segments.”*<sup>20</sup> Persaud see the possible solution in custodial databases recording the quantity and quality (i.e. the price information) of all transactions. But still, this does not solve the openness respectively closeness of markets as suggested by Nesvetailova. Yet, we can see how elusive concept of market liquidity can be. To gauge it more accurately, the relevant measures should include the volatility of liquidity. This needs to be done especially in situation when liquidity disappears completely – it means in case of liquidity black hole.

## 2.2. Who is who in financial markets?

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<sup>19</sup> To our knowledge, term „liquidity black holes“ was used for the first time by Nicholas N. Taleb, „Dynamic Hedging“ in 1997 (page 68-69)

<sup>20</sup> Nesvetailova A (2008). *The end of a great illusion: credit crunch and liquidity meltdown*, DIIS Working Paper no 2008/23, page 5

We have been speaking quite a lot about so called market participants so far but we haven't disclosed who these people really are. Let us just briefly summarize which types of investors we can meet in financial markets.

Firstly, we can divide market participants into two groups – institutional, represented by the banks, pension funds, mutual funds, etc. and the small or individual investors. It is obvious, that large institutional investors carry on the majority of transactions and substantially affect trading volume. On the other hand, the individual investors take position in relatively small transactions and quite often use the intermediaries to process their requests. Secondly, and perhaps more importantly we can distinguish 3 types of investors according to their purpose in financial markets. These are the hedgers, arbitrageurs and speculators. The hedgers enter the markets in order to reduce their risk exposure of their portfolio. Arbitrageurs are the investors actively seeking for unique investment opportunity which can generate risk-free profit. This could be done by conversion of proceeds generated from the inefficient markets with mispriced assets to another market. There are certain benefits stemming from the arbitrage opportunity such as removal of mispricing, enhancement of price stability and last but not least increase in market liquidity.<sup>21</sup> The third group of investors consists of the speculators. The speculators are seeking for unique investment opportunity as well but their decisions are based on different types of analysis. The efficiency of these analyses varies quite a lot which results in quite volatile outcomes of their actions. At some point, the speculators might operate without any analyses and thus they are often quoted as the gamblers. A lot of people consider speculators to be the negative outcome of financial markets responsible for vast market crashes. To some extent this might be true – namely, we can mention for instance George Soros - the investor that bet on pound sterling in 1992 and since then he has been dubbed: “ *the man who broke the Bank of England.* “ On the other hand, speculators can add liquidity to the market in periods of illiquid markets and in conjunction with hedgers and arbitrageurs help to increase the stability of market. That is why we should not purely blame the speculators for the financial crises.

The most important distinction of market participants for the aim of our thesis is distinction according to the trading strategies. By this, we mean the positive-feedback and negative-feedback traders. Positive-feedback traders put buy orders in periods of market booms and sell - orders in periods of market downturns. On the other hand, negative-feedback traders buy the assets when the price is (according to their opinion) unreasonably low and sell

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<sup>21</sup> <http://www.citeman.com/5371-traders-in-derivatives-market/>



the assets when the prices are unreasonably high. In other words, positive-feedback traders represent herding behavior, i.e. the situation when these traders feel that part of market participants have better information and they just follow their steps. Thus, in coalition with positive - feedback traders they can restore the equilibrium either if the markets are overheated or distressed. The dangerous problem arises if the positive-feedback traders dominate the market. Bad news might induce dangerous spiral which might turn out in the creation of liquidity Black Holes.

## 2.3. Causes of Liquidity Black Holes

There are numerous reasons for occurrence of liquidity black holes. Modern literature and the recent articles still bring new insights and so the amount of liquidity black holes determinants still increases. We will try to gather as much as possible information by using the well-established literature as well as most up-to date journals.

### 2.3.1. Reasons for positive-feedback trading

Hull (2009) explicitly mentioned 4 reasons for positive-feedback trading - stop-loss rules, dynamic hedging, creating options synthetically and margins. The impact of stop rules will be discussed more properly in next section. The basic idea behind stop - loss strategy is that trading systems enables to set up some predetermined level of assets. When the fair value of the assets decreases under this level the actions to reduce the risk exposure are taken. Systems automatically close the trader's position no matter how deep is the decrease. The negative impact can be multiplied if the traders set up these limits according to some public investment recommendation or for whatever reason which might elicit unreasonable fire-sales in the market (CNBC effect).

Dynamic hedging is another reason for positive-feedback trading. The aim of the portfolio managers is to keep their portfolios delta or eventually gamma neutral. In order to do this they usually use set of call or put options to reduce potential risk. In case of hedging a short option position they have to buy (sell) the assets after increase (decrease) in price of the assets. Conversely, hedging a long option position induces opposite actions and leads to the negative-feedback trading without any consequences on market liquidity. In our opinion, hedging short option position can be dangerous due to specific pay-off scheme of options. We all know that options are the instruments with unlinear pay-off and this could generate larger price drops as the options become "out of money".

Creating options synthetically is the third reason for positive-feedback trading and it is closely connected to the dynamic hedging because hedging short position in an option is equivalent to creating a long position in the same option synthetically.<sup>22</sup> This could be well-demonstrated on the stock market crash in October, 1987. Before this crash, markets had been doing pretty well and the innovated trading applications facilitated creating options synthetically. These applications strongly encouraged positive-feedback trading and created one of the first liquidity black-hole which lasted approximately for 4 months.

The last reason for positive-feedback trading noted by the Hull (2009) is the presence of margins in financial market. Margins are the ever-green of majority crisis which can accelerate the burst of the bubble. For example before the Great Depression in 1932 it was allowed to purchase assets only with 10% of own capital and the rest was financed by the debt. The highly leveraged transactions might lead to so called margin calls in periods of volatile markets forcing traders to close their positions immediately. The classic example of this is the story of Long Term Capital Management (LTCM) which we will discuss in one of the next sections.

### 2.3.2. Market consolidation

In previous sections of this paper we have already mentioned the importance of diversity. In fact, size of the market has very little to do with the market liquidity. In the last two decades, the common trend on financial markets consisted in consolidation of particular markets and creating large alliances such as NOREX or EURONEXT, etc. These actions were generally perceived to add extra liquidity and thus enhance and facilitate trading activities. Notwithstanding, as we noted earlier the turnover is not good proxy for liquidity. The bigger the market, the more participants trade more instruments and the higher is the turnover but contrary the impact on prices is higher and the market might be then less liquid. “*Markets can be bigger and yet thinner: liquidity requires diversity.*”<sup>23</sup> On the other side, one might argue that the more participants in the market the more opinions and strategies they share. In our opinion, the structure of the market participants matters as well. In general, financial institutions (banks, pension funds, mutual funds) dominate in the financial markets. These institutions are usually members of large, international conglomerates. For example the 3 largest financial groups in Czech Republic (ČSOB, KB, ČS) belong also to the largest

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<sup>22</sup> Hull . J.(2009) *Risk management and financial institutions*, 2<sup>nd</sup> edition

<sup>23</sup> Persaud, A. (2002) *Liquidity Black Holes: And Why Modern Financial Regulation in Developed Countries is making Short-Term Capital Flows to Developing Countries Even More Volatile* ; UN discussion paper No. 2002/31, page 6

investors in Czech financial markets. All these financial groups are subsidiaries of the top financial groups in Europe such as KBC group, Societe Generale or Erste group. Hence, the consolidation of financial market is accompanied with the consolidation of financial institutions carrying no additional diversity. The conclusion is that neither market participants are independent.

Hull (2009) reminds the fact that due to VaR-based measures are traders subject to meeting particular criteria which limit their decision. The diversity of their decisions or trading activities is thus reduced. Paradoxically, the Hedge funds, often wrongly identified as the creators of all bubbles and financial crisis can deliver additional liquidity. Poor regulation and variety of trading strategies used by hedge funds put some extra diversity into the market. However, some aggressive strategies might have devastating impacts. In addition, some hedge funds are heavily leveraged to follow their intended strategies. Hence, hedge funds might fail in adding liquidity and diversity to the markets because stressed markets in connection with tightened terms of credit might cause fall of these funds. Persuad (2002) mention (besides market consolidation 2 more forces of reducing the diversity – The collapse of information costs and Market sensitive risk- management systems.

### 2.3.3. The collapse of information costs

Accessibility to the most actual information changed dramatically over the past decades. Information asymmetry between broker and his client was examined by several studies and finally made financial authorities to impose higher regulation standards (e.g. transposition of MiFID directive) to protect the clients. The rogue activities of brokers were suppressed not only by additional regulation but by the informational boom as well. Widespread expansion of cable TV and internet facilitated the process of delivering the hottest news and reduced the price or cost of information to the lowest possible level. One might assume that this giant leap might encourage the information diversity. In fact, the opposite is true. U.S. SEC mandated the rule<sup>24</sup> to disclose price-sensitive news to everyone at same time which could be possibly done via internet. The professional investors and analysts are then no longer the persons with comparative advantage. Furthermore, Well-known TV channels such as CNBC or CNN broadcasting the news from financial world in real time causes that investors use similar information sets and can react to these news without any delay (Acharya 2001). Since all the participants in the market can share the same information at the same time market becomes one-sided, i.e. all the investors want either buy or sell

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<sup>24</sup> SEC (2000), *Regulation Fair Disclosure* October 23, 2000

particular assets. Given the basic assumption of perfect competition, that there is no information asymmetry among investors (which is also one of the CAPM assumption) the previous situation might actually destroy the market principle. Of course, this is an exaggerated example. It is true that the individual investors have relatively same access to information, but not for all of them is trading full-time job. Secondly, (and may be more importantly) there will be always some sort of insider information making the decisions about future operations more valuable for specific traders. Information symmetry is still quite elusive.

Theory of collapse of information costs was already examined by Morris, Shinn (2001) and was named “*CNBC effect*. “ The conclusion of their paper unveils the fact that public information is *too effective* and elicits the overreaction of agents on the market. One might argue that for example in mid 90’s when there were less TV channels covering the financial news and the internet portals were less sophisticated than nowadays, the markets were more prone to the creation of liquidity black holes. Why then majority of economists agree on proposition, that there will be more liquidity black holes in future? Possible explanation is given by New York Times journalist Paul Krugman<sup>25</sup> who claims that corporations started mimicking behavior of financial market participants. As economy becomes increasingly “financially-marketized” it brings common problems such as bubbles too. In our opinion, another answer for this question consists in the fact that even though there is a higher diversity in TV channels and websites nowadays, sources for these channels has not changed. The same information is then distributed through all these channels making the news exaggerated.

#### 2.3.4. Market sensitive risk - management systems

In previous section we discussed the market consolidation as one of the cause of distress in financial markets. It might sound plausible to consolidate and unify the financial regulation and supervision as well. Typical example of this happening (at the local level) was the merger of all supervisory and regulatory bodies into one single institution (Central Bank) in 2004 in Czech Republic. At the global level, we can see the tendency of global authorities to unite the risk policies and simultaneously calling for stringent prudence. Persuad (2002) claims that this might be a good idea but he identifies the problem in change of the risk regulatory buckets for market sensitive measures. There are 3 reasons for that.

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<sup>25</sup> Krugman P. (2001) *Out of the loop*, NewYork times, March 4, 2001, <http://www.nytimes.com/2001/03/04/opinion/04KRUG.html>

The usage of few broad risk categories might escalate in the regulatory arbitrage. For instance, considering that according to BASEL I rules, the financial institution has to maintain 8% of capital due to default risk but in fact the real default risk is lower, then it might be profitable to securitize the loan and remove the low risk loan from portfolio. Secondly, increasing demand for structured products attracted financial engineers to invent new and more complex products which were hard to capture by the broad risk buckets. Last, but not least, there is common perception that public officials cannot beat the market when assessing the risk. This bunch of possible explanations facilitated and accelerated the implementation of market-sensitive risk management tools. Hence, new innovations in risk management “*has not led to a more robust and efficient financial system, but one that is more prone to financial crisis and induces more concentration of financial risks.*” (Persaud 2000). Here comes Value at risk again.

One of the basic assumptions underlying VaR is that all the market participants work independently. As we showed earlier this is not true. Risk managers usually put some limits for so called DEAR – daily earnings at risk. Once the limit is exceeded they must take further steps by selling the most volatile or highly correlated assets. In fact, to some extent the behavior of banks is relative to the behavior of other banks. Herding behavior is basically understood as the negative element on financial markets but there exists some rational clarification in banking sector, no matter how detrimental it could be. This clarification is closely connected with moral hazard – foregoing of some risky projects because of not bearing the potential negative consequences of that investment. Financial institutions might simply rely on fact that if the majority of them enters similar positions, which might result in a loss, they would be bailed out by central banks or government. Thus, the DEAR limit is exceeded (due to increased volatility in particular market) not only by one institution but by a whole group of banks. Portfolio managers in co-operation with risk managers decide to sell the assets as soon as possible, triggering further sales. The situation becomes more serious, so some banks in spite of reducing DEAR sell different asset (held partly by the herd) which is uncorrelated with the first one. This contributes to the higher volatility and the previous (un)correlation between second and first assets will be now very significant. Moreover, the DEAR constraints will be hit at those institutions which were not affected at the first level of this process. The spiral effect is then extended internationally, even to the destinations which were not initially concerned with business of banks on the other side of world. The cohesion of herding behavior and VaR could be dangerous not only because of previous example. Sophisticated VaR systems identify markets with low correlation and volatility which should

“guarantee” relatively safe returns as well as the most risky (i.e. high correlation and volatility) markets which gives deterrent warning and prevent from any investment. This gives rise to the so called perplexing paradigm: The observation of safety creates risk (as the herd chases after what was safe and investors become overly concentrated) and the observation of risk creates safety (as the herds avoids what was risky) <sup>26</sup>.

