University of Szeged
Faculty of Economics and Business Administration
Doctoral School in Economics

Attila Ács

THE RELATIONSHIP OF LIQUIDITY AND REAL ECONOMICS

A case study of the United States

Theses of doctoral dissertation

Supervisor:

Dr. Katalin Botos

University of Szeged

Faculty of Economics and Business Administration

Dr. Gyula Pap

University of Szeged

Bolyai Institute, Department of Stochastics

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Content

1. Motivation of the research topic

About liquidity readers can find themselves facing similar mystery, as Carl Menger, who in his 1892 written essay defined the existence of money as enigmatic. The word "liquidity" is used to describe different phenomenons, like market, central bank, funding, global, monetary and micro liquidity, which suggests existence of a common feature. However there is no paper in the international literature which would define the concept of liquidity itself.

Papers dealing with liquidity got multiplicated from the middle of the 2000's. These studies for the most part lacked a clear definition of liquidity and missed the importance of market innovations and the changed information content of money aggregates (Rüffer, Stracca (2006)). Insightfulness got blurred by the strong integration of world capital and financial markets and consequently the difference between bank credit and capital markets, intermediaries and customers, national and international markets became thinner (Botos (1987), p. 162).

In the financial system of the United States the importance of the capital market grew in the supply of credit. Investment banks or broker-dealers became the driving force of financial innovation and came to the forefront at the 2008 financial crisis. The role of banks as the dominant suppliers of credit has increasingly been supplanted by market-based institutions, especially those involved in the securitization process. As a consequence money stock measured as balance sheet aggregate of the commercial banks does not convey proper information about the underlying liquidity developments (Adrian, Shin (2008a)). As highlighted by Lamfalussy (1969) in addition to the sheer quantitative growth of liquidity the qualitative changes of financial organizations, the greater flexibility offered by increased intermediation and hence a greater degree of liquidity within the economy must take into account too.

2. The goal and propositions of the research

The goal of the thesis is multiple. First it gives a new and universal interpretation of liquidity and a novel but at the same time traditional measure of it by offering broker-dealers aggregated balance sheet for that purpose. Secondly the thesis takes on investigate the influence of broker dealers onto real economy and investment assets. In accordance the thesis addresses the following propositions:

Proposition 1: Liquidity is the ease of money function transformation.

Proposition 2: Broker-dealers aggregated balance sheet is the most suitable measure of general liquidity conditions.

Proposition 3: Broker-dealers aggregated balance sheet as a measure of general liquidity conditions has influence over real economy.

Proposition 4: Broker-dealers aggregated balance sheet as a measure of general liquidity conditions has influence over certain asset prices.

3. Structure of the thesis

The first chapter of the thesis introduces different kind, definition and measure of liquidity: the distinction of inside and outside liquidity, and macroeconomic (or monetary), market, funding and global liquidity. Monetary aggregates generally used up to this day to gauge liquidity and the reasons of their short monetary policy carrier get detailed. The last subchapter addresses the critique concerning the different kind of liquidity measurements.

The second chapter takes a historical and judicious approach to present the development and influencing factors of liquidity. The intention of the chapter is to grab common factors influencing the different kind of liquidity and to bring them to a common denominator. Money functions will be of great help to understand the message of the chapter. In a succession subchapters follow a logical thread which explores efforts of early financial services providers to guarantee money functions and the concept of money function transformation get introduced. The main point of the section serves as the confirmation of Proposition 1: the essence of liquidity can be grabbed by the ease of money function transformation.

The third chapter deals with the current financial system based on money- and capital markets, discusses securitising, repurchase agreement and its market. Functioning of broker-dealers, evolution of their relative weight in the economy, their risk management technique and its consequence onto magnifying pro-cyclicality of the economy discussed in this section. The last subsection introduces broker-dealers aggregated balance sheet as a measure of liquidity. The ambition of the chapter is to give enough support to the proposal and at the same time serves as the proof of the Proposition 2.

The forth chapter endeavour to put the concepts of the previous one in a macroeconomic and capital market context in conjunction with the stylized facts concerning the development of broker-dealers' balance sheet. This section illustrates broker-dealers'

balance sheet expansion in terms of U.S. gross national product and M2 monetary aggregate. The chapter contains a description of change of asset and liability composition of broker-dealer aggregated balance sheet. Furthermore a shift in the leverage of broker-dealers at the beginning of 90's gets documented. Finally relevant monetary policy transmission mechanisms and implications are covered too from broker-dealers' point of view.

The fifth chapter characterized by a mathematical approach and deals with the methodology used to prove the statements of the Proposition 3 and 4 of the thesis. After the derivation of stationary vector auto-regression model (VAR) its application get introduced: the Granger causality, the orthogonalised impulse response function and the variance decomposition.

The penultimate, sixth chapter deals with the econometric analyses itself and the use of VAR models in the academic literature. After the identification of the VAR model and the outputs originating from it comes the checking and corroboration of the results and serves as the proof of the Proposition 3. The incorporation of asset prices into the VAR model serves to dispel any misconception about the quantitative results and provides the proof of Proposition 4 at the same time.

The last chapter summarizes the results, the Propositions and the contribution of the thesis to the academic literature. The final subchapter includes the critiques and about future research methodology states some alternatives.

4. The proof of Proposition 1, definition of liquidity

The word "liquidity" is used to describe different phenomenons. There is e.g. market, central bank, funding, global, monetary and micro liquidity but it means credit too and can be measured by quantities, prices and spreads. The common denominator is the ability of raising cash or deposit, the ultimate paying instrument and liquidity refers to the ease to raise money. Von Mises ([1953], p 331) defines a person liquid when she/he can settle a debt on the day when it falls due. In case of banks applies the same: "liquidity is that condition of the bank's assets which will enable it to meet all its liabilities, not merely in full, but also in time." However this definition is true in case of every economic agent not only of banks. An economic agent is liquid if it possesses enough cash or deposit to extinguish it liabilities. Having cash or deposit implies saving or asset which is exchangeable for money or the agent is worthy of credit that is solvent.

As the money is essentially a social phenomenon (Menger [1892]), the same can be said about liquidity. A social relationship implies confidence and liquidity is a confidential relationship. Confidence is indispensable and a very sensitive constituent of liquidity. Trust up to this day is the most important cornerstone of liquidity, the main source of what Bagehot (1873) drew attention almost a century and a half ago. According to Warsh (2007) liquidity is confidence.

