Universität Bayreuth
Rechts- und Wirtschaftswissenschaftliche Fakultät
Wirtschaftswissenschaftliche Diskussionspapiere

# Reviewing Excess Liquidity Measures

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## A Comparison for Asset Markets

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Discussion Paper 04-11
May 2011

ISSN 1611-3837

## Abstract

The conduct of US monetary policy is often accompanied by controversial debates on the adequacy of monetary conditions. These can result from different concepts of excess liquidity measures. The paper analyzes the theoretical and empirical information content of these concepts for asset markets. The analysis classifies, reviews and assesses measures of monetary conditions. For those that qualify as excess liquidity measures, the analysis continues with a comparison of the sources of imbalances and a discussion of the adequacy for asset markets. The theoretical results are cross-checked with empirical evidence. All excess liquidity measures are estimated and compared in the light of recent US asset bubbles. The analysis draws the following main conclusions. Firstly, not all measures of monetary conditions qualify as excess liquidity measure. Secondly, the increasing relevance of asset markets leads to growing distortions of excess liquidity measures. Thirdly, the choice of excess liquidity measure has influence on the assessment of monetary conditions in asset markets.

**Key words:** monetary overhang, real money gap, nominal money gap, credit ratios, leverage ratios, price gap, natural interest rate gap, Taylor gap
**JEL classification:** E5, G1

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**Acknowledgement:** The author would like to thank Bernhard Herz, Matthias Kieninger and Matthias Kollenda for helpful comments.

# 1 Motivation

It comes as no surprise that the conduct of US monetary policy is often accompanied by controversial debates on the adequacy of monetary conditions. While consumer price inflation has been modest in recent years, asset markets have experienced several asset bubbles.[1] The Federal Reserve is repeatedly accused of causing asset bubbles due to an asymmetric monetary policy (see Roubini, 2006; Hoffmann and Schnabl, 2009). This asymmetry implies that the Federal Reserve does not act to prevent the formation of asset bubbles, but mitigates the aftermaths of collapsing asset bubbles (see Greenspan, 2004; Kohn, 2004). For instance, the collapse of the so-called dot-com bubble in 2001 was accompanied by quick, deep and long-lasting interest rate cuts of the Federal Reserve to historically low levels. This creation of excess liquidity is suspected to have triggered the recent asset bubble in the US real estate market (see Taylor, 2009). However, representatives of the Federal Reserve still insist that monetary conditions during this time were appropriate (see Greenspan, 2007; Bernanke, 2010).

Different perceptions of appropriate monetary conditions can arise due to different concepts of excess liquidity measures. These concepts use different indicator variables — interest rates, credit and money aggregates — to indicate an excess or a shortage of liquidity in an economy. In a hypothetical world with closed economies characterized by a complete and perfect financial system[2] *(interest rates)*, where all funds are channelled through financial intermediaries which are merely engaged in lending activities on the asset side *(credit aggregates)* and in deposit taking on the liability side *(money aggregates)* of the balance sheet, no measure of monetary conditions would contain information beyond the others (see Rüffer and Stracca, 2006, p. 9).

[1]See Phillips and Yu (2009) and Drescher (2011) for estimations on the dates of originations and collapses of US asset bubbles.

[2]A complete and perfect financial system implies that every agent can borrow money from and lend money to every other agent at any time at the same interest rate.

However, the prevailing characteristics of the world today differ in every respect. We live in a world consisting of open economies with incomplete and imperfect financial systems, exposed to various financial frictions (see, e.g., Bernanke and Gertler, 1989; Bernanke et al., 1996; Adrian and Shin, 2008b). Most of these have developed from classical bank- to market-intermediated financial systems with a wide multiplicity of financial instruments and intermediaries, which are engaged in businesses that depart from activities of pure lending and deposit taking. From this point of view, it should come as no surprise that most empirical literature obtains ambivalent results if and when, to what extent excess liquidity measures indicate potential risks to future inflation (see, e.g., Detken and Smets, 2004; Gouteron and Szpiro, 2005; Adalid and Detken, 2007; Greiber and Setzer, 2007). As a result, empirical evidence on a positive causal relationship from monetary conditions to asset prices is not as clear as theory suggests (see Wicksell, 1898; von Hayek, 1929; Kindleberger, 1996; Allen and Gale, 2000).

The paper aims to review excess liquidity measures for asset markets. The review is split into two steps. In a first step, the paper assesses the qualification of measures of monetary conditions as measures of excess liquidity. While measures of monetary conditions describe the accessability to funds in an economy, measures of excess liquidity additionally assess its potential risk to future inflation. The analysis focuses on the concepts of monetary overhang, real and nominal money gap, credit ratios, leverage ratios, price gap, natural interest rate gap and Taylor gap. In the following, these concepts have to fulfill the following requirements to qualify as excess liquidity measure. Firstly, they have to provide theoretically derived equilibrium values. Secondly, they have to indicate potential risk to future inflation. In a second step, the paper compares the theoretical and empirical information content of excess liquidity measures. The theoretical information content is evaluated by a comparison of the sources of imbalances and a discussion of the adequacy for asset markets. The empirical information content is examined by a comparison of excess liquidity measures during recent US asset bubbles.

The paper contributes to existing literature by providing a comprehensive overview and assessment of excess liquidity measures for asset markets. In detail, the paper addresses the following research questions: which measures of monetary conditions qualify best as measure of excess liquidity? What does the growing relevance of asset markets imply for the adequacy of excess liquidity measures? And how did these measures develop before, during and after recent US asset bubbles?

The paper is organized as follows. Section 2 classifies, reviews and assesses measures of monetary conditions regarding the qualification as measure of excess liquidity. Section 3 compares the sources of imbalances and discusses the adequacy for asset markets. Section 4 estimates and compares the development of excess liquidity measures during recent US asset bubbles. Section 5 summarizes the main findings.

## 2 Measures of monetary conditions

In the following, measures of monetary conditions are classified into a quantity or price dimension depending upon the indicator variable. The quantity dimension subsumes those concepts that address the volume, whereas the price dimension is associated with those concepts that refer to a market price.

### 2.1 The quantity dimension

The quantity dimension comprises all concepts that use money and credit aggregates as indicator variable. Money and credit can be distinguished with respect to three characteristics, namely the financial asset in question, the holder and the issuer of the financial asset (see IMF, 2000, p. 57, §281). Considering the financial asset dimension, the distinguishing characteristic of money is its degree of moneyness. The moneyness of an asset depends on its suitability as storage of value and degree of market liquidity (see IMF, 2000, p. 59, §§287-288). The issuer of money has to be part of the depository sector, whereas the issuer of credit depends upon the aggregate in question. The holder of money is by definition the money holding sector, which is typically composed of all resident sectors excluding the government and depository corporations sector. Again, the holder of credit depends on the aggregate in question. Based on these distinguishing characteristics of money and credit aggregates, the quantity dimension is further differentiated into the money and credit view.

### 2.1.1 The money view

The money view incorporates all concepts of the quantity dimension that use money aggregates as indicator variable for monetary conditions, such as the *monetary overhang*, the *real money gap* and the *nominal money gap*. All these concepts build upon the equation of exchange, famously stated by Hume (1752, p. 127) and Mill (1848, pp. 15). By definition, the equation of exchange states that the financial side (left-hand side) has to match the real side of the economy (right-hand side):

$$M_t \times V_t \equiv P_t \times Y_t, \tag{1}$$

where $M_t$ denotes the nominal money stock, $V_t$ the velocity of money, $P_t$ the aggregated price level and $Y_t$ is a measure for real output. Restating the equation of exchange with respect to the natural logarithm and growth rates yields:

$$\Delta m_t + \Delta v_t \equiv \Delta p_t + \Delta y_t, \tag{2}$$

where $\Delta$ is the first-order difference operator. The variable $\Delta m_t$ denotes the rate of money growth, $\Delta v_t$ is the change in velocity of money, $\Delta p_t$ is the inflation rate and $\Delta y_t$ is the change in output. Since the equation of exchange is an identity its relation is always true by definition. The capacity of the equation of exchange comes along with the application of the quantity theory of money (see, e.g., Newcomb, 1885; Fisher, 1985).