### 2.3.5. The impact of capital requirements

The impact of capital requirements follows the previous section market sensitive risk-management systems. The regulation & supervision is the main topic of numerous academic conferences as well as the topic for politicians. The prevailing strategy is to create one global regulatory framework which should prevent market participants from regulatory arbitrage. Prior to the Basel I framework there were vast differences in capital requirements across the countries. Basel I framework was eventually replaced with Basel II reflecting the actual trends in risk management but it seems that this was still insufficient. One single unified framework should solve the regulatory arbitrage issues but it can bring negative outcome as well. For instance, increased capital requirement (for example due to bad news) forces banks to react in the same way when managing the market risk. Lack of diversity in capital requirements induce banks to carry on similar transactions in order to reduce their exposures as we already described this fact in previous section. In addition, the credit risk is involved as well. In periods of economic downturn default probabilities increase and so do the capital requirements for loans under the Basel II internal-ratings based models.<sup>27</sup>

### 2.3.6. Liquidity spirals

Now we are going to describe the creation of liquidity spiral as we tackled this topic shortly in literature overview. There are basically 4 sources for this situation. We start from the borrower’s point of view and balance sheet effects – Loss spiral and Margin spiral.

#### **Borrower’s point of view Loss and Margin spiral**

At first, we start with loss spiral which is closely linked with the process of leveraging and deleveraging. In this example it is clear how leverage can be useful and simultaneously dangerous too. If some investor finance purchase of asset by 90% of loan and by 10% of his own capital then his leverage ratio is 10%. Thus, he royally benefits from the

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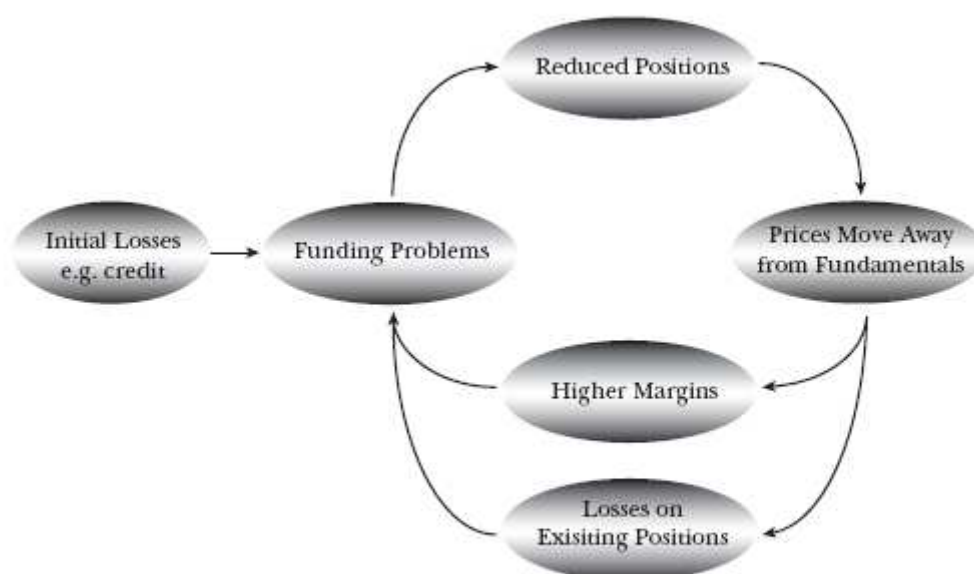
<sup>26</sup> Persuad A. Sending the herd off the cliff edge: the disturbing interaction between herding and market-sensitive risk management systems, Institute of International Finance, Washington, 2000, page 8

<sup>27</sup> Hull John – *Risk management and Financial Institutions*, 2nd edition, 2009

upward movement in value of assets price but he terribly suffers from the decline in the value of assets. In addition, he has to maintain the leverage ratio which forces him to reduce the position in asset dramatically.

Figure 2.

### The Two Liquidity Spirals: Loss Spiral and Margin Spiral



Source: Brunnermeier and Pedersen (forthcoming).

Note: Funding problems force leveraged investors to unwind their positions causing 1) more losses and 2) higher margins and haircuts, which in turn exacerbate the funding problems and so on.

For example, if the initial price of asset is 100\$ and it decreases by 10% to 91\$, the reduction of his capital is from 10 to 1 decline which means by 90%. At this stage, his own capital is 1\$ but the loan is 90\$ which gives the leverage ratio approximately 1.1%. In order to maintain the leverage ratio he can add some extra money but rather reduces position in assets. In this case he must reduce the position from 90\$ to 10\$. Unwinding such a large position generates further selling and the spiral goes on and on and the contagious effect hit other investors. This might again attract some aggressive traders such as hedge funds waiting for re-entering the market and by predatory trading forcing the others to close their positions at depressed prices.<sup>28</sup> Yet, we have already described how relatively small change in asset price might trigger huge fire-sales liquidations due to leverage. The loss spiral negatively affects stocks with low market liquidity more extremely. This is simply because these stocks are

<sup>28</sup> Brunnermaier M., Pedersen L. (2005) *Predatory Trading*, The Journal of Finance, Vol. LX, NO. 4

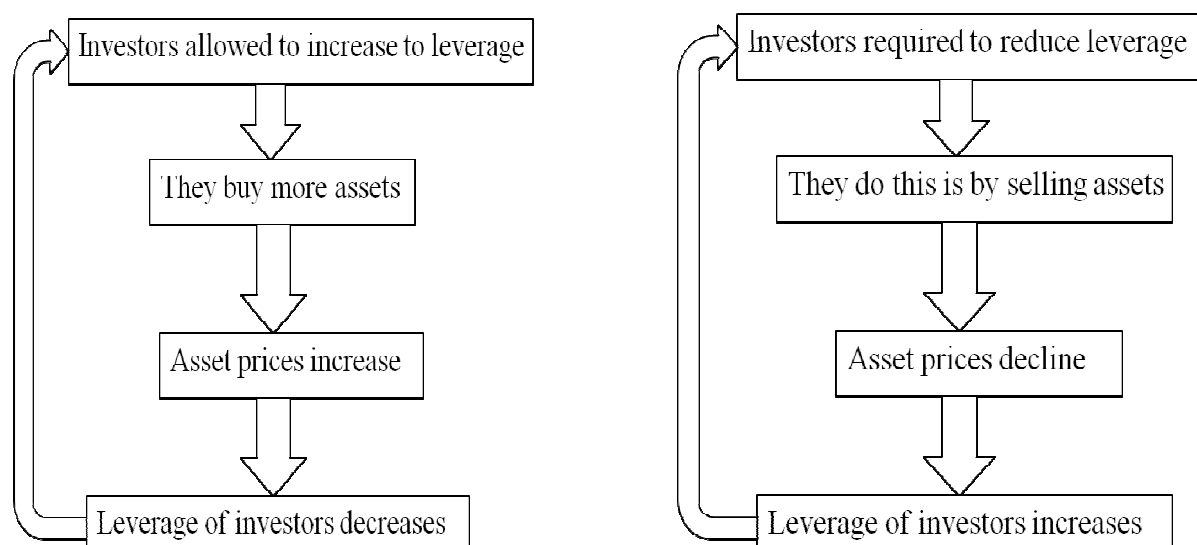
much more complicated to trade at time of financial distress. Let's now focus on Margin spiral.

Margin (or haircut) spiral makes loss spiral even more severe. By loss spiral, we considered the leverage ratio to be constant, which does not hold for margin spiral. Increases in margins (or haircuts) force investor to sell even more because he needs to reduce his leverage ratio. Moreover, in times of huge price drops, margins/haircuts spike, which elicit tightening the terms of credit. The increases of margins/haircuts together with lending standards following the price drops seem to be controversial. One might expect that price drops caused by insufficient liquidity (but perceived to be temporary) might attract new investors eagerly waiting for this good opportunity. Lenders would then relax lending standards by lowering margins after the decline in prices. Brunnermeier, Pedersen (2009) argue that there are 3 reasons why the opposite is true.

At first, huge price drops tend to be followed by higher volatility and this evoke higher margins. Secondly, the increase in margins accompanied with price drops arises due to higher importance of information asymmetry. The quality of assets pledged as collateral is checked more deeply by using some sort of impairment tests. The third reason is again related to the risk managers. Relying purely on historical data when estimating future volatility, results in a situation when large decline in asset prices generates higher volatility estimates and naturally higher margins - despite the fact that this decline might signal good buying opportunity. Hull (2009) emphasizes the problem of using purchased assets which are often pledged as collateral. As the price of these asset grows the value of the collateral increases as well enabling further purchases which leads to the creation of bubble that sooner or later bursts. The opposite process (de-leveraging) might occur as well. The whole process of leveraging and deleveraging is depicted by Figure 3.



Figure 3.



Source: John C. Hull: *Risk Management and Financial Institutions 2e*, Chapter 19

To sum it up, the increases in assets prices enable investors in long positions to benefit from these upside movements, raise the funds by new borrowings, use the proceeds from borrowings to purchase additional assets and by this purchase increase the demand for this assets and consequently their prices. On the other hand, the loss spiral is caused by taking the opposite steps. The decline in assets prices causes the capital loss for the investors; increase the requirements for maintaining the leverage ratio resulting in liquidation of the original position by selling the assets and thus lowering the demand leading to further selling. Both of these spirals are dangerous albeit the perception of market participants differ. The first type of spiral is characterized by hubris, overconfidence and overoptimism the second type is typical for fear and distress.

### Lending Channel

Now we are going to look on the spiral from the opposite view through lending channel. According to Brunnermeier this channel is mainly driven by two mechanisms: moral hazard and hoarding. By moral hazard he points out to the classical agency problems determined by Jensen, Meckling (1976) who proposed that for shareholders with no big stake in company is very expensive to monitor the activities of the management. The widespread structure of shareholders (especially common for U.S. companies) thus does not offer adequate incentive to monitor lending activities. This is quite questionable, since lending money is the banks core business and the credit risk is usually highly monitored and also well-developed part of risk management.

On the other hand the relaxation of lending standards (remember NINJA mortgages) was precedent to subprime crisis. Precautionary hoarding refers to the situation when lenders refuse to provide loans because of potential loss from interim shocks.<sup>29</sup> Hoarding grows as the probability of interim shocks increases or when the access to the funds is expected to get worse. One might argue, that the role of central bank should be (besides moral hazard and hoarding) the third mechanism affecting market liquidity. Apparently, the situation on Czech interbank market where liquidity completely dried up in 2008 showed that mechanisms used by central bank (i.e. shifting the prime rate) do not considerably affect interbank market. Credit-crunch is therefore perfect example of precautionary hoarding.

### 2.3.7. Runs on financial institutions & Network effects

Last two channels were partly tackled earlier in the text and we do not consider them to be as important as previous channels.

Runs on financial institutions were common for period of Great Depression in 1930s. This phenomenon concerns the early withdrawals by the clients scared of the fact that financial institution cannot satisfy all the clients' needs due to its illiquidity. Deposit insurance should prevent banks from these runs and to some extent we can affirm that since the Great Depression the amount of runs decreased. However, the recent crisis pointed to another type of runs - the runs on the institutions who issued asset-backed securities.<sup>30</sup> Namely, these problems occurred to Bear Stearns, AIG (margin run) or Northern Rock.

Network effects caused by counterparty credit risk and verging to gridlock risk represent the last channel. The globalization of financial markets induced the market participants to be lenders and borrowers within single institution at the same time.

### 2.3.8. Spreading the risk or shifting the risk?

Persuad (2005) deals with the interesting puzzle about the huge increase of defaults and distress around the world in 2002 as the consequence of large drops in equity indices and extreme volatility in financial markets. However, the commercial banks survived this period almost without any problems. The proponents of financial innovations attributed this fact to the greater stability and safety in financial markets. In fact, the systemic risk cannot be diversified away and the financial innovations including credit derivatives and so called asset-

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<sup>29</sup> Brunnermeier, M.; Pedersen, L. (2009) *Deciphering the Liquidity and CreditCrunch 2007–2008*, Journal of Economic Perspectives—Volume 23, Number 1—Winter 2009—Pages 77–100

<sup>30</sup> Brunnermeier, M.; Pedersen, L. (2009) *Deciphering the Liquidity and CreditCrunch 2007–2008*, Journal of Economic Perspectives—Volume 23, Number 1, page 20

backed up securities only transferred risk to another counterparties. Also the regulators and supervisors were not right when considering that new hedging instruments and techniques, collapse of computing costs, and the Basle Accord helped to increase safety in markets.