Liquidity changed appearance through its evolutionary process several times. One thing that has been a constant factor in the course of time is confidence. Liquidity implies value and liaison between agents. Up to this day trust is the cornerstone of liquidity, of what Bagehot drew attention almost a century and a half ago.[1] The emphasis is on trust: confidence in the markets, institutions, agents, state, business plan and business conditions in general.[2] In fact, the word *credit* derives from the Latin language where "*credere*" means to trust. Guarantee and safety is the crucial point in case of liquidity. Only after guaranteeing trustworthiness can any bank-like service develop.

According to Kiyotaki and Moore [2001] to hold money there has to be a set of mutually-sustaining, absolute and infinite beliefs about its acceptance by every economic agent. Faith is so much a fundamental part of money that they draw direct parallel with religion. Both concern beliefs about eternity; e.g. on the U.S. dollar "In God We Trust" inscription can be read. Or on the bill of exchange as added assurance, the text of the "*Al nome di Dio*" appear, making default blasphemous (Kohn [1999b]).

Money functions are very useful to understand the essence of liquidity. Unit of account, medium of exchange and store of value money functions constitute a logical order. Wicksell ((1898), p. 22) recognised the importance of making distinction between the latter two money functions. To imagine the store of value function of money is hard without the other two functions, and the medium of exchange function in the lack of unit of account function. The unit of account money function in a fiat money system is given and depends on inflation.

Ancient time moneychangers can be viewed as first initiatives to guarantee the money functions – making money to function by offering information insensitive coins to the public.

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[1] As Bagehot put it ([1873], p. 267-268): "A man of known wealth, known integrity, and known ability is largely entrusted with the money of his neighbours. The confidence is strictly personal. His neighbours know him, and trust him because they know him. They see daily his manner of life, and judge from it that their confidence is deserved. In rural districts, and in former times, it was difficult for a man to ruin himself except at the place in which he lived."

[2] See Selgin [1988] p. 134.

Moneychangers to perform their activity first had to gain public trust and trusted for one reason became trusted for a different purpose; coin validation and safekeeping was followed by money transfer. By assuring the value of coins the moneychangers provided liquidity service for the economy, making possible that exchanges of equal values take place. Scarcity of precious metals assured permanence value of coins. The spatial and time dimension of money together with the inconveniences of bartering guarantees the general acceptance of money.

The offsetting value of a payment obligation apart from saving can be made up by credit or loan. From this point of view liquidity means solvency. Not money but liquidity what really matters (Botos (2013b)), that is the arrangement of money and its condition to be ready for lending. Moneychangers aside from guaranteeing the unit of account function of money in a certain way organised the market of coins too. The first bank-like formations created the market of borrowable funds, helping savers and potential debtors to find each other.

Typically financial institutions and non-financial companies can borrow funds herded with precautionary motive from households. Than borrowers relend those funds or achieve due payments and make investments. Landing and investment can be viewed as a transformation process of money store of value function into its medium of exchange function. In lending transactions borrower institutions primarily have to assure the store of value function of money for savers, while for borrowers the payment function of money get forwarded since they borrowed not to pile up money but to make investments and meet payment obligations.

Stored wealth automatically creates demand for investment. Bagehot ([1873] p. 331-332) writes about capitalists difficulty to put "their money where they could find it at an hour's notice" and "placing their savings at interest on good security. So great was that difficulty that the practice of hoarding was common." In accordance innovation of financial institutions aims not only to lessen economic agents' liquidity constraints but to satisfy their diverse saving needs (origination of negotiable private debt). This process implies the presence of well functioning organised markets and the concomitant market risk. Well organised liquid markets help agents to re-transform money functions by sale of assets. Raising cash or deposit money by sale of assets to meet payment obligations in due time the agent is liquid by definition.

The role of bank capital is to cover losses from intermediation and to assure prompt solvency of the bank (Diamond (1984); Brunnermeier, Sannikov (2011)). In case of financial

intermediation the bilateral relationship observed earlier in case of lending and payment services offered by moneychangers broadens to a trilateral one: savers – agent – debtors. Since financial institutions 'convert' depositors' money into loans, the institutional guarantee is essentially a function of the quality of loans. Innovative steps of financial institutions can be viewed as efforts to bridge depositors' confidence deficit and maintain public confidence.

Banks seek to create negotiable information-insensitive bank debt like deposits. Negotiability first of all requires safety. This means the value of the bank debt is close to constant; and secondly it is not subject to adverse selection during market transactions, that is nobody pays anyone for private information regarding the value of the bank debt and speculates on that information (Gorton, Metrick (2010b)). By producing negotiable private debt banks make possible for strangers lacking confidential relationship to pay debt in a cashless way by simply debiting their bank current account. Banks' effort to produce negotiable, safe and information-insensitive private debt implicitly involves warranty of the money store of value function too.

In accordance with the previous paragraph liquidity – aside from economic agents productive activity – is the ease of money function transformation. Economic agents pile up money for its store of value function and invest to earn some return. Issuers of credit instruments and shares look for money for its medium of exchange function to achieve investments, pay debts and consume. Landing and investment can be viewed as a transformation process of money store of value function into its medium of exchange function. Hence liquidity can be interpreted as the ease of this money transformation process which gives rises to debt (deposit, debt security) and equity (share). Liquidity is dependent on savers' and lenders' confidence in the retransformation of debt and equity into cash. To put it simply liquidity is confidence.

Along confidence liquidity is function of financial innovation. Money function transformation usually happens trough a mediator (bank or broker). The operation of financial intermediaries can be viewed as a process which makes the transformation process faster, cheaper and safer and satisfies economic agents' diverse demand for savings and financial resources. Falling value of securities (debt, ownership) makes raising cash against securities more difficult and liquidity diminishes. The funding, stock market and security market liquidity all refer to the ease of converting investment back into cash. Liquidity problems arise because the store of value function of money is not fully guaranteed. This way the Proposition 1 of the thesis is proved.