All three concepts of the money view base on the quantity theory of money, which provides — given the stability of money demand — a causal link from money growth to inflation.[3] According to the advocates of monetarism the underlying transmission channel builds on changes in relative prices (see Meltzer, 1995, p. 51).[4] Every shock to the quantity of money alters the absolute and relative marginal utility of money (see Meltzer, 1995, p. 52). The restoring of portfolio imbalances works through the real balance effect, as stated by Patinkin (1959). The re-balancing continues until the relative marginal utilities are equal to the relative prices (see Meltzer, 1995, p. 52). Every optimal portfolio implies the existence of a desired real money stock. Any deviation from it triggers transactions to regain the desired real money stock. At the current aggregated price level, the reduction of real money imbalances can be successfully accomplished by individuals but not by the economy as a whole, since any purchase of an item by one agent is the sale by another agent (see Congdon, 2005, p. 38). For the economy as a whole the desired real money stock can only be achieved by changes in the aggregated price level (see Fisher, 1985, pp. 55). This mechanism is at work until the current and desired real money stocks are conform. Friedman (1956) established the neo-quantity theory by restating the quantity theory of money with respect to the determinants of the velocity of money. For the long-term the famously drawn affirmation of Friedman (1963, p. 17) that *"inflation is always and everywhere a monetary phenomenon"* mirrors today's tenet of mainstream economists perfectly. Finding the determinants of money demand satisfies the pre-condition to apply the quantity theory since the money demand is inversely related to the velocity of money. Against this backdrop, money demand models relate money developments to their underlying economic forces. The well-established quantity theory of money ensures that the monetary overhang, the real and nominal money gap,

[3]If money demand is not stable or at least predictable, it is not possible to determine a growth rate of money consistent with stability of the aggregated price level (see ECB, 2001b, p. 43).

[4]The monetarism transmission channel starts in the asset market and spills over to the real economy since most assets exhibit lower cost of information and transactions (see Meltzer, 1995, p. 55).

fulfill the first requirement of excess liquidity measures to provide theoretically derived equilibrium values.

All three concepts of the money view have in common that imbalances are determined by the difference between the current and an equilibrium (real) money stock. A positive deviation refers to excess liquidity, while a liquidity shortfall is associated with a negative deviation. The main difference between the concepts is the way the (real) money stock equilibrium is modeled. Standard econometric approaches model money demand as a function of a scale variable $y_t$, e.g. a measure of transaction or wealth,[5] and a variable representing the opportunity costs $oc_t$, e.g. a representative interest rate spread (see, e.g., Lucas Jr., 1988; Stock and Watson, 1993; Ball, 2001). In case of nominal money demand this yields:

$$m_t = \beta_0 + p_t + \beta_y y_t + \beta_{oc} oc_t + \epsilon_t. \tag{3}$$

In real money demand models the price level $p_t$ is subtracted. Typically, money demand models are formulated in natural logarithm (except of interest rates), so that the parameters $\beta_y$ and $\beta_{oc}$ can be interpreted as the income/wealth elasticity[6] and the interest rate spread semi-elasticity[7] of money, respectively.

***Monetary overhang.*** The concept of monetary overhang is defined as the deviation of the nominal money stock $m_t$ from its estimated equilibrium $m_t^{*MO}$, which is determined by current realizations of the nominal money demand (see, e.g., ECB, 2001b; Tödter, 2002):

[5]The choice of the scale variable depends upon which functions money is assigned to (see ECB, 2001b, p. 42). The transaction approach of the money demand pledges for the use of an income variable, whereas the portfolio approach pledges for the use of a wealth variable (see Santoni, 1987, p. 18).

[6]In most empirical estimations the parameter $\beta_y$ is often found to be positive and greater one, capturing the effect that money is held not only for the purpose of transaction, but also for portfolio allocation purposes (see ECB, 2001b, p. 42).

[7]The parameter $\beta_{oc}$ is often found to be negative, reflecting investors' portfolio adjustments when opportunity costs alter. Lower market rates motivate to increase money holdings since these narrow the spread between opportunity costs of money holdings and their own rate of interest (see ECB, 2001b, p. 46).

$$m_t - m_t^{*MO} = m_t - (\beta_0 + p_t + \beta_y y_t + \beta_{oc} oc_t) = \epsilon_t. \quad (4)$$

The current money stock represents the identity of realized money demand and supply. By contrast, the equilibrium money stock represents the desired money demand. The monetary overhang includes information on short-term dynamics, which are not captured by the long-term money demand model (see ECB, 2001b, p. 49). For instance, deviations of the realized money stock from the desired money stock can arise due to costs of information and adjustment (see Tödter, 2002, p. 3). If the realized money stock is above (below) the desired money stock, the concept of monetary overhang signals upward (downward) inflation pressure. The property of the concept to indicate potential risks to future inflation fulfills the second requirement of excess liquidity measures. Now as both requirements are accomplished monetary overhang qualifies as excess liquidity measure.

***Real money gap.*** The concept of real money gap is defined as the deviation of real money stock $m_{real,t}$ from its estimated equilibrium $m_{real,t}^{*RMG}$, which assumes that the goods market $y_t$ and money market $i_t$ are in balance (see, e.g. ECB, 2001a; Tödter, 2002; ECB, 2004):

$$m_{real,t}^{*RMG} = m_t^* - p_t = \beta_0 + \beta_y \bar{y}_t + \beta_{oc} \bar{oc}_t. \quad (5)$$

In this vein, the real money gap can be expressed as a linear combination of disequilibria in the goods and money market as well as a residual:

$$m_{real,t} - m_{real,t}^{*RMG} = \underbrace{\overbrace{\beta_y(y_t - \bar{y}_t)}^{goods\ market} + \overbrace{\beta_{oc}(oc_t - \bar{oc}_t)}^{money\ market} \quad + \quad \overbrace{\epsilon_t.}^{money\ residuum}}_{price\ gap} \quad (6)$$

In the concept of real money gap upward (downward) inflation pressure results due to a positive (negative) mismatch in the production capacity $y_t - \bar{y}_t$, differentials in opportunity costs $oc_t - \bar{oc}_t$ and because of a money residuum $\epsilon_t$.These sources of imbalance restrain the second requirement of excess liquidity measures to indicate potential risk to future inflation. Hence, the real money gap also qualifies as excess liquidity measure.

***Nominal money gap.*** The concept of nominal money gap describes the deviation of nominal money stock $m_t$ from its estimated equilibrium $m_t^{*NMG}$ (see, e.g., Tödter, 2002; ECB, 2004). The equilibrium is calculated by extrapolating the money stock of a base period with a reference value for money growth. The reference value is derived by expressing the nominal money demand of equation (3) in growth rates:

$$\Delta m_t = \Delta p_t + \beta_y \Delta y_t + \beta_{oc} \Delta oc_t + \Delta \epsilon_t. \tag{7}$$

All determinants are set to equal their medium-term values, since only these should be key to achieve the medium-term inflation target ($\Delta p_t = \Delta p_t^*$). Output is stated as potential output ($E[\Delta y_t] = \Delta \bar{y}_t$), interest rates are assumed to be stationary ($E[\Delta oc_t] = 0$) and changes in the error term are expected to be zero ($E[\Delta \epsilon_t] = 0$). Based on equation (7) all these substitutions yield to the reference value for money growth $\Delta m_t^{*NMG}$ (see Masuch et al., 2001, p. 129):

$$\Delta m_t^{*NMG} = \Delta p_t^* + \beta_y \Delta \bar{y}_t. \tag{8}$$

Since the concept of nominal money gap refers to levels rather than growth rates a base period $t = 0$ has to be chosen as a reference point in time. The resulting reference money stock can generally be expressed as:

$$m_t^{*nmg} = m_0 + \Delta m_t^{*NMG} \times t = m_0 + (\Delta p_t^* + \beta_y \Delta \bar{y}_t) \times t. \tag{9}$$