On the other hand, these regulators put so much effort to protect banks while devoting less time for other financial institutions. Considering the interconnected markets, large international financial conglomerates including all the types of financial institutions we must admit that focusing predominantly on banks is highly insufficient and leads to the concentration of risk. In addition, portfolio managers of insurance companies are allowed invest only into limited set of instruments and in bad periods their yield on portfolio is lower than the liabilities they have to meet. This could be the reason for providing more default protection (CDS) and tendency to use more risky credit derivatives and even equities in order to maintain their liquidity and solvency. While these actions are far more than safe for insurance companies they try to reduce risk exposure by moving the risk to the off-balance sheets.

### 2.3.9. Irrational Exuberance

Last but not least reason for creation of liquidity black holes was introduced by John Hull and can be characterized by the term irrational exuberance. Hull mentioned the famous speech of Alan Greenspan, the Federal Reserve Board chairman on December 5, 1996 in which he claimed :” *How do we know when irrational exuberance has unduly escalated asset values?*”<sup>31</sup> This phrase pointed to the power of one single statement made by respectable person and its impact on the financial markets. This sentence by Alan Greenspan was, need to say followed by the stock prices declines worldwide. Irrational exuberance is connected basically with traders and portfolio managers of different financial institutions, who might become interested in particular market or even in particular asset. Compensation scheme for these market participants is set to reward highly successful individuals. Thus, at some point they might become highly irrational and bet only on one card which reinforces further increases in prices till the bubble drops. On the other hand, it might not be irrational but strictly rational process. As noted in the beginning of this master thesis... “*As long as the music is playing (in terms of liquidity) you’ve got to get up and dance*”. In our opinion, these traders are not stupid, they just surf on the wave of global optimism and as the first signal of bursting the bubble appears, they will immediately leave the position. We already know that unwinding the position quickly is not so easy and what are the other consequences it brings.

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<sup>31</sup> <http://www.irrationalexuberance.com/definition.htm>

Having finished, the discussion about potential reasons for liquidity black holes we will now focus on the past and more recent crisis in which liquidity black holes occurred.

### 3. Liquidity Crisis and Black holes in History- Lessons learned

#### 3.1. Story of Long Term Capital management/ Russian crisis

There were many liquidity crises which consequently resulted in liquidity black holes in the past.

The biggest disaster and perfect demonstration of how liquidity matters was the story of hedge fund called Long Term capital Management (LTCM) whose downturn followed the Russian crisis in 1998. Unlike the Asian crisis, the risk of default stemmed from tradable instruments instead of the bank loan credit risk. Secondly, the duration of Russian crisis was shorter than the Asian crisis but still it was perceived (by the majority of market participants, analysts and so on) to be much more severe.<sup>32</sup> It also demonstrated the unexpected fact that one particular event on emerging markets can disrupt the stability on the well-developed U.S. markets. Last but not least, despite the fact Russian crisis is closely related to LTCM fund it is worthy to separate these events. While the outcome of Russian crisis is concerned with credit risk, the LTCM near-collapse unveiled global liquidity shock.

Let's now focus on LTCM fund. This hedge fund was founded by famous and respectable bond trader John Meriwether, former employee of Salomon brothers. Meriwether gathered a team composed of academics as well as the best bond traders. Among others, his team included Nobel Prize winners Myron Scholes and Robert Merton. LTCM strategy consisted in mixing academic approach represented by quantitative models and market approach represented by the experience of traders. In conjunction with authority of Meriwether LTCM created solid prospects of highly profitable organization which attracted a lot of investors including major investment banks. Scholes and Merton believed they could reduce risk exposure to almost zero level and Scholes claimed that "*LTCM works like a giant vacuum cleaner sucking up nickels that everyone else had overlooked.*"<sup>33</sup> Apparently, putting these approaches together was not as easy as it was supposed to be but even though Meriwether and his team managed to raise \$1.25 billion mainly due to large institutional investors including the well-established investment banks. The large investors were not discouraged even by the extraordinarily high fees or the commitment to deposit funds for at least 3 years.

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<sup>32</sup> Dungey M., González – Hermosillo B., Martin V., (2002) *International Contagion effects from the Russian crisis and the LTCM near-collapse*, IMF working paper

<sup>33</sup> <http://www.econlib.org/library/Enc/bios/Scholes.html>

LTCM tried to discover arbitrage opportunities by using large market databases and modern computers which enabled them to monitor general patterns across the market. Whenever the movements on the market deviated from the pattern or from the models invented by the academics it was a signal for arbitrage. Note, that LTCM history started in 1994 when the computers were much less developed than those used by traders nowadays and the use of internet was limited as well. Despite well-announced intended strategy supported by academic background the real trading activities were far simpler showing that the practical skills of traders were slightly predominant. One of the trading strategies can be depicted as follows:

$$r_{\text{equity}} = r_{\text{assets}} + L(r_{\text{assets}} - r_{\text{debt}})^{34} \quad (3.1)$$

where  $r_{\text{equity}}$  is the rate of return on equity capital,  $r_{\text{assets}}$  stands for rate of return on overall capital,  $r_{\text{debt}}$  is the interest rate on debt and  $L$  is the leverage ratio (i.e. debt to equity ratio). The equation 3.1 clearly demonstrates that LTCM profitability was amplified by the leverage ratio. Yet, we all know how dangerous leverage can be and why it is often referred as the two-edged sword like in the following equation:

$$\text{risk}_{\text{equity}} = (L+1)\text{risk}_{\text{assets}} \quad (3.2)$$

In other words, equity risk of a leveraged position is multiplied by the  $(L+1)$  factor. This equation assumes the risk to be measured by standard deviation as in modern portfolio theory as well as measured by  $\beta$  in CAPM. In this case the debt is risk-free. LTCM leverage ratio was about 30% which means that LTCM needed only 1% higher return on capital ratio than the interest rate on debt to generate 30% return on equity capital while keeping costs of capital very low. Such low costs of capital were reached due to strong bargaining power of LTCM dealers and the fact that none of the banks wanted to end up business with LTCM fund.

LTCM concerned about speculative position and so called convergence arbitrage based on interest rates differences. Consider company that issues two types of bonds with different liquidity promising the same pay-offs - the less liquid bond A and more liquid bond B which means that bond A will be always cheaper than bond B. In this case LTCM enters long position in bond A and simultaneously short bond B while expecting that the prices will converge in future. If there is an upward movement in the interest rates the prices of both bonds decline approximately by the same amount so that the collateral paid for bond A will be the same as the collateral received from bond B and vice versa.

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<sup>34</sup> <http://www.sjsu.edu/faculty/watkins/lcm.htm>

This strategy was generally accepted by all relevant bodies in LTCM management and it generated abnormal profits for almost four years. LTCM fund beat all the benchmarks such as DJIA or S&P 500 which attracted additional investor to put their money into this “cash-machine.” On the origin of LTCM in 1994 there were 80 investors pulling together \$1.3 billion as an initial equity capitalization while almost four years later (in December 1997) this equity capitalization increased by \$5.7 billion to approximately \$7 billion. During first two years the average return of fund reached tremendous 40% and during the next year it was still outstanding 27%. In the beginning of 1998 the portfolio of LTCM amounted to more than \$100 billion while net asset value stands at some \$4 billion.<sup>35</sup> The magnitude and importance of LTCM fund can be depicted by its position in swaps where LTCM held 5% of entire global market. Everything was going fine till the summer 1998.

In august 1998 Russian Government devalues Ruble and declares moratorium on \$13.5 billion of its treasury debt.<sup>36</sup> What followed is often referred as the *flight to quality* which meant that investors immediately closed their risky positions in emerging markets such as Russia and (re)entered the well-developed markets taking positions in most secure instruments dominated by the risk-free government bonds. The Russian sovereign default would be less severe for LTCM if it was not followed by the collapse of Russian currency. LTCM was selling the rubles believing this could hedge their exposure but Russian government stopped international trading with its currency to prevent Russia from the attacks of speculators. The most disastrous thing that no one from the sophisticated LTCM team expected was the above mentioned *flight to quality* which can be transcribed as the *flight to liquidity*. Investors demanded highly-liquid assets on the U.S. markets and they were willing to pay incredibly high premiums even for the risk-free assets with lower liquidity. Investors preferred the recently issued instruments so called “on-the-run” securities traded on U.S. treasury market. Panic behavior could be demonstrated by the widened spread between “on the run” and “of the run” treasury bonds which is usually insignificant.

The major part of LTCM un-hedged risk lied in its balance sheet that was extremely sensitive to the price of “liquidity. In periods, when liquidity played more important role its short positions values rose more dramatically than the values of long positions. The situation was more exacerbated by the unanticipated decrease in the amount of issued U.S. Treasury market making the flight to liquidity in U.S. markets more intense. Another problem causing

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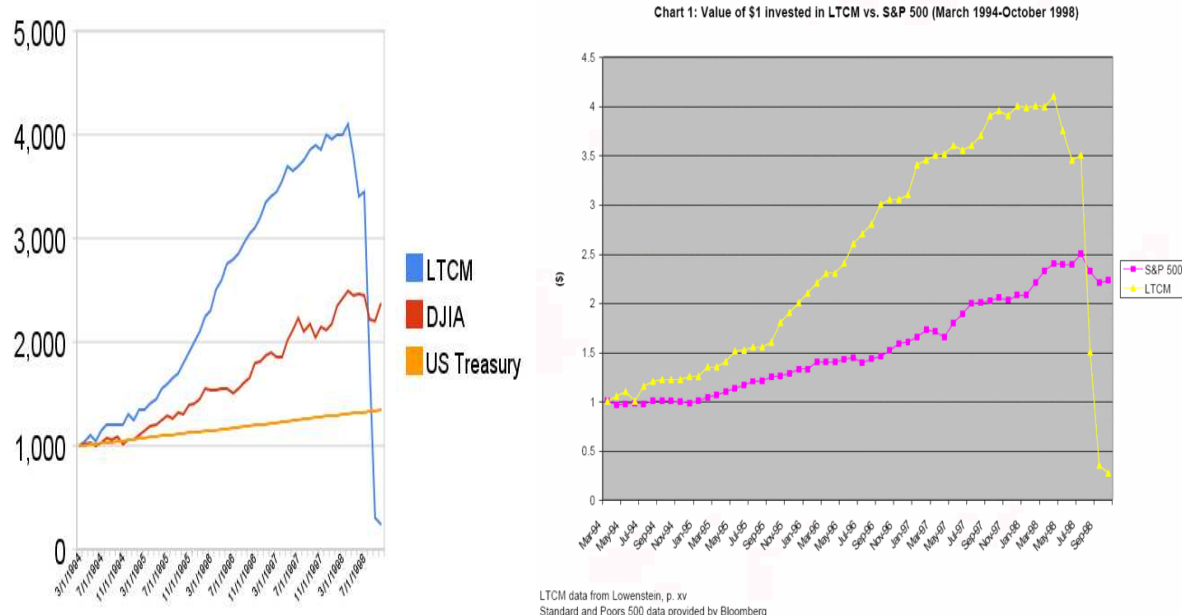
<sup>35</sup> Edwards Franklin R. *Hedge Funds and the Collapse of Long-Term Capital Management*, *Journal of Economic Perspectives*—Volume 13, Number 2—Spring 1999—Pages 189–210

<sup>36</sup> <http://www.erisk.com/Learning/CaseStudies/Long-TermCapitalManagemen.asp>

the “near-collapse” of LTCM covered the top bond traders within LTCM. Their hubris and overconfidence contributed to the additional betting on the changes in financial markets ignoring the financial turmoil and Russian Crisis. LTCM strategy was focused on the “normal” markets with less volatility but during summer 1998 the markets were extremely volatile. We know that highly volatile markets sooner or later become less volatile but time factor played crucial role for LTCM causing extreme losses in its portfolio value.

On the 1<sup>st</sup> of September 1998 John Meriwether officially admit that LTCM fund is in serious troubles and set specific rules for current investors in LTCM which allowed them to withdraw only 12% of their money and not before December 1998. Equity capitalization dropped to \$ 2.3 billion. Three weeks later is the total value of equity capitalization only \$600 million. Value of \$1 invested thus dramatically declined within few weeks as it is depicted in Figure 4.

Figure 4



Value of \$1 invested in LTCM in Comparison with major U.S. indices

Source: Lowenstein's R. When Genius Failed: The Rise and Fall of Long-Term Capital Management, Random House Trade Paperbacks, 2001

At this point, LTCM hit their margin constraints and its main creditors were thinking of whether to initiate margin calls. With relatively unchanged amount of assets which totaled about \$126 billion the leverage ratio increased from some 30 to 1 unbelievable 55 to 1. The creditors were in tricky situation because they were aware of the danger it could bring to the market. In addition, most of the creditors were investors in LTCM as well which made their



decisions even more complicated. The next day, on 23rd September AIG, Goldman Sachs and the oracle of Omaha - Warren Buffet offer to buy LTCM fund for \$ 250 million and bail out this fund by \$4 billion injection but the deal was rejected. The global threat of upcoming systemic crises led FED reserve bank to take the inevitable steps as soon as possible. On the same day in the afternoon, FED decided to create group of commercial and investment banks<sup>37</sup> (including the LTCM creditors) which should add \$3.5 billion into LTCM while taking over the management of the fund in exchange for 90% of LTCM's equity.<sup>38</sup> The whole process was smoothly accepted by these institutions without any remarkable complaints. We would not have expected FED reserve bank to initiate such steps since the LTCM was a hedge fund whose regulation is quite limited. Apparently, LTCM became too big too fail which justified these steps. In addition, other significant investors such as Salomon Brothers, Merrill Lynch, etc. held similar positions and the negative impact of the Russian default might have deteriorate the systemic stability even more.