5. The significance and functioning of broker-dealers

In a financial system, characterised by vigorous innovation like that of the United States, monetary aggregates are no longer proper measure of liquidity. Monetary aggregates are liabilities of the deposit-taking banks. In a market-based financial system outstanding amount of financial commercial papers and repurchase agreement is better measure of aggregate credit conditions that influence the economy, and outstanding sum of those at the burst of the recent financial crisis was only 20% less than M2 money aggregate (Adrian – Shin (2009a)). The size of the broker-dealers aggregated balance sheet peaked in 2007 at 3200 billion dollars. In the second half of 2008 it fell abruptly to 2000 billion and since then hovers around. While the evolution of the M2 money aggregate shows an opposite picture. In 2007 was above 7000 billion of dollars and progressively reached 10,000 billion in 2012. This argument leads to an alternative measure of liquidity.

Liquidity means ability for immediate payment. Payment requires cash or deposit and agents possess money due to savings coming from previous economic activity, credit which requires solvency, or sale of assets. The action of trading assets for money necessitates markets and from this standpoint liquidity denotes market liquidity. Solvency is a more complicated phenomenon and in this case liquidity refers to the ease of obtaining credit or loan. From this perspective liquidity indicates the possibility to gain credit which can be measured by balance sheet aggregates of financial institutions performing financial intermediation and by the difference between deposit rates and credit rates (credit spread). This way liquidity is the ability of financial intermediaries to expand balance sheets and following Adrian and Shin's (2009a) interpretation liquidity should be understood in terms of the growth of balance sheets (i.e. as a flow, rather than as a stock).

In line with the above written the best solution were to look at the evolution of a big economic agent's balance sheet wherein all kind of liquidity exerts influence. These expectations are met by broker-dealers who played a key role in the eruption of the recent financial crisis in 2008. Furthermore out of the seven steps of securitisation three is done by broker-dealers (Adrian, Ashcraft (2012). Securitisation is the product of the shadow banking system. These shadow banks in the past decades provided sources of low-cost credit opportunities by converting opaque, risky, long-term assets into money-like and apparently riskless short-term liabilities (Pozsar et al (2010)).

Broker-dealers finance their highly leveraged balance sheets to a significant extant trough repurchase agreements or repo.[3] As Gorton and Metrick [2010] put it, repo is a kind of private money for institutional investors and nonfinancial firms which need a means to keep cash in a secure way, earn some interest, and have ready access to money in case of need arise. Securities that function as money are short-term debt, backed by diversified portfolios and have to be information insensitive. The latter stipulation means that the securities are immune from adverse selection when trading. In case of large economic shock information-insensitive debt can become information-sensitive. This is the loss of confidence which triggers fear of adverse selection and reduces liquidity (Gorton, Metrick [2010]).

Another way to create information insensitive security is haircut, the difference between the current market price of the security and the price at which it is sold in a repo transaction. Repo haircut aims to cut off from the collateral the information sensitive part. Haircut is applied during a repo transaction to protect a lender against adverse selection in case she has to sell the collateral if the borrower goes bankrupt or simple does not want to buy back the collateral (Dang, Gorton, Holmström [2011]). The haircut makes the underlying security liquid and repo can function as an interest earning money. According to Kiyotaki and Moore [2001] non-interest-bearing *fiat* money is not a logical necessity it is merely the consequence of a liquidity shortage. Fiat money may ultimately disappear, driven out by ultra-liquid, privately-issued securities that receive interest (like repo).

Nevertheless, agents still face a very similar problem as in ancient times in case of coins; that is the quality or value of the asset. This problem is addressed by several ways. First, credit rating agencies assess the credit risk of an issuer or a debt instrument. Rating agencies can be viewed as the modern version of moneychangers as they classify assets according to their fair value store. Thus haircuts vary depending on the identity of the counterparties and the rating of the collateral. Higher valued collateral makes debt less information sensitive and an adequately collateralized debt is fundamentally riskless. Second, as in Pozsar *et al* [2010], in the process of credit intermediation dealers enhance the credit quality of debt issued through the use of priority of claims. Third, credit intermediation is further improved through the use of third-party liquidity and credit guarantees, generally in the form of liquidity or credit put options. Use of derivatives in risk management serves to hedge the store of value function of money.

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[3] In a repurchase agreement, the borrower sells a security today for a price below the current market price on the understanding that it will buy it back in the future at a pre-agreed price.

## 5.1 Balance sheet management of broker-dealers

Figure 1. recreates the scatter chart as in Adrian and Shin [2010] for US Investment Banks. The horizontal axis measures the growth in leverage, as measured by the change in log assets minus the change in log equity of U.S. security broker-dealers where data drawn from the Flow of Funds accounts (1968 - 1991). The strongly positive relationship between changes in total assets and changes in leverage clearly can be seen, that is leverage is pro-cyclical. The 45-degree line indicates the set of points where (log) equity is unchanged. However producing the scatter chart for the period between 1992 and 2012, where 4 quarts data with extremely high leverage are missing (1999q4, 2002q4, 2008q3 and 2008q4), we get a different view. The points are not any more clustered around the 45-degree line but around a much flatter line. This indicates that balance sheet management of broker-dealers changed at the beginning of the '90s. This is confirmed by Figure 3. which demonstrates that balance sheet management of broker-dealers from the beginning of the 90's happened mainly through the change of leverage instead of the change of assets.
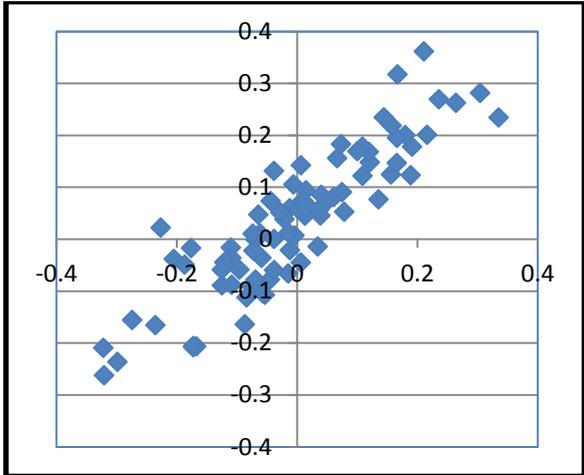
1. **Figure: Leverage Growth and Asset Growth of US broker-dealers, 1968q1-1991q4**
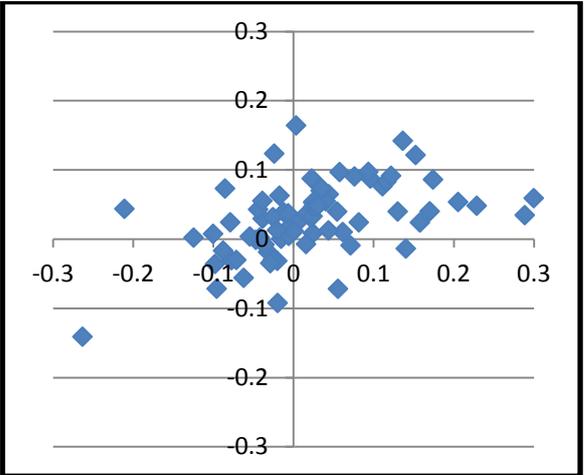
2. **Figure: Leverage Growth and Asset Growth of US broker-dealers, 1992q1-2012q2**
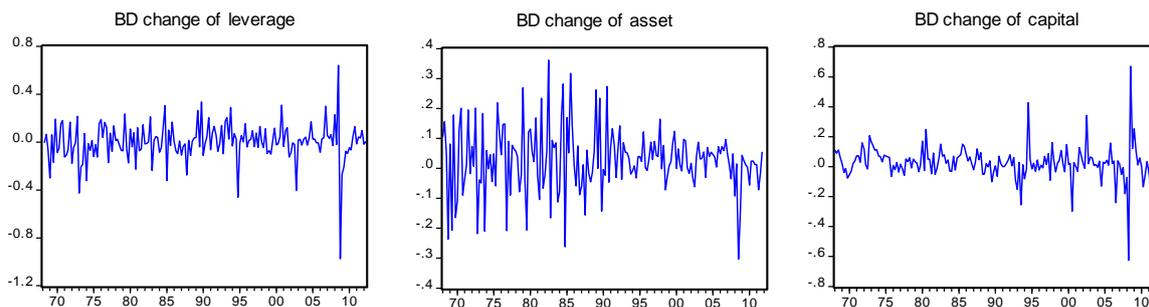
3. **Figure: Change of leverage, assets and capital of broker-dealers, 1968-2012. Data source is Federal Reserve Flow-of-Fund**