Hence, according to the nominal money gap imbalances in monetary conditions are determined by the difference between the current money stock and its equilibrium:

$$m_t - m_t^{*NMG} = m_t - (m_0 + (\Delta p_t^* + \beta_y \Delta \bar{y}_t) \times t). \tag{10}$$

Substituting the current money stock $m_t$ and the money stock of the base period $m_0$

in equation (10) with their equation of exchange representations yields the following simplified expression for the nominal money gap (for the derivation see appendix A.1):

$$m_t - m_t^{*NMG} = \underbrace{[\bar{p}_t - p_t]}_{price\ gap} \quad + \quad \underbrace{[p_t - \hat{p}_t]}_{price\ target\ gap} \tag{11}$$

The concept of nominal money gap expresses money demand imbalances as the sum of price gap and price target gap. As discussed in detail for the concept of price gap below, the price gap captures the derivation of the equilibrium price level $\bar{p}_t$ and the current price level $p_t$. The price target gap captures past monetary policy errors by the difference of the current price level $p_t$ and the accumulated inflation targets $\hat{p}_t$ (Tödter, 2002, p. 5). The nominal money gap adjusts the real money gap by a "performance statistic" for realized excess inflation. The inclusion of monetary policy errors contradicts the second requirement of excess liquidity measures to indicate potential risks to future inflation. For this reason, the nominal money gap does not qualify as excess liquidity measure here.

### 2.1.2 The credit view

The credit view incorporates concepts of the quantity dimension that refer to credit aggregates as indicator variable for monetary conditions; in particular that includes *credit ratios* and *leverage ratios*.

***Credit ratios.*** Credit ratios typically oppose the financial and real side of an economy. The underlying motivation of credit ratios is to link both sides of the economy.[8] The most prominent credit ratio is 'credit to the private sector' to (real) GDP (see, e.g., Borio et al., 1994; Borio and Lowe, 2002; Adalid and Detken, 2007; Schularick and Taylor, 2009):

[8] Credit ratios are also known from financial development economics, where these are used in empirical studies as a proxy for the financial depth of an economy.

$$Credit\ ratio = \frac{Credit\ to\ the\ private\ sector}{(real)\ GDP}. \tag{12}$$

In case of credit ratios the interpretation is not as straight forward as it might seem at the first glance, since up to present no theory exists that provides theoretically derived equilibrium values. Instead, the literature often uses trend values as substitutes, which are interpreted as financial imbalances (see, e.g., Borio and Lowe, 2002; Detken and Smets, 2004; Assenmacher-Wesche and Gerlach, 2010). Hence, credit ratios do not fulfill the first requirement of excess liquidity measures to provide theoretically derived equilibrium values.

Moreover, the danger to be exposed to spurious relationships without an underlying equilibrium theory is inherent. Insofar it seems to be rather arbitrary to infer theoretical implications from credit gaps regarding an excess or a shortage of liquidity. As a result, credit ratios do not fulfill the second requirement to indicate potential risks to future inflation. As credit ratios do not fulfill both requirements they do not qualify as excess liquidity measures here.

***Leverage ratios.*** In recent times leverage ratios have been increasingly used to measure monetary conditions in the financial system and in specific asset markets. The most prominent leverage ratios are (a) liability-to-equity (see, e.g., Adrian and Shin, 2008b, 2009, 2010) and (b) liability-to-assets (see, e.g., Drescher and Herz, 2010):

$$(a)\ \ leverage = \frac{liability}{equity} \qquad \text{and} \qquad (b)\ \ leverage = \frac{liability}{assets}. \tag{13}$$

In general, leverage ratios indicate how much liabilities are incurred by the debtor and accepted by the debtee for every unit of (a) equity or (b) asset on the debtor's balance sheet, respectively. A high leverage points to loose monetary conditions since asset purchases are financed to (a) a low degree by equity or (b) a high degree by liabilities.

Adrian and Shin (2008b, 2009, 2010) are among the first who focus on monetary conditions in the entire financial system using leverage ratios. They argue that the leverage of security brokers and dealers influence asset prices since their leverage has a procyclic nature by being positively related to the overall balance sheet size. Any discrepancy between the current and targeted leverage can be defined as "surplus capacity" since security brokers and dealers target certain leverage levels due to Value-at-Risk considerations (see Adrian and Shin, 2008a).

Drescher and Herz (2010) use leverage ratios and develop the concept of market leverage to measure monetary conditions in specific asset markets. Market leverage measures the average leverage of all asset holders in a particular asset market. The concept links monetary conditions of asset holders to their influence on asset markets. Monetary conditions are approximated by liability-to-asset ratios thereby indicating to what extent assets are financed by debt. The influence of asset holders on asset markets is approximated by their share of ownership.

Indeed, leverage ratios are predestinated to indicate monetary conditions in financial markets but lack to provide theoretically derived equilibrium values. This implies that leverage ratios fail to fulfill the first requirement of excess liquidity measures. The second requirement to indicate potential risk to future inflation has also to be denied on theoretical basis although some empirical studies find causal relationsship between leverage ratios and asset prices (see, e.g. Adrian et al., 2010; Drescher and Herz, 2010). Nevertheless, leverage ratios do not fulfill both requirements and hence do not qualify as excess liquidity measures here.

## 2.2 The price dimension

The price dimension subsumes measures of monetary conditions that use market prices as indicator variable for monetary conditions. The most prominent concepts of this dimension are the *price gap*, the *natural interest rate gap* and the *Taylor gap*.

***Price gap.*** The concept of price gap (also known as "p-star") is familiar to the concepts of the money view, but uses the price level as indicator variable. It bases on the idea that the current price level tends toward its equilibrium price level. The concept was pioneered by Hallman et al. (1989, 1991) and is an alternative to express the real money gap by using a different formulation. The price gap defines the velocity of money directly through the equation of exchange, while the real money gap captures it indirectly through the money demand equation (see Masuch et al., 2001, p. 136). As the concept of price gap also builds on the quantity theory of money, it accomplishes the first requirement to provide theoretically derived equilibrium values. The equation of exchange representations of the current and the equilibrium price level are given by:

$$p_t = m_t + v_t - y_t \qquad \text{and} \qquad p_t^{*PS} = m_t + \bar{v} - \bar{y}, \tag{14}$$

respectively. The equilibrium price level $p_t^{*PS}$ is defined by the current money stock as well as by the equilibrium levels of output and velocity of money. The resulting price gap can be decomposed into an output gap $(y_t - \bar{y})$ and a liquidity gap $(\bar{v} - v_t)$:

$$p_t^{*PS} - p_t = \underbrace{(y_t - \bar{y})}_{\textit{output gap}} + \underbrace{(\bar{v} - v_t).}_{\textit{liquidity gap}} \tag{15}$$

Real output and velocity of money are interdependent and therefore partly offset the effects of each other (see appendix A.3). For this reason, it makes sense to substitute the current velocity of money with the equation of exchange representation:

$$p_t^{*PS} - p_t = (m_t - p_t + \bar{v}) - \bar{y}. \tag{16}$$

It becomes clear that the price gap depends on the wedge between the real money stock adjusted by the trend velocity of money and real potential output. An increase (decrease) in the permanent price level can only occur if too much (little) money chases too few (many) goods (see Herz and Roeger, 1997; Belke and Polleit, 2009). With the price level tending to its equilibrium, a positive (negative) wedge indicates upward (downward) inflation pressure. This property makes the price gap fulfill the second requirement to indicate potential risks to future inflation. The completion of both requirements qualifies the concept of price gap as excess liquidity measure here.