Only few moments after take-over of LTCM fund, banks concerned with this fund started to reevaluate the items on their balance sheet connected with LTCM and the massive write-offs were done.

To sum it up, the “cash-machine” called LTCM turned into huge disaster resulting in a total loss close to \$4 billion. The above mentioned fact that too many investors were holding same positions was one of the reasons of liquidity black holes. Basically, there are two explanations for this concentration of opinions – firstly, the computer systems creating the financial models for the leveraged investors generated same results: those on-the-run treasuries were substantially more expensive than the off-the-run Treasuries. Secondly, many of the investment banks received information about trading activities of LTCM through their internal deals with LTCM and they just mimicked the strategy of this fund. The Russian sovereign default causing almost fall of the LTCM led to worldwide contagion of global liquidity shock affecting emerging as well modern and well-established markets. Moreover, the contagion effect stemming from LTCM fund was more widespread than the initial shock from Russian crisis.<sup>39</sup> The changes in market liquidity (including emerging and well-developed market) covering the period of rise and fall LTCM is depicted in Figure 5.

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<sup>37</sup> For instance the group included banks such as Goldman Sachs, Merrill Lynch, J. P. Morgan, Morgan Stanley, Union Bank of Switzerland, Lehman Brothers,

<sup>38</sup> <http://www.erisk.com/Learning/CaseStudies/Long-TermCapitalManagemen.asp>

<sup>39</sup> Dungey M., González – Hermosillo B., Martin V., (2002) *International Contagion effects from the Russian crisis and the LTCM near-collapse*, IMF working paper

Figure 5



Source: State street, Persaud, A. (2002) Liquidity Black Holes; UN discussion paper No. 2002/31

Liquidity index for emerging markets was created by using State Street's cross-border custodial data covering approximately 10% of the world's tradable securities across 42 countries. Based on Froot, Connel, Seasholes (1999) methodology Figure 5 shows the average percentage price impact faced by an overseas investor when buying or selling one basis point of the capitalization of an emerging equity market. Froot, Connel, Seasholes (1999) regresses returns on contemporaneous buys and sells.

Graph clearly demonstrates how the LTCM near-collapse and the flight to liquidity widened the buy-sell spread in emerging markets (expressed as an average % return per bps. of market capitalization in equity market) and reached the historic high levels. If we focus on the Buys/Sells gap from Late 1998 to spring 1999 we can conclude that this period was characterized by positive – feedback trading, i.e. further selling generated declines in returns and vice versa.

LTCM did not represent the first crisis of highly leveraged fund (e.g. Orange county fund suffered also huge losses) but definitely changed the common perception about liquidity risk. Its strategy based on deviations between market value and fair value did not take into account the aspect of market liquidity and its potential threat for systemic crisis.

### 3.2. Asian liquidity crisis 1997- 1998

In July 1997 had some Asian countries experienced severe financial crisis which is sometimes known as "Tom Yum Goong crisis" named after the Thai hot-and-sour soup for its specific progress. In comparison with LTCM/ Russian crisis, it is obvious that those 2 crises happened almost simultaneously. This might indicate the contagion effect and infection of one financial system by another. We are certain that these events share at least one common factor – the liquidity risk.

First of all, we must define the situation in Asia prior to the onset of the crisis. Asian countries, namely South Korea, Malaysia, Indonesia and Thailand were often referred as the “New Asian tigers” which symbolized their extraordinary economic growth. New Asian tigers managed to maintain annual average growth of GDP from 4.7% (Indonesia) to 7.4 % (Korea) for 30 years. Large flows of capital were transferred to these “ever-growing” countries. At some point these large inflows represented half of the total capital assessed to developing countries.

However, nothing lasts forever and so do this unprecedented long growth. There were some rumors about potential collapse of Asian countries asserting that economic growth was based only on the capital investments and that total factor productivity affected GDP marginally.<sup>40</sup> In other words, the GDP growth was too much concentrated on capital flows and once these flows stop the disaster scenario will occur. In second quarter of 1997, portfolio flows to Asian countries amounted roughly 10% of the portfolios of internationally focused equity funds<sup>41</sup> which gives evidence of excessive concentration.

Triggering point which caused the upcoming crash was the switch of exchange rate regime from currency peg (Thai Baht to USD) to the free - floating regime. Thailand's economy was closely dependent on the inflows of “hot money” still demanding higher and higher inflows which was unsustainable. Malaysia and Indonesia suffered from so called “crony capitalism”. By “crony capitalism” we mean that distribution of profit from large capital inflows which were unevenly allocated to the certain groups. Information about change of the currency regime spread rapidly and investors lost the confidence in Asian markets. Nearly perpetual economic growth turned into massive downturn causing GDP falls

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<sup>40</sup> Krugman P. (1995) *The myth of Asian miracle*, Foreign affairs, Stanford University

<sup>41</sup> Persuad A. (2003) *Liquidity Black Holes – Understanding, Quantifying and Managing Financial Liquidity risk*, Risk Books, First edition

by 16.5% (Korea) or by 15.3% (Thailand) in 1998. The Asian miracle turned into Asian mirage. The prices of assets were in a free-fall with no future prospects which made investors to put further sell orders and we already know that this usually generates only one possible outcome – liquidity black hole. Radelet, Sachs (1998) argued that crisis was the result of self-fulfilling prophecy and concluding it was crisis of liquidity not solvency.<sup>42</sup> Radelet, Sachs (1998) also noted that the prophecy was encouraged by the lack of urgently needed reforms. This theory was not accepted by the majority of economists for simply reason. If those countries need to be reformed, how could then they sustain such a growth lasting for decades? Or if the necessity of general reforms was so obvious, why the crisis was then unanticipated? Finally, IMF intervened and provided \$40 billion injection to initiate the recovery of Asian countries but obviously, it was too late.

### 3.3. Liquidity crises – lessons learned

Due to limited space for this part of master thesis we have named only a few liquidity crises. There were numerous examples of liquidity crises (Ashanti Goldfield, Northern Rock, Metallgesellschaft, Orange County) in history but we consider them for the purpose of this master thesis less important. LTCM/Russian and Asian crises are the most glaring examples of liquidity black holes.

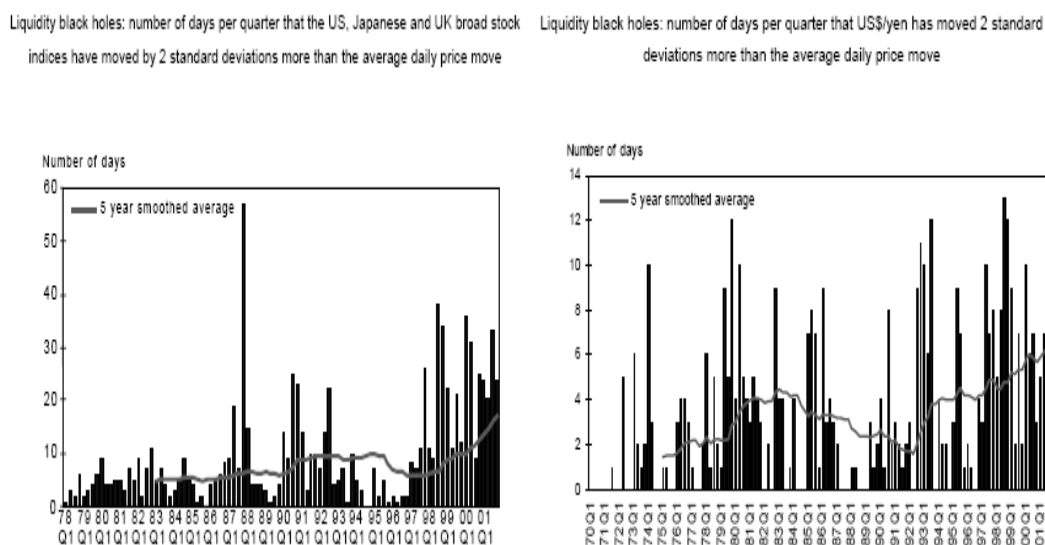
Asian countries had experienced shocks in terms of liquidity funding risk followed by liquidity trading risk. Similarly, Russian/ LTCM crises demonstrated almost the same process despite the fact that it occurred on separate markets. Asian and Russian crises also showed that country default risk should not be underestimated. A recent event in Greece, which is close to the country default and has to introduce austerity plan is clear evidence.

Perhaps more important characteristic was the loss of confidence in the markets accompanied by increased manifestation of herding behavior. It is hard to predict, what would have been the consequences if the IMF or FED reserve bank had not bailed out the countries and institutions. Essential point for this master thesis is the finding that the market liquidity can immediately evaporate no matter if we are in mature markets or in emerging markets. IMF changed its stand-points regarding to market liquidity in mature markets and since 1999 officially admits the occurrence of liquidity black holes during the year 1998 in Treasury, repo and Dollar/Yen market. Despite the willingness of IMF to take quick steps to provide help to the Asian countries, these attempts had not succeeded in restoring market confidence.

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<sup>42</sup> Radelet S., Sachs J. (1998) *The East Asian Financial Crisis: Diagnosis, Remedies, Prospects*, Brookings Papers on Economic Activity, Volume 1, 1998, 1-74

Figure 6



Source: State Street

Apparently, none of the markets is protected from this phenomenon. The spikes in volatility (we will discuss it in next section) indicate increased appearance of liquidity black holes in 1998 and 2001. There is one more interesting conclusion of these crises. From the previous text we can derive that liquidity black holes will appear more frequently in emerging markets in future. Emerging markets are driven not only by the local changes but they also depend on changes in major markets such as NYSE, LSE etc. and therefore they have to absorb much more new public announcements.

As a consequence of previous crises financial stability forum was established<sup>43</sup> calling for greater disclosures in hedge funds. This has become popular evergreen since then and whenever there is any sort of crisis politicians require higher regulation of hedge funds and bigger transparency in their activities. In fact, information symmetry is not sufficient condition for bubble-less markets and even in absolutely transparent environment crises will appear. There is some sort of anecdotal evidence that information symmetry is a good thing as we already discussed this topic in chapter devoted to causes of liquidity black holes.

Last thing, we would like to point out about general disclosures and absolute transparency is the different impact for particular subjects. Consider the most recent crisis concerning the potential sovereign default of Greece. In this case, government “cooked the

<sup>43</sup> <http://www.financialstabilityboard.org/about/history.htm>

books” and manipulated the data about public debt. If the manipulations were disclosed earlier, then market participants trading government bonds would regain confidence shortly. On the other hand, think of the consequence of LTCM crisis, if the FED had decided to uncover all the counterparties of LTCM fund. In our opinion, decline in market confidence would be even more dramatic.

## 4. Measuring Liquidity Black Holes

We have already discussed the pros and cons of using bid-ask spread. Avinash Persaud suggest that the easiest way how to capture the frequency of liquidity black holes is to simply sum up all the spikes in volatility. In other words, we calculate all the days in which the broad market index has moved by 2 standard deviations more than the average daily market move.<sup>44</sup> To capture the average daily market move we introduce arithmetic return:

$$r_i = \frac{r_t - r_{t-1}}{r_{t-1}} \quad (4.1)$$

Or for continuous compounding:

$$r_{log} = \ln \left( \frac{r_t}{r_{t-1}} \right) \quad (4.2)$$

We will plot standard deviation on annual basis as follows:

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^N (r_i - \bar{r})^2} \quad (4.3)$$

Where  $n$  represents number of observations and  $\bar{r}$  is the average daily price move.

The biggest advantage of this method is its simplicity in combination of easy access to the data. In contrast, there is no explanation of using 2 standard deviations as the signal of liquidity black hole. We are aware that such volatility indicates a huge price changes but we miss some sort of empirical justification for this model. The second question related to this measure is how to convert this measure in case we want to find out if there is occurrence of liquidity black hole in shorter period. We assume that this ratio is constant.

Moreover, we should not put liquidity and volatility on equal level. Naturally there is strong correlation between those two variables but volatility might not be entirely explained by occurrence of liquidity black holes. The causal relationship goes from liquidity black holes, not the opposite way. Persaud (2001) describes it through the well-functioning market where traders adjust their bids according to recent public announcement. Conversely, Ill-

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<sup>44</sup> Persaud, A. (2002) *Liquidity Black Holes*; UN discussion paper No. 2002/31

functioning market is the market where decreases of asset prices induced by new public information trigger further falls. Hence, this measure of spike in volatility captures all liquidity black holes, but not all the spikes might represent liquidity black hole.