Furthermore, it makes sense to have a look at the evolution of the ratio between two quantity measure of liquidity and nominal GDP. Figure 4. tells of broker-dealers' vigorously growing balance sheet compared to U.S. nominal GDP and M2 monetary aggregate.[4] It is straightforward to say that the role of broker-dealers could have grown remarkably in terms of liquidity, even if the velocity of money and the transaction demand for money changed over time. However, to decide it is matter of empirics.
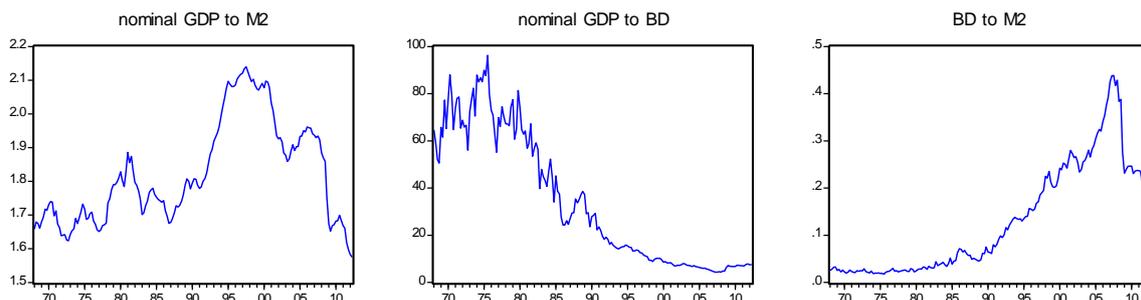
4. **Figure: Relative change of nominal GDP to M2 monetary aggregat and broker-dealers and to each other, 1968-2012. Data source is Federal Reserve Flow-of-Funds.**

6. Proof of Proposition 2

Liquidity is a complex phenomenon which entails that its measure requires discretion. Role of risk-taking and valuation have to be incorporated in a proper liquidity measure, thus bank leverage ratios, risk appetite measures (VIX), carry-to-risk ratios, asset prices and spreads, P/E ratios all have influence on liquidity (Domansky at al (2011)). Disyatat (2010) also highlights that leverage, asset quality, risk perception is all relevant for the effects of monetary policy shocks to unfold. Borio and Zhu (2008) draw attention to importance of the risk-taking channel. „It is in the context of the risk-taking channel that notions of "liquidity",

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[4] With counterpart of monetary aggregates, that is commercial banks' aggregated balance sheet we get nearly the same graph as they track each other very closely.

best thought of as the ease with which perceptions of value can be turned into purchasing power, acquire added significance".

To use broker-dealers aggregated balance sheet as measure of general liquidity conditions is underpinned by the following arguments:.

1) In accordance with Proposition 1 liquidity is the ease of money function transformation and broker-dealers take a dual role in it: in the process of securitisation originate credits and produce negotiable debt securities, while by market-making and underwriting roles in securities markets provide market-liquidity. Moreover organise markets for products used in hedging and risk management activity.

2) Asset prices, risk management and leverage play an important role in the evolution of broker-dealers balance sheet. Due to actively managed portfolio and marked-to-market balance sheets, the confidence factor infiltrates trough asset prices which incorporate market expectations, economic and political outlook, different kind of earning indicators (e.g. P/E ratio) and risk taking.

3) Broker-dealers can be regarded as the quick force of financial and capital markets. Hence effect of every kind of liquidity (market, funding, macroeconomic, monetary and global) infiltrates straight or indirectly in their reactions and eventually balance sheets which can be viewed as a liquidity barometer.

4) Broker-dealers are the main driving force of financial innovation, thus effect of financial innovation makes its way in their balance-sheet data.

5) Aggregated balance sheet size of broker-dealers is considerable, 25-30% in terms of commercial banks balance sheet.

These arguments give enough support and prove Proposition 2 which proposes aggregated balance of broker-dealers as measure of general liquidity conditions.

7. Methodology

To empirically address the issue, aggregated balance-sheet data of broker-dealers from the US flow-of-fund got incorporated into a Vector Auto-Regression (VAR) model. The results show that: (1) the M2 monetary aggregate does not have impact on GDP; (2) balance-sheet data of broker-dealers gives rise to significant impact in case of GDP. The results support the idea to restore balance sheet quantities in the conduct of monetary policy.