***Natural interest rate gap.*** The concept of natural interest rate gap builds on Wicksell's loanable funds theory (Wicksell, 1898), which essentially distinguishes between two interest rates, namely the natural and market real interest rate. The natural real interest rate is the equilibrium interest rate — determined by savings supply and investment demand — that is consistent with the stability of the aggregated price level. The market real interest rate is the equilibrium interest rate — determined by supply of and demand for credit — in the loan market. The difference between both real interest rates is expressed by the natural interest rate gap $r_t^{NIIR}$:

$$r_t^{NIIG} = r_t - r_t^*, \tag{17}$$

where $r_t$ denotes the market real interest rate and $r_t^*$ represents the natural real interest rate. In general, a negative (positive) natural interest rate gap indicates expansionary (restrictive) monetary conditions, which cause a surge (fall) in the aggregated price level. For instance, an increase in the amount of credit via net money creation lowers the market interest rate below the natural interest rate in the loan market so that supply increases relatively to demand. The natural interest rate remains unaffected since it is determined by real factors, such as time preferences and productivity (see Belke and Polleit, 2009, pp. 176). The adjustment mechanism that causes an increase in the aggregated price level is known as "Wicksell's cumulative process" (Wicksell, 1898, 1906). The negative natural interest rate implies that the marginal product of capital exceeds the marginal costs of capital. This causes planned investments to exceed planned savings by the amount of net money creation. The following demand-driven increase in output exceeds potential output and causes prices to rise for all types of goods, services and assets. The increase in the aggregated price level continues up to the point when the loan market is in its long-term equilibrium, implying that the marginal cost of capital are equal to the marginal product of capital. The first requirement for excess liquidity measures to provide theoretically derived equilibrium values is fulfilled by the natural real interest rate. Additionally, the second requirement to indicate potential risk to future inflation is accomplished by Wicksell's loanable funds theory. As the natural real interest rate gap satisfies both requirements, it qualifies as excess liquidity measure here.

***Taylor gap.*** In his seminal work Taylor (1993) shows that monetary policy of the US Federal Reserve between 1982 and 1992 can be described by an interest rate reaction function, the well-known Taylor rule.[9] Nowadays, the Taylor rule is often modified by a smoothing term to capture monetary policy's inertia (see Goodfriend, 1987). In general, Taylor-type rules for monetary policy of central banks can be formulized as (see, e.g., Clarida et al., 2000; Drescher et al., 2010):

$$i_t^{TR} = \rho i_{t-1}^{TR} + (1-\rho)[r_t^* + \beta_p(\Delta p_t^e - \Delta p_t^*) + \Delta p_t^e + \beta_y(y_t - \bar{y}_t)], \tag{18}$$

where the variables $i_t^{TR}$ denote the Taylor rate for the operating interest rate target, $r^*$ the natural real interest rate, $\Delta p_t^e$ is the expected inflation and $\Delta p_t^*$ the inflation target. The variable $y_t$ represents real output and $\bar{y}_t$ is its potential. The parameter $\rho$ denotes the smoothing term, whereas the parameters $\beta_y > 0$ and $\beta_p > 1$ refer to the reaction coefficients on output and inflation gap, respectively. The parameter for the inflation gap has to take on values above one to fulfill determinancy condition, known as the Taylor-principle (see Gali, 2002; Woodford, 2002). Woodford (2001, pp. 233)

[9] The original Taylor rule is given as follows r = p + 0.5y + 0.5(p - 2) + 2, where r denotes the Federal Funds Rate, p is a proxy for the expected inflation rate and y represents the output gap. The inflation target and long-term real interest rate are assumed to be constant and appraised to be 2.

shows theoretically that the stabilization goals in the Taylor rule can be derived from a quadradic loss function of representative households, if monetary policy seeks to minimize fluctuations in inflation and output.

Beyond this descriptive application, Taylor-type rules are often used in a prescriptive way as guidelines for optimal monetary policy (see Taylor, 2000). In a first step, parameters are chosen for a period of continuing price stability so that monetary policy is best described. In a second step, these parameters are used to calculate the Taylor-type rate for the period in question. The interest rate difference between both is called the Taylor gap $i_t^{TG}$:

$$i_t^{TG} = i_t - i_t^{TR}. \tag{19}$$

A negative Taylor gap ($i_t < i_t^{TR}$) is associated with excess liquidity, whereas a positive Taylor gap ($i_t > i_t^{TR}$) refers to a shortage of liquidity. The nexus between the theoretical background provided by Woodford (2001, pp. 233) and the prescriptive use of Taylor-type rules as equilibrium values for the Taylor rate fulfills both requirements of excess liquidity measures. As a result, the Taylor gap qualifies as excess liquidity measure here.

## 3 Excess liquidity measures

### 3.1 Sources of imbalances

The following comparison focuses on those concepts that qualified earlier as excess liquidity measures, namely the monetary overhang (MO), real money gap (RMG), price gap (PS), natural interest rate gap (NIIG) and Taylor gap (TG).[10] All these concepts have in common that they provide theoretically derived equilibrium values and indicate potential risk to future inflation. Nevertheless, each concept provides a different quantity and quality of information. The differences in the quantity of information are analyzed

[10] As the concept of price gap is inversely related to the concept of real money gap (see appendix A.4) the remainder merely focuses on the latter of both. Of course, all results for the real money gap also hold for the price gap.

by comparing the sources of imbalances for each concept. A valid comparison requires that all concepts refer to the same indicator variable for monetary conditions. Analogous to the approach of Bundesbank (1999, p. 53) it is assumed that excess liquidity measures of the quantity and price dimension relate to each other as follows:

$$m_t - m_t^* = -\lambda(i_t - i_t^*). \tag{20}$$

The link between both is expressed by the function $\lambda$. The function is negative since money stock and interest rates should be inversely related. Moreover, the function should be nonlinear, inter alia, due to the zero lower bound of interest rates[11] and unconventional measures of monetary policy[12].

Table 1 summarizes the theoretical information content of excess liquidity measures by referring to their determinants. The sources of imbalances are split into reasonable blocks of information on inflation pressure stemming from goods market, money market, expectations and misalignments. For the sake of interpretation, each parameter depicts its empirical anticipated sign.

| | goods market pressure | money market pressure | expectation pressure | misalignment pressure |
|---|---|---|---|---|
| MO | – | – | – | $\epsilon_t$ |
| RMG | $\beta_y(y_t - \bar{y}_t)$ | $\beta_{oc}(oc_t^* - oc_t)$ | – | $\epsilon_t$ |
| NIIG | – | $\lambda(i_t^* - i_t)$ | – | – |
| TG | $\lambda\beta_y(y_t - \bar{y}_t)$ | $\lambda(i_t^* - i_t)$ | $\lambda\beta_{\Delta p}(\Delta p_t^e - \Delta p_t^*)$ | – |

Notes: MO = Monetary overhang, RMG = Real money gap, NIIG = Natural interest rate gap, TG = Taylor gap.

Table 1: Sources of imbalances

All excess liquidity measures differ in the sources of imbalance. The monetary overhang merely captures information which stem from misalignments due to costs of information

[11] In case of zero lower bound, the money stock can increase even though the operative policy rate has reached the zero lower bound.

[12] In case of unconventional measures of monetary policy, these can have an effect on the money stock without having an effect on the operative policy rate.

and adjustment (see Tödter, 2002, p. 3). Additionally, the real money gap also incorporates information that result from disequilibria on goods and money markets. For that reason, the real money gap is often denoted as "summary statistic" (see Masuch et al., 2001, p. 138). The natural interest rate gap captures information from disequilibria in the money market. The Taylor gap additionally takes into account information, which stem from goods and money markets as well as from expected excess inflation. The quality of information provided by each excess liquidity measure has to be evaluated empirically for every economy on its own, regarding its specific economic structure and institutions.