Cohen, Shinn (2003) provide more sophisticated type of measure based on the vector auto regressive regression. In fact, this model had been invented by Hasbrouck in 1991 but Cohen, Shinn used it as the relevant measure for liquidity black holes. This approach is completely different from the previous model of Avinash Persuad. As we noted earlier, liquidity black holes depend on which type of investors dominates the market. Hence, Cohen, Shinn (2003) built up their model to capture the positive-feedback trading - investors buying on rising markets and selling on falling markets. This could be done by focusing on order flow as one of the key determinant of assets price changes. Using such a model might enable us to assess the causality – i.e. whether the increases in prices induce more buy orders and vice versa. Positive-feedback trading arises if majority of market participants are constrained and these participants are aware that other participants are constrained as well. The effect can be much enhanced if traders are close to their trading limits.<sup>45</sup> Original methodology for positive-feedback trading introduced by Hasbrouck (1991) and is based on estimating two-variable vector auto regression as follows:

$$r_t = \sum_{i=1}^5 \alpha_i r_{t-i} + \sum_{i=0}^5 \beta_i trade_{t-i} + \varepsilon_{1,t} \quad (4.3)$$

$$trade_t = \sum_{i=1}^5 \gamma_i r_{t-i} + \sum_{i=0}^5 \delta_i trade_{t-i} + \varepsilon_{2,t} \quad (4.4)$$

Where  $r_t$  is the return variable,  $trade_t$  (which is a signed trade variable ) is represented by 2 variables: 1<sup>st</sup> variable -  $x_t$  - is an indicator equaling 1 for buyer –initiated transaction, -1 for seller initiated transaction and 0 if there is price change without transaction. 2<sup>nd</sup> variable -  $v_t$  represents the size if the trade in millions of dollars multiplied by 1 for buyer- initiated transaction and -1 for seller-initiated transaction. Including  $\beta_o trade_t$  on the right-hand of the equation (4.3) enables us to capture trades only a moment before revision of quotes.

The illustration of positive-feedback trading is in figure 7b - while the market with no positive-feedback trading (and without liquidity black holes) is in figure 7a

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<sup>45</sup> Persuad, A.(2003) *Liquidity Black Holes Understanding, Quantifying and Managing Financial Liquidity Risk* management books, first edition, , p.125



Figure 7 a,b

Explanatory variables		Endogenous variables	
		Returns	Signed trades
	Past Returns	-	-
	Past signed trades	+	+

Explanatory variables		Endogenous variables	
		Returns	Signed trades
	Past Returns	? / -	+
	Past signed trades	+	+

#### 4.1. BCBS liquidity metrics

In the first part of our thesis, we discussed the principles for sound liquidity management. Basel committee for banking supervision presumably considered these principles to be insufficient and issued new paper called *International framework for liquidity risk measurement, standards and monitoring in December 2009* as a result of enormous amount of banks asking for bailout. In this new framework BCBS focused on resiliency and liquidity stress testing for internationally active banks.

According to BCBS survey more than 25 measures and concepts are used globally by local supervisors and in order to implement more consistency, BCBS introduced set of monitoring tools dealing with contractual maturity mismatch, contraction of funding, available unencumbered assets and market-related monitoring tools.

Main goal of BCBS paper was introduction of two new liquidity measures Liquidity coverage ratio (LCR) and Net Stable Funding (NSF) ratio. LCR should serve as a measure of short term resiliency of the liquidity risk to survive critical periods for approximately 30 days. NSF is basically designed to capture structural issues related to funding choices and promote resiliency over longer-term time horizons.<sup>46</sup> The LCR identifies amount of unencumbered high quality liquid assets that could be used to offset the net cash outflows.

$$\frac{\text{Stock of high quality liquid assets}}{\text{Net cash outflows over a 30-day time period}} \geq 100\% \quad (4.5)$$

<sup>46</sup> BCBS (2009) *International framework for liquidity risk measurement, standards and monitoring*, Report of Basel committee for Bank Supervision, BCBS 165BCBS paper 165, page 2

Apparently, LCR is well-known ratio used by banks as an internal metric used for expressing the exposure to contingent liquidity events. The purpose of introducing new “LCR” consists in precise definition of the numerator (Stock of high quality liquid assets) and denominator (Net cash outflows over a 30- day period.) High quality liquid assets are the assets which are easily convertible into cash without any value losses. The question is, what kind of assets is classified as highly liquid after financial turmoil 2007/09? BCBS determines fundamental characteristics (low credit and market risk, ease and certainty of valuation, low correlation with risky assets) and market – related characteristics (active and sizable market, presence of committed market makers, low market concentration, flight to quality). More specifically, BCBS published list of high quality liquid assets which contains following assets – Cash, central bank reserves, marketable securities, representing claims on or claims guaranteed by sovereigns, central banks, non-central government public sector entities and under certain conditions corporate and covered bonds can be included. We appreciate that BCBS precisely distinguished high quality liquid assets in this paper and gave a signal of how to evaluate liquidity risk at least at elementary levels. On the opposite, this precise specification could be a little bit tricky – Maintaining certain level of high quality liquid assets might lead to remarkable concentration of banks in these assets just in order to fulfill BCBS requirements. Net cash outflows are defined as cumulative expected cash outflows minus cumulative expected cash inflows arising in the specified stress scenario in the time period under consideration. Cash outflows comprise retail deposits, unsecured wholesale funding run-offs provided by small business customers, non – financial corporate customers, corporate customers and other legal entities or secured funding run – offs. Cumulative expected cash outflows are multiplied by expected percentages depending on amount of money assumed to roll-off and by specified draw-down amounts to various off-balance commitments.<sup>47</sup> Cumulative expected cash inflows should be calculated with respect to the basic accountancy rule – prudence rule. This means that only near or 100% sure cash inflows should be counted. Supervisors should also monitor the concentration of cash inflows. Capital inflows are namely retail, wholesale inflows, reverse repos and secured lendings, lines of credit or other cash inflows.

Net stable funding ratio measures the amount of longer – term stable sources of funding employed by an institution relative to the liquidity profiles of the assets funded and

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<sup>47</sup> BCBS (2009) *International framework for liquidity risk measurement, standards and monitoring*, Report of Basel committee for Bank Supervision, BCBS 165BCBS paper 165, page 11

the potential for contingent calls on funding arising from off-balance sheet commitments.<sup>48</sup>

$$\frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}} > 100\% \quad (4.6)$$

This ratio better reflects current problems of hiding toxic assets in off-balance sheet. Thus NSR better captures all the liquidity risk exposure on as well as off-balance sheet commitments. By “available amount of stable funding” is meant total amount of institution capital, preferred stocks, liabilities with durations one year or longer and portion of stable non-maturity deposits or term deposits with maturities of less than one year that would be expected to stay with the institution for an extended period in an idiosyncratic stress event. Required amount of stable funding is monitored and adjusted by supervisor who determines relevant types and amounts of particular assets tracked as required. Required stable funding factors that are assigned to particular assets are the parameters that could not be monetized through sales or used as collateral.<sup>49</sup>

In remainder of BCBS paper is described classification of monitoring tools and the weights assigned to these tools. We have already discussed some of them (GAP analysis, market concentration, etc.) and therefore we skip this part of the paper. In conclusion, it is important to say that LCR and NSF ratio are intended as minimum requirements that banks have to meet. These measures do not have ambitions to solve whole liquidity issue but might serve as basic buffers identifying potential liquidity crisis.

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<sup>48</sup>BCBS (2009) *International framework for liquidity risk measurement, standards and monitoring*, Report of Basel comitee for Bank Supervision, BCBS 165BCBS paper 165, page 3

<sup>49</sup> BCBS (2009) *International framework for liquidity risk measurement, standards and monitoring*, Report of Basel comitee for Bank Supervision, BCBS 165BCBS paper 165, page 22

## **5. Liquidity Black Holes in Czech financial markets**

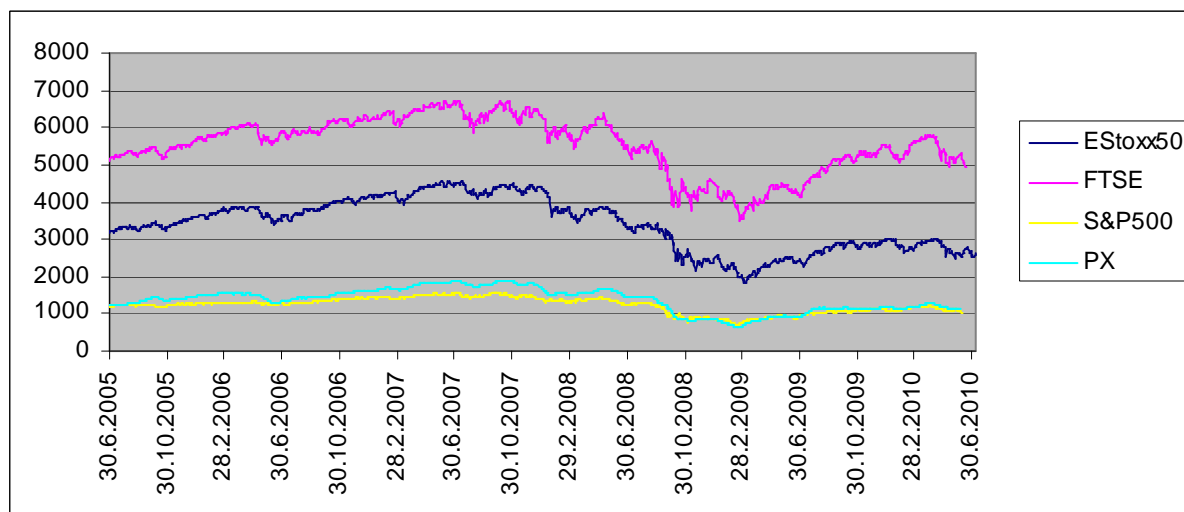
In following sections we will examine presence of liquidity black holes in Czech financial markets especially in stock market, inter-bank market and foreign exchange market. In section devoted to stock market we will try to use both measures as described in previous section in comparison with major worldwide indices. We will test theoretical predictions for period starting in mid 2005 to mid 2010 with special emphasis to the period of financial turmoil in 2007 - 2009.

### **5.1. Stock Market**

Stock markets attract most investors in general and therefore are often examined by numerous of academics. Movements in stock markets usually precede economic growth or declines. This is simply because big corporations, whose shares are traded, go public in order to raise funds. An access to the funds in stock market determines investment policy of each public company and therefore assesses economic growth.

For this master thesis we picked the well known indices S&P500, FTSE100, EUROSTOXX and compared it to Czech stock exchange index Px. Despite different composition of each index, amount of stocks included (S&P 500 includes 500 instruments, FTSE includes 100, EUROSTOXX includes 50, but Px approximately only 13 stocks!) and other factors all indices are significantly and positively correlated as depicted in Figure 8. In addition, each of these indices covers stocks from various industries and therefore offers diversity for prospective investment decisions. Rapid credit boom starting in 2003 triggered the growth of all indices lasting till the mid of 2007 when well known U.S. subprime mortgage crisis burst. Apparently, within the subprime crises in 2007 the major foreign indices started to decline and this was followed with some time lag by Px index. The largest declines were recognized in autumn 2008 when Lehman Brothers went bankrupt. All the indices selected for this thesis lost more than half of their values within one or two quarters.

Figure 8



Source: Thomson Reuters, Xetra 3000, *FTSE*, *EUROSTOXX* values adjusted to fit this graph

Figure 9

	S& P500	FTSE 100	EUROSTOXX	PX	Total
IX-05	3	2	4	-	5
XII-05	5	4	4	4	17
III-06	2	3	3	3	11
VI-06	5	4	2	4	15
IX-06	5	4	3	5	17
XII-06	4	4	5	9	14
III-07	4	4	4	1	12
VI-07	4	3	3	0	14
IX-07	3	4	3	4	12
XII-07	6	12	4	2	31
III-08	3	3	3	12	21
VI-08	4	4	4	0	12
IX-08	7	2	3	8	20
XII-08	4	6	5	9	24
III-09	3	4	6	2	15
VI-09	3	2	2	8	15
IX-09	6	3	4	11	24
XII-09	4	4	2	15	25
III-10	3	2	3	3	11
VI-10	6	4	3	3	16
Total	84	78	70	103	335

Source: Reuters + own computations

According to Figure 9 total number of liquidity black holes for this period is 335. Apart from index PX the largest amount of liquidity black holes (84) is assigned to S&P 500 index. This is plausible for our hypothesis that even broad portfolio of instruments of high quality attracting millions of investors does not overcome liquidity risk. In this case, despite the relatively small differences the fewer instruments traded within the index the less liquidity black holes.