A VAR model of order p can be written as

$$y_t = c + \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \ldots + \Phi_p y_{t-p} + \varepsilon_t \qquad (5.3.3)$$

where y_t is an $(n \times 1)$ vector of endogenous variables, c_t is an $(n \times 1)$ vector of constant coefficients, $\Phi_{i,t}, i = 1, \ldots, p$, are $(n \times n)$ fixed coefficient matrices, and ε_t is an $(n \times 1)$ dimensional Gaussian white noise process, that is

$E(\varepsilon_t) = 0$ and

$E(\varepsilon_t \varepsilon_t') = \Omega$ if $t = \tau$ and 0 otherwise, where Ω is an $(n \times n)$ dimensional semidefinite matrix.

Let c_i denote the ith element of the vector c and let $\phi_{ij}^{(1)}$ to denote the row i, column j element of the matrix Φ_1. Then the first row of the vector system in (5.3.3) can be written as

$$y_{1t} = c_1 + \phi_{11}^{(1)} y_{1,t-1} + \phi_{12}^{(1)} y_{2,t-1} + \ldots + \phi_{1n}^{(1)} y_{n,t-1} +$$
$$+ \phi_{11}^{(2)} y_{1,t-2} + \phi_{12}^{(2)} y_{2,t-2} + \ldots + \phi_{1n}^{(2)} y_{n,t-2} + \ldots$$
$$+ \phi_{11}^{(p)} y_{1,t-p} + \phi_{12}^{(p)} y_{2,t-p} + \ldots + \phi_{1n}^{(p)} y_{n,t-p} + \varepsilon_{1t} \qquad (5.3.4)$$

Hence, a vector autoregression is a system of equations in which each regression has the same explanatory variables and each variable is regressed on a constant and p of its own lags as well as on p lags of each of the other variables in the VAR.

For a covariance-stationary process, the parameters c and $\Phi_1, \ldots, \Phi_p$ c can be defined as the coefficients of the projection of y, on a constant and $y_{t-1}, \ldots, y_{t-p}$. From the properties of projection follows that ε_t and $y_{t-1}, \ldots, y_{t-p}$ are uncorrelated, and the parameters of a VAR can be estimated consistently with n OLS (ordinary least squares) regressions ((Hamilton (1994), 257-261 o.).

　　VAR models are mostly used to generate impulse response functions (IRF), since a general VAR(p) model has many parameters, and it may be difficult to interpret them due to interactions and feedback between the model variables. IRFs trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the VAR errors, assuming that this error returns to zero in subsequent periods and that all other errors are equal to zero (Stock, Watson (2001)). The response of variables to a shock in one of the other variables can be interpreted as "effect" (Cochrane (1997), 37 o.).

Impulse-response function can be generated from, the infinite moving average form of a VAR model. A $MA(\infty)$ representation of a VAR can be written as:

$$y_t = \mu + \varepsilon_t + \Psi_1\varepsilon_{t-1} + \Psi_2\varepsilon_{t-2} + \Psi_3\varepsilon_{t-3} + \ldots = \mu + \sum_{j=0}^{\infty} \Psi_j\varepsilon_{t-j} = \mu + \Psi(L)\varepsilon_t, \qquad (5.3.13)$$

where Ψ_j is $(n \times n)$ matrix of the moving average coefficients for $j = 1, 2, \ldots$, and ε_t follows a vector white noise process.

If goal of research is structural inference that is to explore the causal relationship between variables, the difficulty of differentiating between correlation and causation come forward which is called the identification problem in econometrics (Stock, Watson (2001)). However it is quite natural that macroeconomic variables that are in a relationship with each other going to correlate which makes inference and IRSs correlated too. To overcame this problem Sims suggested using the $\Omega = ADA'$ Cholesky decomposition of the Ω covariance matrix of VAR errors. The Cholesky decomposition going to result in a unique A lower (and upper) triangular matrix with 1s in the diagonal and in diagonal matrix D with positive values in the diagonal. With matrix A the we can construct the following $(n \times 1)$ u_t vector $u_t = A^{-1}\varepsilon_t$, and rearranging we get the $Au_t = \varepsilon_t$ expression. Writing out the matrixes get the following:

$$\begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ a_{21} & 1 & 0 & \cdots & 0 \\ a_{31} & a_{32} & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & 1 \end{bmatrix} \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ \vdots \\ u_{nt} \end{bmatrix} = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \vdots \\ \varepsilon_{nt} \end{bmatrix}. \qquad (5.4.8)$$

Thus in a VAR process of order p, the first equation contains no instantaneous y's on the right-hand side, u_{1t} is simply equals ε_{1t} in the first equation (if the VAR error terms are uncorrelated then $A = I_n$). The second equation may contain y_{1t} and otherwise lagged y's on the right-hand side.

Using the coefficient matrixes form the $MA(\infty)$ representation of the VAR (5.3.13) we can produce:

$$\frac{\partial \hat{E}(y_{t+s} \mid y_{jt}, y_{j-1,t}, \ldots, y_{1t}, x_{t-1})}{\partial y_{jt}} = \Psi_s a_j, \qquad (5.4.18)$$

A plot of the above (5.4.18) expression as a function of s is known as an orthogonalized impulse-response function. It is based on decomposing the original VAR innovations ($e_{1t}, \ldots, e_{nt}$) into a set of uncorrelated components ($u_{1t}, \ldots, u_{nt}$) and calculating the consequences for y_{t+s}, of a

unit impulse in u_{jt} These multipliers describe how new information about y_jt, causes us to revise our forecast of y_{t+s}, (Hamilton (1994), 320-323 o.).