### 3.2 Excess liquidity measures and asset markets

All excess liquidity measures typically incorporate consumer prices by referring to consumption markets, i.e. markets of goods and services, but often lack the inclusion of asset prices as they neglect investment markets, i.e. markets of financial and real assets. For instance, although the equation of exchange originally refers to the aggregated price level of the economy, most empirical studies employ a consumer price index as proxy variable. Actually, this is in contrast to the idea of monetarism that the rebalancing of (real) money stock imbalances works through all prices of the economy (see Meltzer, 1995, p. 52). In doing so, excess liquidity measures do not capture the reduction of money stock imbalances that are accomplished through asset markets by changes in asset prices.

The focus on consumer markets has important consequences for the interpretation of monetary conditions. In an economy where the size of asset markets is rather negligible, a consumer price index can be a reasonable proxy for the aggregated price level. But the mere use of consumer prices might lead to a fallacy along with the increasing relevance of asset markets. This is because an increase in the relevance of asset markets leads to growing distortions of excess liquidity measures. For instance, in the last decades industrialized countries like the US have been hit by a huge supply shock of goods and services from emerging economies. This shock has increased the price elasticity of export supply of emerging economies and thereby promoted modest US consumer price inflation. Demand pressure on US consumer markets has been partly absorbed by cheap imports from abroad. In contrast, US asset markets have not been subject to an equivalent supply shock of financial assets from abroad due to mostly underdeveloped financial markets of emerging economies. Instead, US asset markets have even faced a demand shock for goods quality financial assets, since emerging economies lack to produce such assets (see Caballero, 2006). Hence, emerging economies can not dampen asset price increases by an equivalent export of financial claims on assets. These circumstances imply that excess liquidity might be able to unfold different effects on asset and consumer prices, respectively. The analysis of Belke et al. (2008) confirms that the price elasticity of supply in asset markets seems to be higher than in goods and service markets. This implies a long-term shift in relative prices between consumer and asset markets.

# 4 Empirical analysis

## 4.1 Estimation results

***Monetary overhang/real money gap.*** The pre-condition for the estimation of excess liquidity measures that build on the quantity theory of money is a stable money demand function. The analysis focuses on the period from 1995:1 to 2009:4 due to a structural break of US M2 velocity during the 1990s (see figure 10 in appendix A.6). Unit root and stationarity tests indicate that all employed level variables are integrated of order one and thus exhibit unit roots in their levels (see table 5 in appendix A.7). To avoid spurious regressions (see Granger and Newbold, 1974) the study accounts for these statistical properties by testing for cointegration relations using the methodology of Johansen (1991, 1995). Following Calza et al. (2001) the long-term stability of (real) money demand functions are tested in a system of equations to take advantage of existing interdependencies. The application of vector error correction models (VECMs) makes it possible to distinguish between short- and long-term dynamics of (real) money demand functions. The VECM for the monetary overhang and the real money gap is given by:

$$\Delta x_t = \Pi x_{t-1} + \sum_{j=0}^{J} \Gamma_j \Delta x_{t-j} + \Phi d_t + \epsilon_t \quad \text{with} \quad \Pi = \alpha\beta', \tag{21}$$

where $x_t$ represents the $k$-vector of nonstationary I(1)-variables. The vector $d_t$ captures all deterministic terms, such as intercepts. The cointegrating vector for the monetary overhang is given by $(m_t, p_t, c, y_t, oc_t)$, whereas the cointegrating vector of the real money gap is represented by $(m_{real,t}, c, y_t, oc_t)$. The vector $\epsilon_t$ consists of i.i.d. error terms. The parameter vectors $\alpha$, $\Gamma_j$ and $\phi$ represent the adjustment coefficients of the VECM, the short-term (semi-)elasiticities and intercepts of the vector autoregression (VAR) part, respectively. The cointegration vector is denoted by $\beta'$. In case of monetary overhang the price parameter $\beta_p$ is restricted to one (see equation (4)). Since the trends of time series are stochastic an intercept is included in both, the cointegration vector and the VAR. Based on the Akaike criterion with a maximum lag length of 10 the optimal lag length of the VAR part is chosen for the monetary overhang to be 6 and for the real money gap to be 7 (Akaike, 1974). Each, the trace and maximum eigenvalue statistics indicate at the 5 % significance level for the monetary overhang one and for the real money gap two cointegration relations. To cross-check the plausibility of the cointegration vectors the relationships are also estimated using the two-step Engle-Granger procedure (Engle and Granger, 1987).[13] The ADF-, PP- and KPSS-tests confirm the results of the Johansen procedure by pointing to the existence of cointegration relations. Table 2 reports the resulting cointegration vectors.

[13]Some authors, such as Gonzalo and Lee (1998), argue that in some cases the Johansen procedure can lead to spurious cointegration relations.

| Messure | Method | Period | $m_t$ | $p_t$ | $y_t$ | $oc_t$ | *constant* |
|---|---|---|---|---|---|---|---|
| MO | Johansen | 1995:1-2009:4 | 1 | -1 | -1.27 $^{***}$ $(-50.18)$ | 2.46$^{***}$ (6.15) | 8.26 |
| MO | Engle & Granger | 1995:1-2009:4 | 1 | -1 | -1.27 $^{***}$ (??) | 2.42$^{***}$ (??) | 8.27$^{***}$ (??) |
| RMG | Johansen | 1995:1-2009:4 | 1 | – | -1.11$^{***}$ $(-6.65)$ | 5.36$^{***}$ (0.66) | 1.63 |
| RMG | Engle & Granger | 1995:1-2009:4 | 1 | – | -1.07$^{***}$ (??) | 7.52$^{***}$ (??) | 1.23$^{***}$ (??) |

Notes: MO = Monetary overhang, RMG = Real money gap.

Table 2: Cointegration vector

All parameters depict the anticipated sign.[14] The volume of transactions are positively and opportunity costs are negatively related to the (real) money demand. Moreover, all parameters are statistical significant at the 1% level. The development of nominal M2 and its estimated long-term equilibrium is given in figure 1. The monetary overhang is illustrated in figure 2.

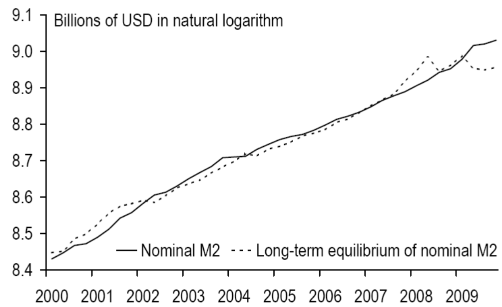


Figure 1: Nominal M2

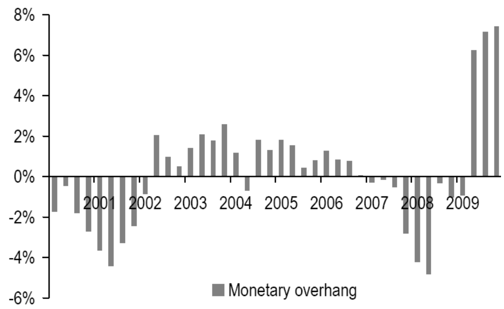


Figure 2: Monetary overhang

Figure 3 describes the development of real M2 and its estimated long-term equilibrium. The real money gap is shown in figure 4.

[14] Since table 2 reports cointegration vectors, all parameters have to be multiplied by -1 to interpret the effects of the corresponding variables correctly.