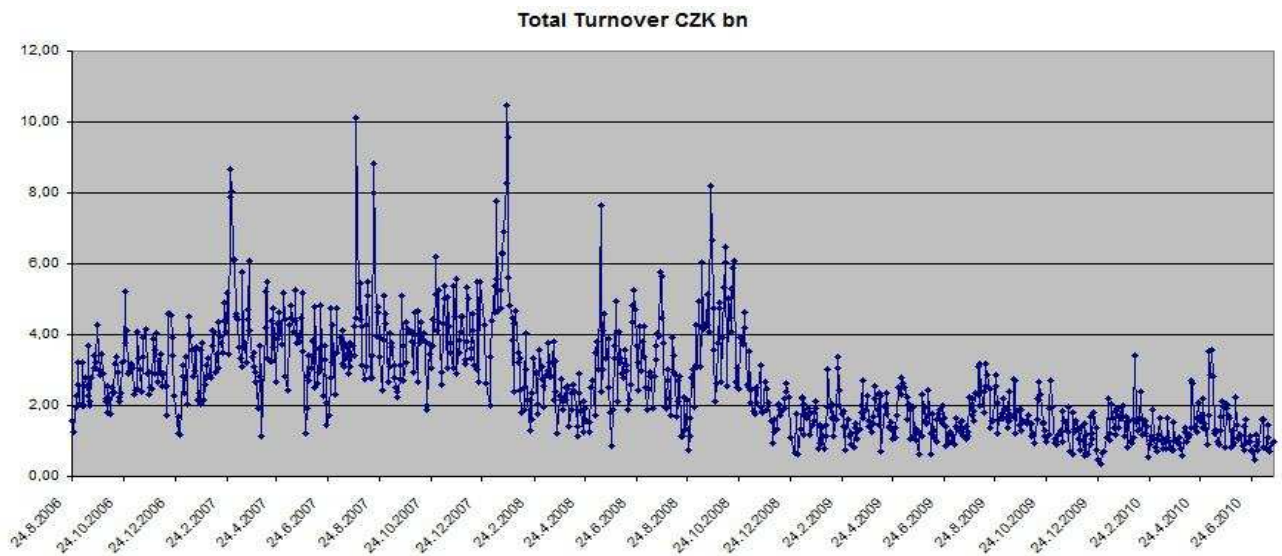
However, PX index incurred within the last five years 103 liquidity black holes which is by 40 black holes more than S&P500. We believe this might be due to the higher amount of events that emerging markets have to incorporate. Volatility is contagious and emerging markets has to face two types of information – information coming from well-developed markets and information from emerging market itself. In addition, investors from well-developed countries consider central/eastern Europe as a bunch of similar countries with insignificant difference and do not care about specific market conditions. In their flight to quality they unwind large positions causing price declines and triggering herding behavior.

If we take a look at time period with the highest frequency of liquidity black holes we resume that the most prone period for liquidity black holes was from 09/2007 till 03/2008 and from 6/2008 till the end of 2009 which could be reported as a response on subprime crisis respectively to the fall of Lehman Brothers and bailout of other banks. We can also see that Czech stock market reacted with a certain time lag which contributes to the hypothesis that financial crisis was “imported” to Czech Republic.

We have also found out that liquidity black holes in Czech stock market usually lasts for more than one day( usually at least for 3 consecutive days). As an extreme example 12 black holes in January 2008 occurred within 13 consecutive days! Further details can be found in Appendix of this master thesis.

Unfortunately, we are unable to test positive- feedback trading due to the lack of important data about initiators of transactions while these data are considered as highly confidential. In order to support our hypothesis of liquidity black holes in Czech stock market we rather focus on total turnover in stock market. We must take into account changes in Px composition (new IPO, delistings) which might substantially affect short term liquidity. Initial public involve ECM (December 2006), AAA (September 2007) VIG (February 2008), NWR (May 2008) and KIT digital (January 2010). Contrary, shares of Zentiva were delisted in April 2009. Total turnover in Stock market is depicted in Figure 10

Figure 10



Source: Patria Finance

We received data only for period starting in august 2006 till June 2010 but for purpose of this master thesis it is enough. Key periods were first quarter of 2008 and then 3<sup>rd</sup> and 4<sup>th</sup> quarter of 2009 when total number of liquidity black holes exceeded amount of 10. First quarter of 2008 is characterized by extremely high turnover reaching more than 10 billions CZK followed by dramatic decrease far below the average of the first three months. 3<sup>rd</sup> and 4<sup>th</sup> period of 2009 is characterized by low trading activity as a whole for two reasons – Firstly, it was summer which is always connected with lower trading activity and secondly whole year 2009 was affected by decrease in trading activity. In this environment every large transaction can substantially increase volatility and elicit liquidity black holes. New IPOs or delistings from Prague Stock exchanges affected turnover without any remarkable significance.

## 5.2. Inter - bank market

Inter-bank market is designed for short-term operations (usually over-night operations) between commercial banks and central bank. Financial turmoil culminating in autumn 2008 has deeply affected Prague inter-bank market as well. Millions of transactions were processed in order to satisfy short-term liquidity needs of banks in “pre-Lehman Brothers fall” period. However, fall of this investment bank triggered the forthcoming global liquidity/credit crunch and completely paralyzed Czech inter-bank market. Firstly, we will analyze the amount of liquid assets in aggregate balance sheet and the Capital adequacy ratio. Secondly, we will explore the history and progress of inter-bank interest rates.

At first, all the CEOs of major banks in Czech Republic claimed the financial stability of “their” banks. They often supported their speeches by asserting the ample liquidity measured by loans/ deposits ratio<sup>50</sup> without speaking about liquidity trading risk. To be fair, there was no bank which ran into difficulties or which would ask the government for bailout.

On the other hand, the bankers did not emphasize the situation in inter-bank market where the liquidity disappeared over night and destroyed whole market.

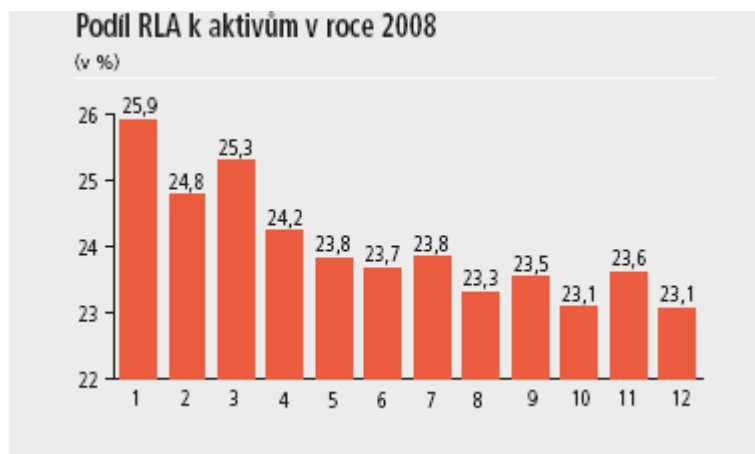
Figure 11

<b>Liquidity</b>						
	31.12.2006	31.12.2007	31.12.2008	31.03.2009	31.12.2009	I. Q 2010
Highly liquid assets in total (netto)	957 437	899 035	932 672	1 050 943	1 036 245	1 120 823
Highly liquid assets/assets in total (%)	30,38	23,97	23,06	25,46	25,31	27,26
Capital adequacy ratio (%)	11,49	11,55	12,32	12,86	14,11	14,30

Source: ČNB, Basic indicators of bank sector (Základní ukazatele bankovního sektoru k)

31. 3. 2010

Figure 12 – Highly liquid assets/total assets ratio in 2008



Source: ČNB, Financial supervision report 2008 (Zpráva o výkonu dohledu nad finančním trhem 2008)

If we focus on the basic indicators of liquidity measures published by ČNB it is obvious that there were some deflections in its continuous growth. First decline (by 6.4%) in

<sup>50</sup> [http://www.csob.cz/WebCsob/Csob/O-CSOB/Vztahy-k-investorum/Vyrocní-pololetní-zpravy/Pololetní-zpravy/CSOB\\_pol\\_zprava\\_1H2008.pdf](http://www.csob.cz/WebCsob/Csob/O-CSOB/Vztahy-k-investorum/Vyrocní-pololetní-zpravy/Pololetní-zpravy/CSOB_pol_zprava_1H2008.pdf)



total amount of highly liquid assets was recorded at the end of 2007. Year 2007 was the year of bursting subprime mortgages bubble in the U.S. but this fact should not generate any deep impact on performance of Czech banks since the profits of Czech banks were following growing trend. Despite the crisis of Bear-Stearns, Lehman Brothers etc. the total amount of highly liquid assets increased. When gauging any indicators in time series it is always more relevant to concentrate on relative measures. ČNB provides highly liquid assets/ total assets ratio. Since the end of 2006 this ratio continuously declined from 30.38% to 25.31% at the end of 2009 meaning that highly liquid assets created one quarter of total assets. The lowest values of this indicator were recorded in second half of year 2008.

This could have been assigned to an extraordinary depreciation and write-offs of CDOs and moderate deterioration of client credibility. To sum it up, the funding liquidity had slightly worsened but without dramatic consequences. Another proof of relatively stable funding liquidity is the capital adequacy ratio which has never decreased beyond critical value of 8%. This has been confirmed by the series of stress tests in 2010 which was based on modeling different scenarios.<sup>51</sup>

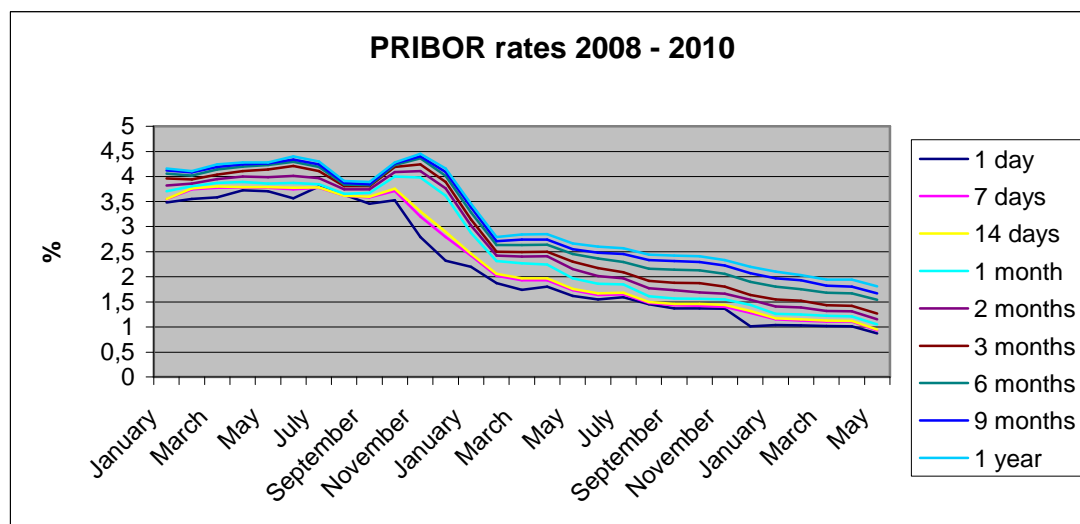
It was noted by one Czech journalist that: *“Financial crisis has started and will continue till the inter-bank market activities will be curbed.”*<sup>52</sup> Regarding to this article, the journalist took a deep look on inter-bank offer rates, so called PRIBOR (Prague interbank offer rate) with different maturities. In normal periods, the inter-bank rates are derived from the ČNB officially stipulated rates, which are slightly lower. As the volatility in financial markets increases the spread between inter - bank rates and officially stipulated rates usually widens. This could be little bit controversial because some central banks might accommodate monetary policy and change the rates. However, central banks try to keep monetary policy transparent and do not follow only one goal. It also takes some time to recognize whether the change in financial market is temporary or persistent. Nonetheless, in 2007 before subprime mortgage crisis, the average spread between 3-month dollar LIBOR and federal fund rate was 10 BPS. Following the subprime mortgage crisis and Bear Stearns fall the spread widened substantially and reached 81 BPS. Nobody expected that the situation could be even worse. In spite of some efforts by FED to increase liquidity of banks and lowering the FED fund rate the spread reached 332bsp. after Lehman Brothers fall.

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<sup>51</sup> Summary of Banks stress tests (Shrnutí výsledků zátěžových testů bank), Financial stability report ČNB, 2010  
<sup>52</sup><http://www.finance.cz/zpravy/finance/197619-financni-krize-zacala-a-skonci-na-mezibankovnim-trhu/>, November 1st, 2008

Let's now move to the Czech inter-bank market. Although we do not have any information related to the volume of transactions in inter-bank market, it was generally perceived and frequently discussed fact that inter-bank market is damaged. The reason for that is quite simple – as the financial crisis spread all around the world the confidence between individual counterparties disappeared immediately. Czech banks regarding to the nature of their business could use their liquidity reserves to overcome this critical period. In addition, relying on their cash reserves or highly liquid assets was exploited as a competitive advantage. Banks operating with ample liquidity reserves could dictate the lending rates to the less liquid banks. This can be well demonstrated by the evolution of PRIBOR and PRIBID rates as we noted earlier in the text.