8. Econometric analysis

Due to the Cholesky decomposition and the resulting recursive ordering, the ordering of the variables in a VAR model is particularly important. Bernanke and Blinder (1992) offer an identification strategy which takes into consideration the time, necessary for a new information to get fully incorporated into the variables. Thus there are slower and faster moving variables. Correspondingly the following ordering of the VAR variables is: U.S. real gross national product (data source *Bureau of Economic Analysis*), seasonally adjusted consumer price index (CPI, data source *Federal Reserve Bank of St. Louis*), M2 money aggregate, Federal Reserve prime rate and aggregated balance sheet of broker-dealers (data source *Federal Reserve*). The recursive relationship of the model variables is as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} u_t^{GDP} \\ u_t^{INF} \\ u_t^{M2} \\ u_t^{R} \\ u_t^{BD} \end{bmatrix} = \begin{bmatrix} \varepsilon_t^{GDP} \\ \varepsilon_t^{INF} \\ \varepsilon_t^{M2} \\ \varepsilon_t^{R} \\ \varepsilon_t^{BD} \end{bmatrix}.$$

To choose the proper time frame of the analysis is relevant as fixed coefficients are estimated. The Federal Reserve began to follow explicit money growth targets in 1970 and gave up setting a target for M1 in 1987 and broader money aggregates in 1993 (Friedman (1996)). Furthermore the dissertation documented the changing behaviour of broker-dealers in terms or leverage and asset management from the 1990s. Hence for the analysis two time frame is determined: from 1968q1 till 1989q4 and from 1990q1 till 2012q2.

To determine the number of lags that should be included, criterion functions can be utilized. Akaike's criterion function (AIC), Hannan Quinn Criterion (HQC) and Schwarz's criterion (BIC) have gained popularity in determination of the number of lags in VAR. AIC is a less parsimonious lag order selection criteria whereas SIC and HQC are highly parsimonious.

However the underlying assumption is that the residuals pass the white noise test. The test statistics offered usually 2 or 3 lags but in every case the longer 3 lags got applied. As highlighted by Kilian (2001) VAR models with insufficient lag length often underestimate the true dynamics of the process and may result in spuriously tight confidence intervals. Impulse response functions can be thought of as curves well approximated by higher order

polynomials. In case of underfitting the lag order amounts to approximating these curves by lower order polynomials and consequently much of the curvature of the impulse response function is erased. The result is misleading estimates and inference.

Variables which proved not to be stationary (RGDP - real GDP, consumer price inflation - CPI, M2, and broker-dealers balance sheet BDTA) got log-differenced to ensure stationarity in the VARs. The stability of the VAR coefficients were tested by using an eigenvalue test. Using the VAR estimates, cumulative impulse response functions for a residual one standard deviation shock got generated.

For the estimation EViews 5th version was used.

9. The proof of the Proposition 3

Cumulative impulse response functions over a 30 month period generated from the VAR models together with the two-standard deviation confidence intervals are reported on Figure 5 and Figure 6. Both set of graphs show the impulse responses of real GDP to a one-standard deviation increase in the M2 money aggregate, the prime rate and broker-dealers.

By comparing the impulse responses the differences in the transmission mechanisms of the two periods can be easily detected. The impulse responses indicate that for the period of 1968q1-1989q4 an increase in M2 is followed by an increase in the real GDP however the reaction is not statistically significant. In case of the period 1990q1-2012q2 real GDP has an opposite, though weaker reaction. In both cases the long-run neutrality of money applies that is an unexpected and exogenous permanent change in the level of money does not lead to a permanent change in the level of output. In case of the prime rate an unexpected increase in R again is followed by different reactions of real GDP for the period 1968q1-1989q4 and 1990q1-2012q2. In case of the former period the statistically significant effect of the prime rate can be due to Federal Reserve's anti-inflationary monetary policy in the 70s and 80s.

The most important impulse response from the point of view of the dissertation can be seen on the right hand side of Figure 6. To an unexpected one-standard error increase in broker-dealers time series real GDP produces a statistically significant and long lasting reaction. The peak response occurs about 5 quarters after the impulse. Note that although the impulse responses of the real GDP to a change in M2 and prime rate fade after 12 months, the cumulative impulse response, shown here, does not fade. It is worth to mention that also for the 1968q1-1989q4 period broker-dealers has a statistically significant effect on real GDP though only for a couple of quarters.

The results of the variance decompositions are in line with the results from impulse responses. For the period of 1968q1-1989q4 the forecast error variance decompositions indicate that M2 money aggregate and broker-dealers innovations account for about 6 and 4 percent of the forecast variance in output after 5 quarters. For the period of 1990q1-2012q2 the forecast error variance decompositions point out that M2 money aggregate account for only about 1 percent of the forecast variance in real GDP while broker-dealers innovations account for 16 percent of the forecast variance in output after 4 quarters. Granger causality tests show that broker-dealers balance sheet Granger cause real GDP for the period 1990q1-2012q2.