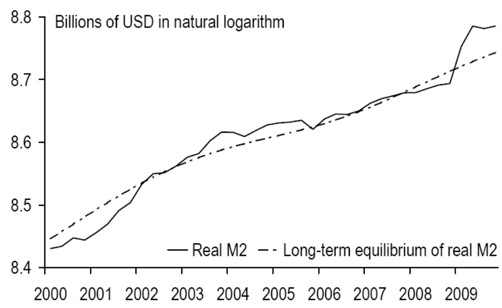


Figure 3: Real M2

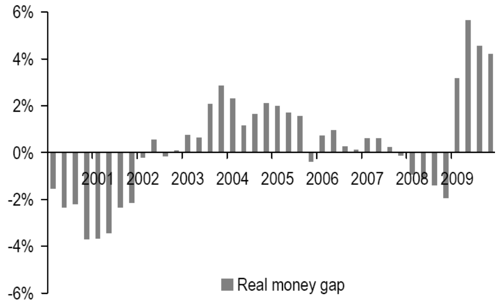


Figure 4: Real money gap

***Natural interest rate gap.*** Following Belke and Polleit (2009) the real natural interest rate can be estimated implicitly using a Taylor-type rule. The procedure averages the real interest rate $r_t$ by correcting for deviations that occur due to inflation gap $(\Delta p_t^e - \Delta p_t^*)$ and output gap $(y_t - y_t^*)$. In this context, the natural real interest rate is the estimated constant $r_t^*$:

$$r_t = r_t^* + \beta_y(\Delta p_t^e - \Delta p_t^*) + \beta_y(y_t - y_t^*). \tag{22}$$

To obtain a time-varying natural real interest rate rolling regressions are performed with windows of five years. The approach makes use of the real-time data base of the Federal Reserve Bank of Philadelphia.[15] Expected inflation is the 1 year ahead expected inflation rate and the implicit inflation target is approximated by the 10 year ahead expected inflation rate, each taken from the Survey of Professional Forecasters.[16] The current output is estimated using an AR-process based on all available real-time data.[17] The output potential is the Hodrick-Prescott (HP) filter trend component (Hodrick and Prescott, 1997).[18] Figure 5 compares the Effective Federal Funds Rate with the natural interest rate. Figure 6 shows the resulting natural interest rate gap.

[15]See http://www.philadelphiafed.org/research-and-data/real-time-center/real-time-data/.

[16]See http://www.philadelphiafed.org/research-and-data/real-time-center/survey-of-professional-forecasters/.

[17]The lag length of the AR-process for the first order differences of real-time GDP is chosen upon the 5% significance level and has a maximum lag length of 5 periods.

[18]The real-time GDP is forecasted 20 periods ahead to cope with end-of-sample problems of the HP filter (see Baxter and King, 1995, pp. 18).

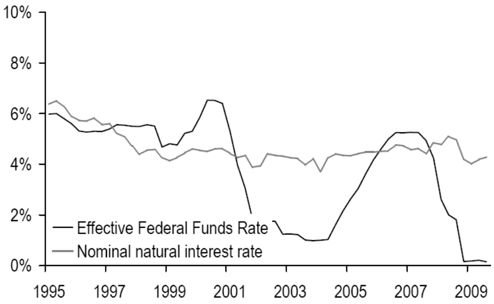


Figure 5: Natural interest rate

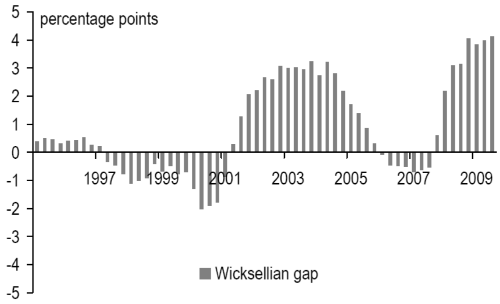


Figure 6: Natural interest rate gap

***Taylor gap.*** In advance to the out-of-sample estimation of the Taylor rate for the period 1995:1 to 2009:4, an in-sample estimation is run for the period 1985:1 to 1994:4 to determine parameters that are consistent with continuing price stability.[19] The estimation is performed using the Generalized Method of Moments (GMM) to reduce endogeneity problems. The natural candidates for instruments are the lagged explanatory variables.[20] Following Clarida et al. (2000) and Drescher et al. (2010) the estimation equation is given by:

$$i_t = \rho i_{t-1} + (1-\rho)[r_t^* + \Delta p_t^e + \beta_p(\Delta p_t^e - \Delta p_t^*) + \beta_y(y_t - y_t^*)] + \epsilon_t. \tag{23}$$

The parameter $\rho$ indicates to what amount the current interest rate depends on its own past realization. The parameters $\beta_p$ and $\beta_y$ represent the reaction coefficents on the inflation and output gap, respectively. The Taylor-type rule is estimated using real-time data to account for data availablity (see Orphanides, 2001). The estimation also uses the previously employed implicit inflation target $\Delta p_t^*$, the estimated natural real interest rate $\Delta p_t^*$, the current output $y_t$ and its potential $y_t^*$. Table 3 reports the estimated in-sample parameters.

[19]The period covers one and a half business cycles — according to the definition of NBER — and has been chosen as it is subject to the "Great Moderation" (see Stock and Watson, 2002).

[20]Using the J-statistic the lag length of instrument variables is chosen to be 4 periods in order to obtain valid overidentifying restrictions.

| In-sample period | $\rho$ | $\beta_y$ | $\beta_p$ | $adj.R^2$ |
|---|---|---|---|---|
| 1985:1-1994:4 | $0.820640^{***}$ (31.23496) | $2.556067^{***}$ (6.351622) | $3.126678^{***}$ (3.217554) | 0.947652 |

Table 3: Parameters of the Taylor-type rule

All parameters are statistically significant at the 1% level and depict the anticipated sign and height. Based on these estimated in-sample parameters the out-of-sample estimation and the resulting Taylor gap can be calculated for the period from 1995:1 to 2009:4. Figure 7 compares the Taylor-type rate with the Effective Federal Fund Rate. Figure 8 illustrates the resulting Taylor gap.

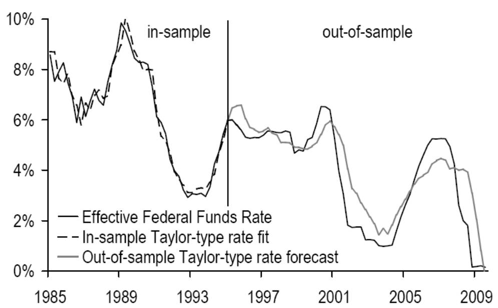


Figure 7: Taylor-type rate

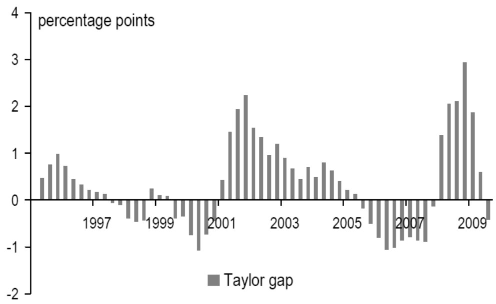


Figure 8: Taylor gap

## 4.2 Developments during recent US asset bubbles

The following analysis compares the empirical information content of all estimated excess liquidity measures. Figure 9 illustrates the development of money based measures, i.e. monetary overhang and real money, as well as interest based measures, i.e. natural interest rate gap and Taylor gap, for the period of analysis from 1995:1 to 2009:4.