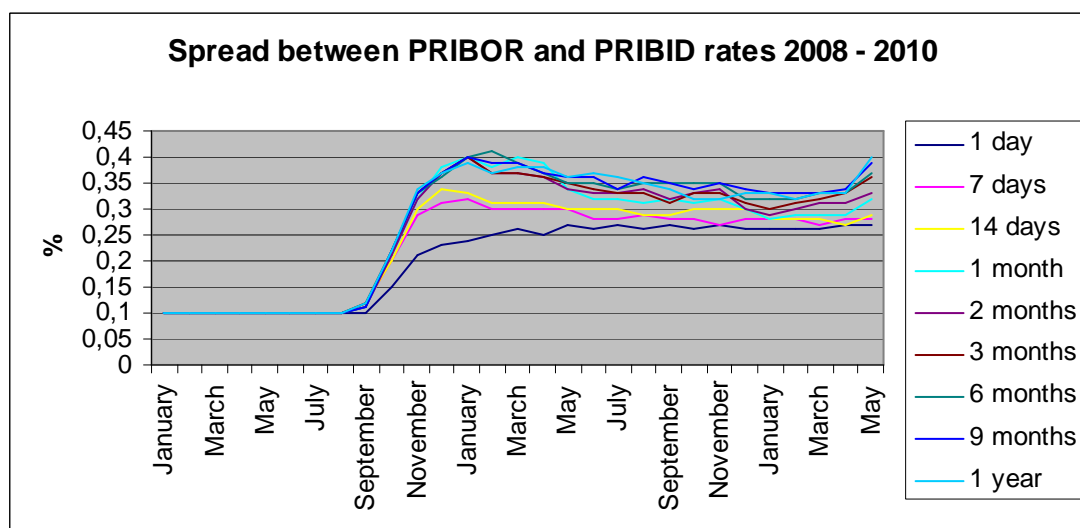
Figure 13



Source: [www.cnb.cz](http://www.cnb.cz)

Moderate conditions in inter-bank market during first half of 2008 were exchanged for dramatic increase of PRIBOR rates in the second half of 2008 which peaked in January 2009. It is worthy to say that from September 2008 the 14-days (or less) rates substantially diverged from the rates with longer maturity. The divergence lasted till spring 2009 and could be assigned to the preference of short-term operations and higher liquidity premium required by lenders. Since then, all the PRIBOR rates constantly decreased towards historical lowest values.

Figure 14



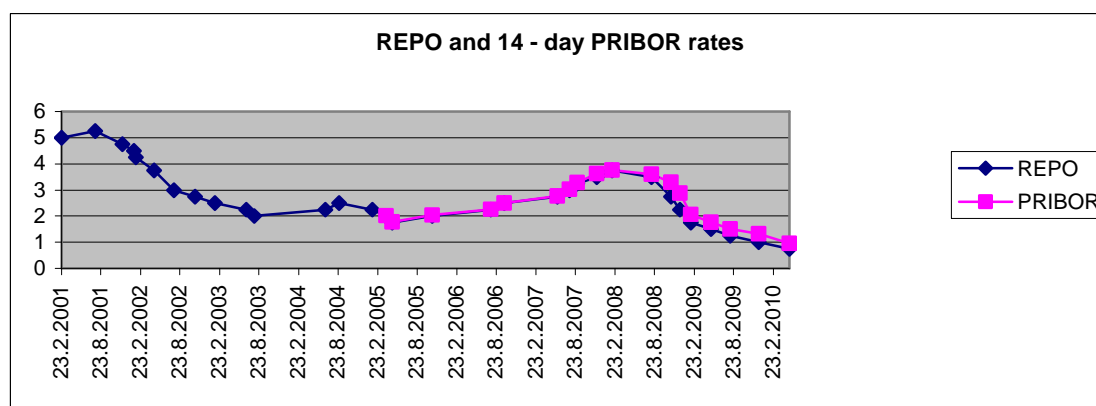
Source: [www.cnb.cz](http://www.cnb.cz)

Figure 14 depicts large jump in PRIBOR – PRIBID SPREAD starting in September 2008. The average spread for the first half of 2008 had not moved for more than 10 BPS. Moreover, the average spread had not crossed 10 BPS level since 2000. The lowest increase of spread in September is assigned to the 1-day PRIBOR (increment by 17 BPS) while the biggest increase belonged to the 1-year PRIBOR (increment by 27 BPS). This is linked to the liquidity premium as in previous situation. According to the research of ČNB covering period from 6th to 10th October 2008 the maturities of inter-bank loans shortened, meaning that no transaction lasting for one year had been confirmed and 90% of transactions were processed on over/night basis. The most intriguing fact is that the large spread (amounting 27 to 40 BPS) still persists even in the middle of 2010. One possible explanation is that PRIBOR is still declining because it serves as a reference interest rate for mortgages and this should attract new demand for mortgages. In conjunction with large SPREAD it might indicate that Banks still have not regained confidence in inter-bank market and do not provide any cash to the less liquid banks.

We still have not discussed role of central bank in inter-bank market. ČNB can basically regulate activities of banks through open-market operations, obligatory minimum reserves or through so called REPO rates. Open market operations are executed very often while obligatory minimum reserves have not changed since July 1999 and are set at 2% from primary deposits. None of those 2 aforementioned operations are processed in inter-bank market. REPO rate is essentially the only instrument of ČNB determined for inter-bank market. REPO rate is rate which commercial banks obtain if they deposit money at central

bank for 14 days. That is why the REPO rates should copy the 14-day PRIBOR which is confirmed in Figure 15.

Figure15



Source: [www.cnb.cz](http://www.cnb.cz)

Repo rate has been decreasing for a long time<sup>53</sup> and recently reached its lowest value amounting to 0.75%. Strong positive correlation of REPO rates and PRIBOR lowered PRIBOR rate but it does not mean that banks are more willing to satisfy their cash needs on inter-bank market. Central bank, as a local currency authority cannot simply add confidence to the market by shifting of interest rate although it is definitely a good signal. We suppose that this might be the reason why smaller (and presumably less liquid) banks tend to introduce savings accounts with large premiums for customers in order to finance their activities.

Unfortunately, we cannot use the same measure of liquidity black holes as for stock market index simply because we are unable to capture daily change and daily volumes. Hence we cannot use any quantitative measures for liquidity black holes or for testing positive-feedback trading. On the other hand, regarding to the comments of many analysts, traders and central bankers we might derive that inter-bank market was impacted by liquidity black holes that closely resembled those black holes in space – i.e. they were invisible but they certainly appeared.

<sup>53</sup> REPO rates were higher than 10% most of the 90's and large deflections in 1997 were linked to the currency crises

### 5.3. Foreign exchange market

Foreign exchange market is generally considered to be one of the most liquid financial markets essentially because of the enormous turnover.<sup>54</sup> Average daily turnover was \$3.2 trillion according to Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity in 2007. Currency conversions are processed every single moment and the needs to make a transaction in foreign currency will last as long as there will be more than one currency in the world. In last few decades, we noticed that governments tend to introduce new currencies generally valid for group of countries and replacing local currencies. That is the way how European monetary union has created and put into effect Euro. There are some efforts to create North American Monetary Union as well grouping together USA, Canada and Mexico in order to introduce new currency so called Amero.<sup>55</sup> Either way, foreign exchange market is dominated by only a few currencies (USD, EUR, GBP, YEN) whose turnover highly exceeds other less traded currency pairs. Apart from some small investors the turnover in foreign exchange market is mainly generated by large banks. For instance, according to the research of market share in 2009, the biggest player in foreign exchange market is Deutsche bank (18.06%) and the top 10 of the biggest dealers represent 72.72% of total market turnover.<sup>56</sup>

Small amount of currency pairs in conjunction with small amount of market participants imply the higher probability of liquidity black holes occurrence. However, situation is not so simple. Hedge funds can substantially affect liquidity – George Soros, "the Man Who Broke the Bank of England" was already discussed in previous section. Central banks play major role in some markets in order to protect currency. Another remarkable point consists in fact that there is not finite amount of "currency." Foreign exchange market deals with various number of derivatives (currency options, swaps, forwards, etc.) meaning that investors can create additional supply through lending/borrowing channel or by taking specific position in derivatives.<sup>57</sup> This is not valid for all countries since there might be imposed local restrictions to curb these activities.

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<sup>54</sup> BIS (2007) *Triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity*,

<sup>55</sup> Cohen Benjamin J. *North American Monetary Union: A United States Perspective*, 2004, University of California, Global and International Studies, UC Santa Barbara

<sup>56</sup> <http://www.reuters.com/article/idUSLDE6460UN20100507>, 30.6.2010

<sup>57</sup> Persuad, A.(2003) *Liquidity Black Holes Understanding, Quantifying and Managing Financial Liquidity Risk* management books, first edition,

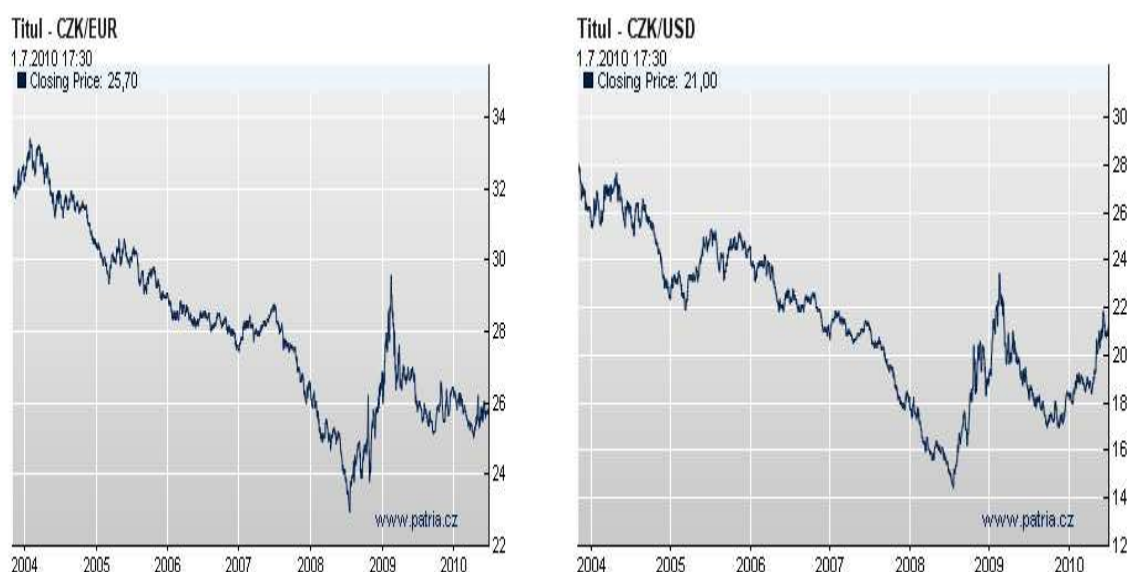
If we were asked to name at least 3 big liquidity black holes in foreign exchange market, our answer would be as follows:

- Black Wednesday (September 17<sup>th</sup>1992), was the day when Pound Sterling departed from exchange rate mechanism ERM. Market participants believed that “floor” set by ERM could not have been overcome (nor the risk management systems considered this scenario) and highly overvalued Pound Sterling was under permanent pressure. In the end Pound Sterling decreased by 15 % in 15 trading days. Other two black holes happened within USD/YEN currency pair and these were „Ascension day for the dollar” (August 15<sup>th</sup> 1995) and more importantly “The day when the carry trade got carried out” (October 7<sup>th</sup> 1998). There was a huge spread in interest rates between USA and Japan in 1998. High interest rates in USA attracted investors to buy US dollars in the forward market and therefore generating profit from carry trades. Global wave of optimism about “easy money” didn’t last forever and U.S. Treasury started to sell dollars which led to unprecedented volatility, triggering large sales by highly leveraged investors. This black hole is considered to be most severe because it resulted in 16% drop in three days.

We will focus on Czech Koruna and its short history. Czech Republic was considered due to its history where almost half of the century reigned Communistic party as a transition economy in 1990s’. Since 1990 till 1997 was Czech Koruna in fixed regime with certain fluctuation bands. Crucial period for Czech Koruna was in May 1997 when due to the some speculators ČNB gave up all efforts in order to protect currency and introduced managed floating regime. Since then, ČNB has used its privilege to intervene only for few times. The very last intervention was in 2002.

Czech Foreign exchange market is dominated by transactions of three currency pairs EUR/CZK, USD/CZK and EUR/USD. If we include spot, outright forward, FX swap and option based contracts then total turnover of EUR/CZK and USD/CZK conversions is approximately equal, while turnover of EUR/USD conversions is by 50% lower. This is simply because EUR/USD conversions are processed through spot operations and not through derivatives contracts. For this master thesis we will abstract from EUR/USD conversions since this currency pair is traded worldwide.

Figure 15a,b



Source: [www.patria.cz](http://www.patria.cz)

Figures 15a, b depict the history of exchange rates for the most traded currency pairs (apart from EUR/USD) in Czech Republic. Financial crisis caused sharp movements in exchange rates 2008 and Czech Koruna appreciated. Secondly, financial crisis confirmed strong positive correlation between USD/CZK and EUR/CZK pairs amounting 0.9249. This would suggest, that strong positive correlation predict similar outcome in liquidity black holes appearance.