These results give statistical evidence to Proposition 3 that is broker-dealers aggregated balance sheet used as a measure of general liquidity conditions has an influence over real economy.
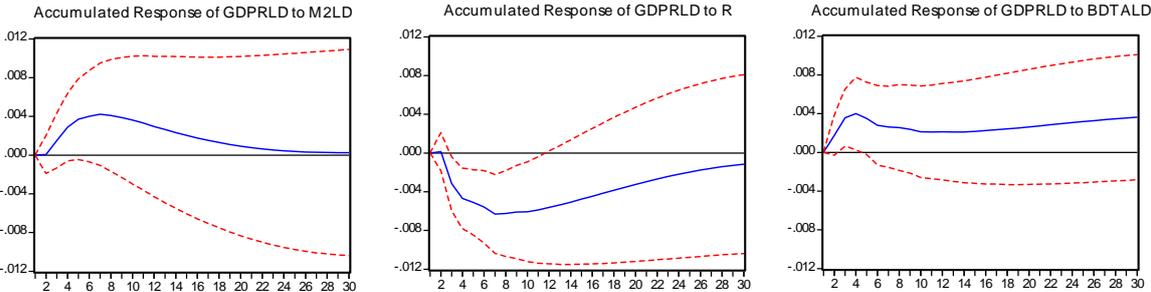
5. Figure: Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E. for 1968q1-1989q4
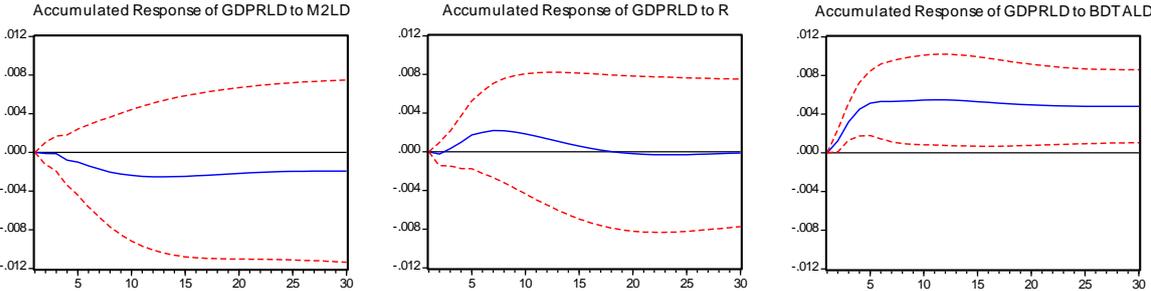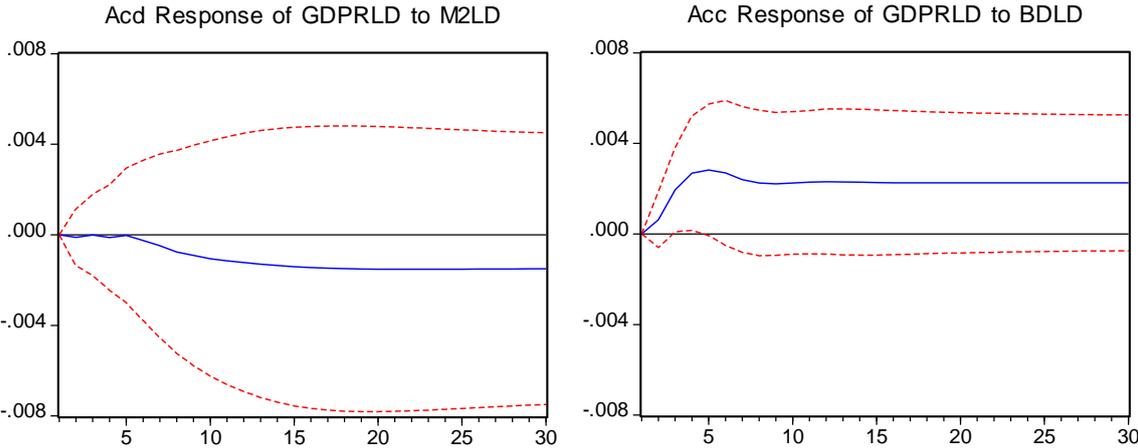

6. Figure: Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E. for 1990q1-2012q2

9.1 Robustness of the results

Checking the robustness of the empirical results is an important part of empirical analysis and serves to confirm the results for the period of 1990q1-2012q2.

Since the ordering of the variables in the VAR determines the recursive causal structure, a further analysis is often performed to determine how sensitive the structural analysis based on the assumed causal ordering. Nonetheless for the ordering used in the Cholesky decomposition do not exists any realistic alternative. This sensitivity analysis is based on estimating the SVAR for different orderings of the variables. If impulse responses change considerably for different orderings of the variables in then it is clear that the assumed recursive causal structure heavily influences the structural inference. For this reason generalised impulse responses were generated too, during which process the ordering of the variables have no influence. However the repeated generalised impulse responses are corresponding to the results seen in Figure 6.

Following Weber, Gerke, Worms (2011) and given the extreme economic events happened in 2007-08, the previous VAR model got re-estimated for an alternative period too, namely 1990q1 and 2007Q2. The impulse response functions seen in Figure 7 largely confirms the results for the 1990q1-2012q2 period, although the reaction of the real GDP to a shock from the broker-dealers lost a significant part of its statistical relevance: the two standard error confidence interval of the impulse response function (signed by the dashed line) comprises the zero axis from the fifth quarter. In addition, the cumulative shocks dropped by half. It is important to mention that this result still supports the Proposition 3, only the statistical evidence got weaker. Furthermore the results indicate that the effect of broker-dealers can be different, asymmetric during an economic expansion and contraction.

7. Figure:Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E. for 1990q1-2007q2

## 10.   The proof of the Proposition 4

The incorporation of asset prices in the VAR model serve dual role. First they are indispensable to prove Proposition 4 secondly they address the problem of possible omitted variable. Thus this exercise can be regarded as further robustness check of Proposition 3.

A major limitation of VAR systems is their potential incompleteness. Although in real economic systems almost everything depends on everything else, usually with low-dimensional VAR models are used in applications. All effects of omitted variables are assumed to be in the innovations. If important variables are omitted from the system, this may lead to major distortions in the impulse responses and makes them worthless for structural interpretations Lütkepohl ((2005), 62 o.). As broker-dealers balance sheet incorporate asset prices and thus expectations, interest rates and spreads among others, incorporation of these variables address the problem caused by potential omitted variables.

To include asset prices in the VAR model, the approach used by Sousa, Zaghini (2004)), and Rüffer, Stracca (2006) has been applied, in accordance with S&P500 index, the 3-month treasury and 10-year bond yield was the last variable in the model, estimated for the period between 1990 and 2012. Real estate prices, concerning their slower price response, got plugged after the consumer price index in the recursive VAR model order. The VAR lag length for the most part remained unchanged, the deciding factor was to reach uncorrelated VAR error terms based on the LM autocorrelation test. The analysis is limited to the period after 1990, and the calculations were completed for the period ending in 2007q2 and 2012q2 respectively.

Based on the results obtained from the VAR models, Proposition 4 applies only for certain assets, namely for the S&P500 stock index return, 3-month treasury bill yields, 10-year government bond yields, BAA-rated corporate bonds and credit spreads. These reactions exhibit similar responses and produce statistically significant results always only for a couple of quarters. As an example, the Figure 8 illustrates 3 impulse response functions generated from the VAR model with the differentiated T-bill yields for the time-period 1990-2012. The real economic output reacts to the shock coming from the broker-dealers the same way as in Figure 6, producing a persistent and statistically significant reaction, while to the shock in Treasury bill yields real GDP shows no statistically significant effect. However, the T-bill yields produce a two-quarter-long significant negative reaction to the unit size shock occurring in the time series of broker-dealers that is an increase of the aggregated balance of broker-dealers results in a decline in the Treasury bill yields. The results of the variance decomposition shows once again that broker-dealers innovations account for about 16 percent