Phillips et al. (2009) and Drescher (2011) indicate the presence of an asset bubble in the US corporate equity market for the beginning of the period in 1995. In line with this, the then-president of the Federal Reserve – Alan Greenspan – already warned in 1996 that the US corporate equity markt might be overvalued by coining the term of “irrational exuberance” (Greenspan, 1996). During this time, all excess liquidity

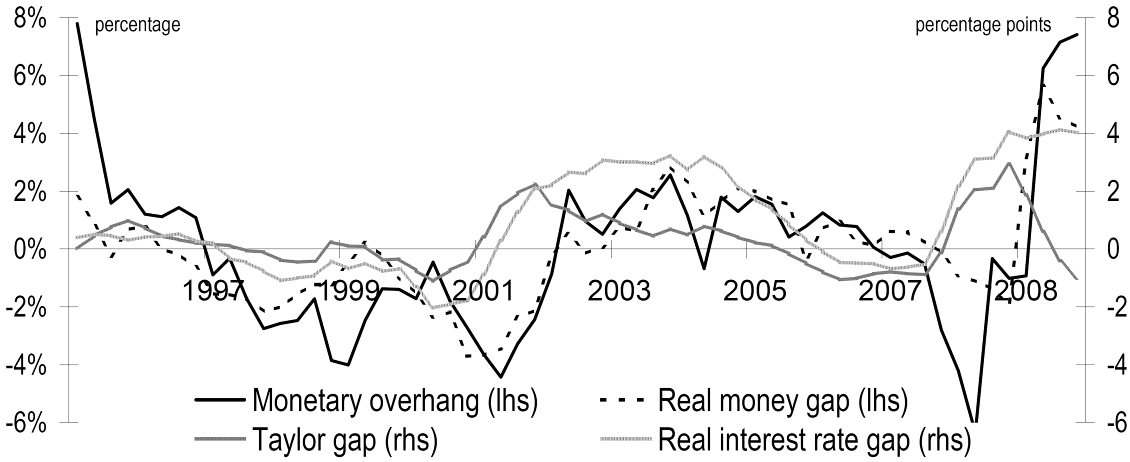


Figure 9: Excess liquidity measures

measures indicate expansionary monetary condition. Then, in the period from 1996 to 1997 excess liquidity measures indicate a turn from an excess to a shortage of liquidity. This change in monetary conditions could be the result of an attempt of the Federal Reserve to dampen increases in corporate equity prices. The US corporate equity bubble reached its peak in 2000 and bursted in 2001. During the subsequent recession in 2001 all excess liquidity measures turned positive again. This swing in monetary conditions could indicate the Federal Reserve's attempt to bring the economy back to its potential growth path. The indication of excess liquidity remains until the period between 2006 and 2007 before these measures begin to indicate a shortage of liquidity again. During this turn in monetary conditions the US real estate bubble was close to its peak and bursted in 2007. The collapse in US real estate prices evoked the set in of the US financial crisis. The fight of the US Federal Reserve against its economic aftermaths is indicated by all excess liquidity measures. In the period from 2007 to 2009 all excess liquidity measures increased and indicated an excess of liquidity. While money based excess liquidity measures sky-rocketed during the financial crisis, interest based excess liquidity measures stopped to increase early.

The empirical evidence illustrates some qualities of excess liquidity measures. Firstly, money based measures, i.e. monetary overhang and real money gap, mirror actions of quantitative easing whereas interest rate based measures, i.e. natural interest rate gap and Taylor gap, do not. Secondly, interest rate based measures usually take the lead and are first to indicate swings in monetary conditions. This leading behavior is probably a result of the inclusion of future sources for imbalances, such as expected inflation.

## 5 Conclusions

The paper analyzes the theoretical and empirical information content of excess liquidity measures for asset markets. The analysis focuses on the concepts of monetary overhang, real money gap, nominal money gap, credit ratios, leverage ratios, price gap, natural interest rate gap and the Taylor gap. Every measure is classified into a quantity or price dimension based upon its indicator variable for monetary conditions. Each classification is followed by a theoretical review of the conceptual framework and an assessment if the concept qualifies as excess liquidity measure. The theoretical comparison of excess liquidity measures focuses on the sources of imbalances and the adequacy for asset markets. The theoretical results are cross-checked with empirical evidence. All excess liquidity measures are estimated and compared in the light of the recent US asset bubbles. The analysis draws the following main conclusions.

Firstly, not all measures of monetary conditions qualify as excess liquidity measure. To qualify as excess liquidity measure, these concepts have to fulfill the following two requirements. They have to provide theoretically derived equilibrium values and indicate potential risks to future inflation. Credit ratios and leverage ratios do not fullfil the first requirement. Insofar it is rather arbitrary to derive conclusions from these measures regarding an excess or a shortage of liquidity. In contrast, all other measures of monetary conditions build on theoretically derived equilibrium values. Nevertheless, the nominal money gap fails to accomplish the second requirement as it includes past monetary policy errors. The analysis showed that the concepts of monetary overhang, real money gap, price gap, natural real interest rate gap and Taylor gap qualify as excess liquidity measures.

Secondly, excess liquidity measures typically have in common that they refer to consumer prices while neglecting asset prices in the determination of an excess or a shortage of liquidity. In an economy where the size of asset markets is rather negligible, consumer prices can be a reasonable proxy variable for the aggregated price level. But the mere use of consumer prices might lead to a fallacy in the wake of an increasing relevance of asset markets. In doing so, excess liquidity measures do not capture the reduction of money stock imbalances that are accomplished through asset markets by changes in asset prices. As a result, the increasing relevance of asset markets leads to growing distortions of excess liquidity measures.

Thirdly, the choice of an excess liquidity measure has influence on the assessment of monetary conditions in asset markets. The theoretical and empirical information contents differ for each excess liquidity measure since these capture different sources of imbalances and have different indicator variables. The theoretical analysis shows that these sources of imbalance refer to pressure stemming from the goods market, money market, expectations and/or misalignments. The empirical analysis shows that the indicator variable plays a role in the assessment of monetary conditions. For instance, money based measures mirror actions of quantitative easing whereas interest rate based measures do not. Nevertheless, interest rate based measures usually take the lead and are first to indicate swings in monetary conditions.

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# A Appendix

## A.1 Derivation of the nominal money gap

Substituting the current money stock $m_t$ and the money stock of the base period $m_0$ of equation (10) with their equation of exchange representations gives:

$$m_t - m_t^{ref} = y_t + p_t - v_t - (y_0 + p_0 - v_0 + (\Delta p_t^* + \beta_y \Delta \bar{y}_t) \times t). \tag{24}$$

The resulting equation of exchange representation of the nominal money gap can be split into three reasonable blocks:

$$m_t - m_t^{ref} = \underbrace{[y_t - y_0 + \beta_y \Delta \bar{y}_t \times t]}_{output\ gap} - \underbrace{[v_t + v_0]}_{liquidity\ gap} + \underbrace{[p_t - (p_0 + \Delta p_t^* \times t)]}_{price\ target\ gap}. \tag{25}$$

This can also be written as:

$$m_t - m_t^{ref} = \underbrace{[y_t - \bar{y}_t]}_{output\ gap} + \underbrace{[v_0 - v_t]}_{liquidity\ gap} + \underbrace{[p_t - \hat{p}_t]}_{price\ target\ gap}, \tag{26}$$

where $\hat{p}_t$ represents the reference price level, given by $\hat{p}_t = p_0 + \sum_{t=1}^{N} \Delta p_t^*$. Given the assumption that the velocity of money is in equilibrium $v_0 = \bar{v}_t$ at the base period, then the following equation holds:

$$m_t - m_t^{ref} = \underbrace{[\bar{p}_t - p_t]}_{price\ gap} + \underbrace{[p_t - \hat{p}_t]}_{price\ target\ gap}. \tag{27}$$

## A.2 The components of the liquidity gap

Substituting the real money demand by the equation of exchange representation of the velocity of money gives:

$$v_t = y_t + p_t - m_t = y_t - (m_t - p_t) = y_t + \beta_y y_t + \beta_i i_t \tag{28}$$

and

$$v_t^* = y_t^* + p_t^* - m_t^* = y_t^* - (m_t^* - p_t^*) = \bar{y}_t + \beta_y \bar{y}_t + \beta_i \bar{i}_t, \tag{29}$$

respectively. The determinants of the liquidity gap become obvious when the current velocity of money is subtracted from the equilibrium velocity of money:

$$\begin{aligned} v_t^* - v_t \quad &= \bar{y}_t - \beta_y \bar{y}_t + \beta_i \bar{i}_t - y_t + \beta_y y_t + \beta_i i_t + \epsilon_t \\ &= -(y_t - \bar{y}_t) + \beta_1 (y_t - \bar{y}_t) - \beta_2 (i_t - \bar{i}_t) + \epsilon_t \\ &= (\beta_1 - 1)(y_t - \bar{y}_t) - \beta_2 (i_t - \bar{i}_t) + \epsilon_t. \end{aligned}$$