Figure 16

	IX-05	XII-05	III-06	VI-06	IX-06	XII-06	III-07	VI-07	IX-07	XII-07
EUR/CZK	5	2	1	1	1	13	4	11	14	5
USD/CZK	3	3	2	4	3	7	1	0	16	4
	III-08	VI-08	IX-08	XII-08	III-09	VI-09	IX-09	XII-09	III-10	VI-10
EUR/CZK	1	10	1	6	1	8	8	1	9	5
USD/CZK	18	2	2	2	0	5	16	5	4	6

Source: own computations

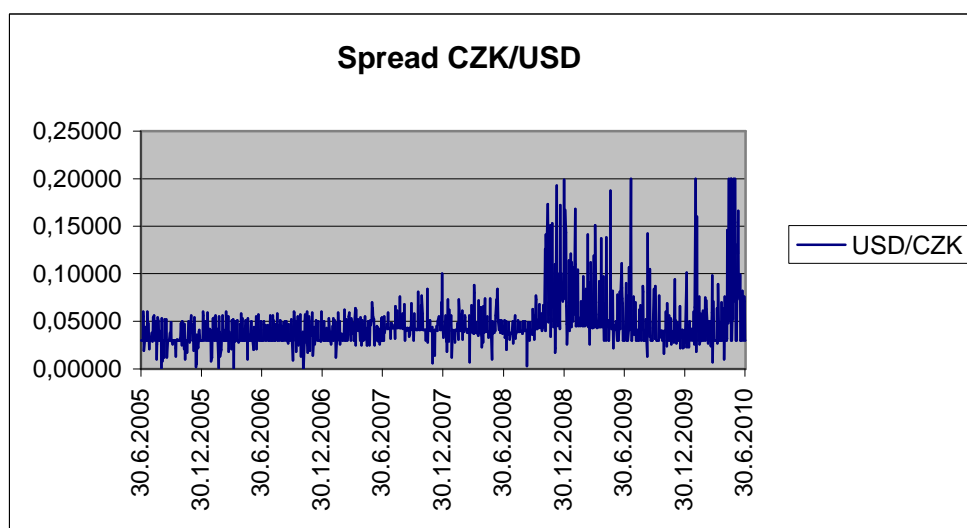
Figure 16 demonstrates that this is not the case. At first glance, it looks like there is no correlation between those currency pairs and liquidity black holes occur randomly. At second glance, we can see that periods with high frequency of black holes within one currency pair (let's say EUR/CZK, VI-07) is followed by higher frequency of liquidity black

holes in the second pair (USD/CZK, IX-07). We believe, that this is basically caused by the herding behavior when appreciation (or depreciation) of one currency (let's say EUR) is followed by flight to the second currency (USD) and vice versa. We can also conclude that periods of “calm trading” with only a few liquidity black holes can be immediately exchanged for periods with overly of liquidity black holes. According to Evans, Lyons (1999) exchange rates are mainly driven through order flow and hence not only by macroeconomic events. Evans, Lyons (1999) findings contribute to the hypothesis that foreign exchange markets are prone to liquidity black holes. We also proved that common knowledge of foreign exchange market as a highly liquid market is not completely plausible.

We did not find any significant correlation between liquidity black holes in stock market and EUR/CZK (correlation coefficient approximately - 0.274) or between stock market and USD/CZK (correlation coefficient approximately 0.2184)

Unfortunately, we are unable to produce similar verification of liquidity black holes by total turnover like in chapter dedicated to Stock market. ČNB provides average daily turnover of individual currency pairs but these data are published randomly for only few months within a year. Hence, we decided to focus on BID/ASK spreads of these currency pairs.

Figure 17

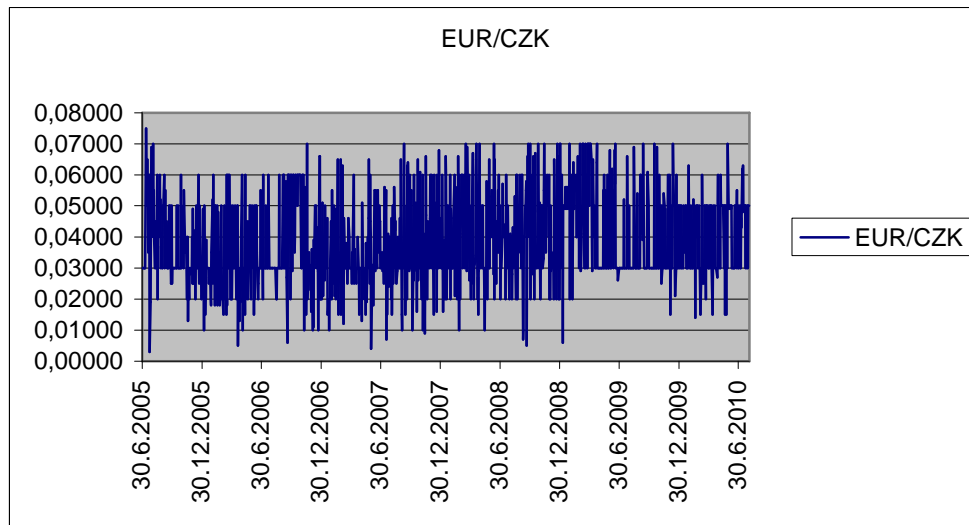


Source: Thomson Reuters, Xetra 3000

Figure 17 clearly demonstrates widening of spread since late 2007 representing ongoing subprime mortgage crisis. Much sharper movements were recorded within 2009 which was also period of numerous black holes.



Figure 18



Source: Thomson Reuters, Xetra 3000

Results for EUR/CZK spread were much more ambiguous. Large spreads were recorded in periods with high amount of black holes as well as in periods with low amount of liquidity black holes. There is some small evidence, that in periods with ample of liquidity black holes were BID-ASK spreads at least little bit larger it is not very significant.

#### 5.4. Solutions for liquidity black holes

Obviously, our ambition is not to completely replace liquidity black holes but to create an environment where markets would be less prone to liquidity black holes.

Despite modern technologies, market consolidation and globalization as a whole, we still feel that financial markets are dominated by only a small group of institutional investors, who are in addition bounded by the strict rules and overall financial regulation. The role of institutional investors is reinforced by introducing multi – pillar systems of pension reforms. In our opinion, financial authorities should focus on strengthening the role of individual investors. We consider the introduction of new, individual investors to the financial markets as the biggest challenge for current politicians.

The concentration of assets of mutual, pension funds etc. in particular should not be underestimated as well. We are aware that legal framework prevent institutional investor from overly concentration but still we think that there might be imposed some rules for unwinding

large positions in assets and that these transactions should be sliced in smaller and consecutive transactions in order to avoid fire-sales.

Next step in preventing from liquidity black holes is the restriction in using leverage and margin trading. Margin trading i.e. buying without required capital was the trigger of the Great depression in 1930s where only 10% of own equity was sufficient to purchase any asset. It is reasonable to consider that if you need to borrow 90% of the purchase price your credibility is very low. Restrictions on margin trading prevent from leveraging/deleveraging effects as we described those effects earlier.

Collapse of information costs was also assigned to one of the reasons for liquidity black holes. Of course, no one can influence the impact of any news but the main point is to follow more fundamental indicators than just relying on the opinion of any analysts in TV. Same strategy should be applied for investment recommendations published by financial institutions. We perceive these activities as an example of conflict of interest. How can any institution give independent free advice to millions of investors whereas operating in financial markets at the same time? Why would financial institutions employed large teams of financial analysts in order to reach comparative advantage when their conclusions are than broadcast in TV or via internet? One possible explanation is that they do so only to show their knowledge and perfect orientation over markets which can attract investors to use services of these institutions. On the other hand, several studies proved that these analysts have a tendency to be more optimistic than the market and therefore their recommendations are wrong. More or less, the main for us is to avoid making a decision based purely on the opinion of others because this is nothing but herding behavior.

Many people blame CEOs and managers of financial institutions for their greed which eventually lead to financial crisis. Hence, these people call for restrictions in compensation schemes of these managers because current settings give incentives to act in short-term horizons without considering any market sustainability. Despite we augment the lack of diversity in whole thesis, we think that there is at least some diversity in horizon of investors. Portfolio managers of Pension funds definitely do not share the same investment horizons like the managers of hedge funds. Compensation schemes of portfolio managers of pension funds thus differs from hedge funds managers and regulating their pay-offs is useless.

The bigger issue for pension fund managers is the restriction for the structure of their portfolio. Jiří Rusnok, the chairman of association of pension funds in Czech Republic often expressed his disappointments about limited trading strategies that pension funds can pursue. As the financial crisis did not occur, nor the conservative strategy of pension funds did

hamper large declines in pension funds profitability and large number of these pension funds had to ask for additional capital. To find some reasonable solution for Pension funds is pretty hard as we outlined it few paragraphs earlier. Pension funds are surety of clients and government. There is a strong pressure to sustain adequate profitability while no bankrupt is admissible. In our opinion no legal framework can absolutely determine certain strategy and optimal structure of portfolio which generate profits and is risk – free. That would be pure cash - machine. We believe that pension funds should care about diversity of their portfolio rather than keeping limits on certain assets in their portfolios.

Some politicians see the ultimate solution for financial markets in imposing so called Tobin tax levied on every single transaction. This should protect investors from unfair brokers who precede large number of deals in order to profit from the transaction fees. On the other hand, this will lead to the lower trading activity. We think that any tax levied on signed trades discourage investors and thus decrease overall liquidity. Hence, Tobin tax is not a good idea.

Last but not least we have to mention risk management tools. It is clear that celebrated VAR techniques are not sufficient for the world we live in. Even the liquidity-adjusted VAR does not remove all the problems connected with risk and (i)liquidity. LA-VAR is definitely more sophisticated tool but in general cannot solve all the problems. A. Persaud in his book concludes<sup>58</sup> that modern risk management tools are extremely focused on short – term correlations and volatilities. Hence, when these correlations and volatilities increase, liquidity black holes occur. However, Long – term oriented investors might not be concerned about increase of these short – run volatilities and might mitigate the consequences. Persaud also noted that liquidity needs losers – the investors who are buying when everyone is selling. The investors breaking market sentiment are usually hedge funds.

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<sup>58</sup> Persaud, A.(2003) *Liquidity Black Holes Understanding, Quantifying and Managing Financial Liquidity Risk* management books, first edition, page 101

## Conclusion and future perspectives

Aim of this master thesis consist in discussion of relevant articles and academic journals dealing with the issues of liquidity risk or more specifically liquidity black holes and applying the adequate measures to gauge liquidity black holes in Czech financial markets. We found evidence of liquidity black holes in stock market, foreign exchange and we believe that liquidity black holes were present in inter-bank market for the reasons discussed above. However, we did not manage to measure causality for determining positive – feedback trading. We tried to summarize individual approaches of liquidity risk and outline potential ways of further research.

As noted for many times earlier in the text, the key factor for liquidity is the diversity, especially diversification of opinions. Investment decisions should not be driven by herding behavior but rather based on fundamental principles and rational judgments. Critical periods, when markets experience severe turbulence are characterized by loss of confidence. As a consequence, governments tend to tighten regulation over financial markets in order to restore equilibrium in financial markets. Recently, we witnessed many attempts to increase the regulation. Namely, we can mention restrictions in compensation schemes for banks top management, new bodies responsible for supervisions or most recently ban of naked short sales in Germany and hedge fund regulation.<sup>59</sup> We believe that these types of new regulation rules might bring negative outcomes. Firstly, majority of these rules has been raised and put in effect by lawmakers and politicians. Although these rules were discussed together with financial engineers from BIS or ECB the final proposal always depend on political willingness. And we all know Downs model of political party competition. Secondly, we lack some sort of systematic global consensus in making new financial rules. Timothy Geithner, secretary of treasury persistently refused the new way of EU financial policy. He also denies hedge fund regulation concluding that this would turn hedge funds into regular institutional investor such as investment banks, mutual funds and so on. Hedge funds are basically designed for running un-traditional and risky trading strategies for wealthy individuals. Everyone who uses the services of hedge funds knows it and has reasons for such a behavior. In addition, hedge funds increase the discipline of particular firms in market, increase the diversity of opinions and point out to some misevaluation or market imperfection. Thus, hedge funds do not initiate systemic crises. Why would then should be hedge funds subject of

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<sup>59</sup> Wall Street Journal, German shock on short-selling splits Europe, May 20, 2010

increased regulation? We think that lost confidence cannot be simply added through some sort of artificial confidence via regulation like we described. Different approaches in regulation support regulatory arbitrage leading to large flows from one market to another depending on the actual trends in markets. In our opinion,(and long history of trading confirms our hypothesis) there will be always some bubbles in financial markets and introducing/banning certain acts (such as Glass Steagal act from 1933) showed that this is not the right way how to prevent markets from these crisis.

We leave this master thesis in period full of uncertainty. In period characterized by problems of banks in Spain, uncertainty about country default in Greece, Portugal or Italy, period of large austerity programs and also in period when results of Banks stress-tests are eagerly awaited. It is hard to express any future expectations about perspectives for Europe in 2 or 3 years. Analysts and economists are much more careful in their macroeconomic predictions than few years ago. This is the positive effect of recent financial turmoil. Financial crisis also showed how underestimated and under-researched liquidity risk is which was followed by boom of academic articles as well as new standards proposed by Bank for international settlement. We believe that now everyone takes liquidity risk seriously and this is definitely good point. Despite the fact, liquidity black holes will be presumably more prevalent in future, we do not think that global liquidity black hole which destroys global financial markets occur since there will be always incentives to trade any kind of instruments.

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