of the forecast variance in output after 5 quarters, and broker-dealers Granger cause real GDP again.
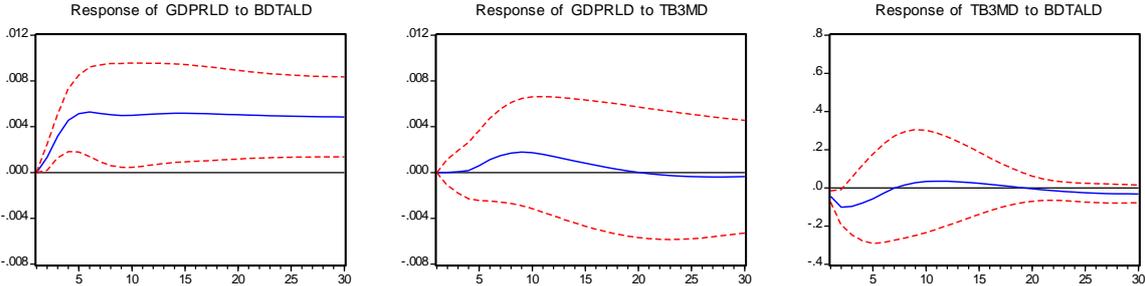
8. Figure: Accumulated Response to Cholesky One S.D. Innovations ± 2 S.E. for 1990q1-2012q2

The reactions of asset prices to a one-standard error shock of broker-dealers proved to be statistically different from zero only for a limited period of time, but reaction always happened in the direction corresponding to intuition. For the alternative 1990q1-2007q2 time period VAR analyzes get repeated for the S&P500 stock index return, 3-month treasury bill yields, 10-year government bond yields, BAA-rated corporate bonds and credit spreads. The results confirmed again the relevant role of broker-dealers, but the statistical significance of the reactions got greatly reduced or eliminated. Thus, the Proposition 4 of the thesis got justified in case of certain asset returns. One reason for the modest results can be the low frequency of asset prices and yields time series. The quarterly data is not well suited in case of assets to detect the desired link macro variables.

11.   Main results of the dissertation

Proposition 1: Liquidity is the ease of money function transformation.

The dissertation presents a new approach to liquidity through the use of money functions. This way liquidity – aside from economic agents productive activity – can be determined as the ease of money function transformation. Economic agents pile up money for its store of value function and invest to earn some return. Issuers of credit instruments and shares look for money for its medium of exchange function to achieve investments, pay debts and consume. Landing and investment can be viewed as a transformation process of money store of value function into its medium of exchange function. Hence liquidity can be interpreted as the ease of this money transformation process which gives rises to debt (deposit, debt security) and equity (share). Liquidity is dependent on savers' and lenders' confidence in the retransformation of debt and equity into cash. To put it simply liquidity is confidence. The money market, capital market, funding, the stock market and bond market

liquidity all expresses the speed and the costs to reconvert investments for cash. The macroeconomic liquidity, measured by quantifies of money, loan and interest rates applied on credits reveal the possibility of obtaining credit. Hence the Proposition 1 got proved.

Proposition 2: Broker-dealers aggregated balance sheet is the most suitable measure of general liquidity conditions.

Along confidence liquidity is function of financial innovation. The operation of financial intermediaries can be viewed as a process which makes the transformation process faster, cheaper and safer and aims to lessen economic agents' liquidity constraints and to satisfy economic agents' diverse saving needs (origination of negotiable private debt).

Broker-dealers participate in money function transformation in a dual way: actively take part in the process of securitisation, create credits and negotiable securities to satisfy economic agents' saving needs with diverse risk profile and organise markets for securities, manage market liquidity. Due to mark-to-market accounting and Value-at-Risk affect of leverage, expectations, valuations and risk appears in broker-dealers balance sheet. Thus their balance sheet can be viewed as a liquidity barometer Broker-dealers are the quick reaction institution of the shadow banking system: affect of different kind of liquidity types appear in their reactions and balance sheets. Being the main driving force of financial innovation, effect of innovation appears in their balance sheet. Given the considerable economic weight of broker-dealers all these facts support the statement of Proposition 2.

Proposition 3: Broker-dealers aggregated balance sheet as a measure of general liquidity conditions has influence over real economy.

The main economics contribution of the dissertation that the long-run neutrality formulated for monetary quantities in case of broker-dealers is not valid. Liquidity measured as broker-dealers aggregated balance sheet, unlike monetary aggregates, is not neutral in real economic terms.

Proposition 4: Broker-dealers aggregated balance sheet as a measure of general liquidity conditions has influence over certain asset prices.

Proposition 4 applies only for certain assets, namely for the S&P500 stock index return, 3-month treasury bill yields, 10-year government bond yields, BAA-rated corporate bonds and credit spreads. The incorporation of asset prices in the VAR model serve dual role. First they are indispensable to prove Proposition 4 secondly they address the problem of

possible omitted variable. Thus this exercise can be regarded as further robustness check of Proposition 3. In general the persistent and statistically significant reaction of real economic output to the shock coming from the broker-dealers remained unchanged for the 1990q1-2012q2 time frame. In case of 1990q1-2007q2 time period this response sometimes got stronger or weaker, gained or lost statistical significance but in every case the reaction remained positive. Thus the results support Proposition 3 are not due to variables omitted from the VAR model.

11.1. Additional contribution of the dissertation to the economics literature

Apart from resulting in a better understanding of the impact of money- and capital market participants' onto real economic the results of the thesis also contribute to monetary theory literature and help to formulate a more accurate judgment about the monetary stance. In the light of the results Bernanke, Gertler, Gilchrist's (1999) "financial accelerator" theory got confirmed; endogenous processes if the credit markets amplify the initial financial shocks, which results in real economic consequences.

The thesis contributes to Disyatat's (2010) bank lending channel interpretation. According to the theory the propagation of monetary policy shocks depends on the overall condition of the financial system, hence leverage, asset quality and risk perception has a determining role. The results, as part of the bank lending channel, concern mostly the bank capital channel, in which channel capital losses and inadequate capital adequacy ratios caused by falling asset prices are restored by deleveraging that is by sale of assets. The theory is supported by the statistically significantly response of real GDP to a shock coming from broker-dealers leverage.

Furthermore, the results enrich and give support to Borio and Zhu's (2007) risk-taking channel theory, provided that effect of the risk-taking channel can be grabbed trough the fluctuations of broker-dealers balance sheet as stated by Adrian and Shin (2010b).

The documentation of changing leverage and asset management of broker-dealers from the early nineties is a further additional contribution of the dissertation to economics literaure.

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