## A.3 The interdependence of output and velocity of money

The output and velocity of money are interdependent. This can be illustrated by transforming equation (2) with respect to the change in velocity of money:

$$\Delta v \equiv \Delta y - (\Delta m - \Delta p). \tag{30}$$

Given the assumption of price stability and substituting the change in real money demand by their economic determinants leads to:

$$\Delta v \equiv \Delta y - (\beta_y \Delta y_t + \beta_i \Delta i_t). \tag{31}$$

Given that interest rates are stationary, it can be shown that if $\beta_y > 1$ ($\beta_y < 1$), then the velocity of money increases (decreases) with a decreasing (increasing) output:

$$\Delta v \equiv (1 - \beta_y)\Delta y. \tag{32}$$

## A.4 Real money gap vs. price gap

To demonstrate the relation between both, the price gap is expressed by the money demand equation. Taking the money demand model of equation (3) and rearranging it with respect to the price level one yields for the current and equilibrium equation:

$$p_t = m_t - \beta_0 - \beta_y y_t - \beta_i i_t - \epsilon_t \qquad \text{and} \qquad p_t^* = m_t - \beta_0 - \beta_y y_t^* - \beta_i i_t^*. \tag{33}$$

Then the price gap can be written as:

$$p_t^* - p_t = \underbrace{\overbrace{\beta_y(y_t - \bar{y}_t)}^{goods\ market} + \overbrace{\beta_i(i_t - \bar{i}_t)}^{money\ market} + \overbrace{\epsilon_t}^{money\ residuum}}_{price\ gap}. \tag{34}$$

Now, it becomes clear that the real money gap and the price gap are equivalent in their determinants, but are inversely related:

$$p_t - p_t^* = -(m_{real,t} - m^*_{real,t}). \tag{35}$$

### A.5 Sources and descriptions of data

All variables, except interest rates, are expressed in natural logarithm. All time series — where necessary — are tranformed to quarterly frequency.

| data | symbol | description | frequency | source |
|---|---|---|---|---|
| Nominal money | $m_t$ | Seasonal adjusted outstanding amounts of M2 in billions of USD. | monthly | FRB |
| Price level | $p_t$ | Seasonal adjusted consumer price index for all urban consumers (all items) with index 1982-84=100. | monthly | BLS |
| Real money | $m_{real,t}$ | Nominal M2 deflated by the consumer price index. | – | oc |
| Inflation | $\varDelta p_t$ | First order difference of the logarthmic consumer price index. | – | oc |
| Expected inflation | $\varDelta p_t^e$ | One-year-ahead inflation forecasts from Survey of Professional Forecasters. | quarterly | FRBP |
| Short-term interest | $i_t^s$ | 3-Month Treasury Constant Maturity Rate. | monthly | FRB |
| Own rate | $i_t^o$ | Component weighted interest rates paid on each single component of M2. | monthly | FRB |
| Instrument rate | $i_t$ | Effective Federal Funds Rate | monthly | FRB |
| Real-time output | $y_t$ | Seasonally adjusted real-time GNP/GDP in billions of real dollars. | monthly | FRBP |
| Potential output | $\bar{y}_t$ | Estimated by means of the HP filter with a smoothing parameter of $\lambda = 1600$. | – | oc |

Notes: Bureau of Labor Statistics (BLS), Board of Governors of the Federal Reserve System (FRB), Federal Reserve Bank of Philadelphia (FRBP), own calculation (oc).

Table 4: The data

## A.6 Velocity of money

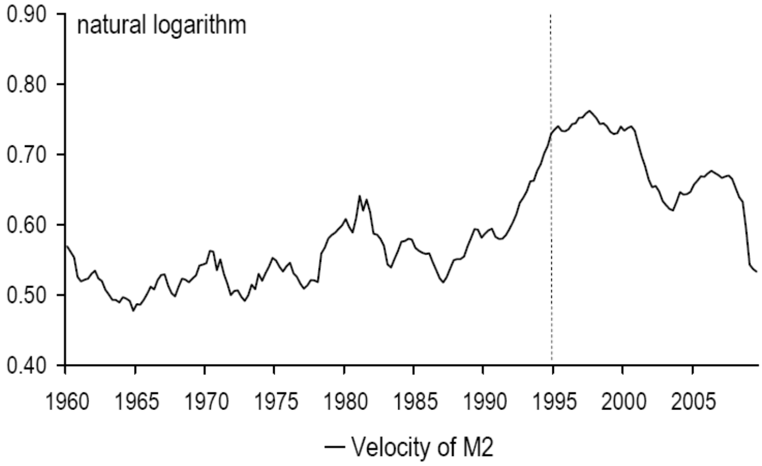


Figure 10: Velocity of M2

## A.7 Statistical properties of time series

| data | nullhypothesis | ADF | PP | nullhypothesis | KPSS |
|---|---|---|---|---|---|
| $m_t$ | I(0) | 0.21 | 0.49 | I(1) | 0.95*** |
| $m_t$ | I(1) | -5.86*** | -5.87*** | I(0) | 0.13 |
| $y_t$ | I(0) | -2.47 | -2.34 | I(1) | 0.93*** |
| $y_t$ | I(1) | -6.95*** | -7.03 | I(0) | 0.48** |
| $p_t$ | I(0) | -0.39 | -0.38 | I(1) | 0.95*** |
| $p_t$ | I(1) | -8.41*** | -8.44*** | I(0) | 0.04 |
| $oc_t$ | I(0) | -2.26 | -1.50 | I(1) | 0.37* |
| $oc_t$ | I(1) | -6.16*** | -6.23*** | I(0) | 0.08 |

The one-sided test critical values for the ADF and PP-tests are taken from MacKinnon (1996) and state for the 1%-level -3.514426 (***), for the 5%-level -2.898145 (**) and for the 10%-level -2.586351 (*). The asymptotic critical values for the KPSS are taken from Kwiatkowski et al. (1992) and are for the 1%-level 0.739000 (***), for the 5%-level 0.463000 (**) and for the 10%-level 0.347000 (*).

Table 5: Time series properties

## A.8 Plausibility of the error correction term

| data | nullhypothesis | ADF | PP | nullhypothesis | KPSS |
|---|---|---|---|---|---|
| Engle & Granger | I(1) | -7.31*** | -7.32*** | I(0) | 0.36* |

The one-sided test critical values for the ADF and PP-tests are taken from MacKinnon (1996) and state for the 1%-level -3.514426 (***), for the 5%-level -2.898145 (**) and for the 10%-level -2.586351 (*). The asymptotic critical values for the KPSS are taken from Kwiatkowski et al. (1992) and are for the 1%-level 0.739000 (***), for the 5%-level 0.463000 (**) and for the 10%-level 0.347000 (*).

Table 6: Plausibility of the error correction term

## A.9 Robustness of the in-sample Taylor-type estimation

| In-sample period | $\rho$ | $\beta_y$ | $\beta_p$ | $adj.R^2$ |
|---|---|---|---|---|
| 1985:1–1996:4 | $0.81^{***}$ (30.21) | $2.39^{***}$ (5.49) | $3.35^{***}$ (3.58) | 0.948185 |
| 1985:1–1997:4 | $0.81^{***}$ (29.34) | $2.43^{***}$ (5.12) | $3.30^{***}$ (3.14) | 0.948981 |
| 1985:1–1998:4 | $0.82^{***}$ (31.52) | $2.56^{***}$ (5.82) | $3.25^{***}$ (3.08) | 0.948746 |
| 1986:1–1995:4 | $0.76^{***}$ (20.99) | $2.17^{***}$ (5.12) | $3.75^{***}$ (3.83) | 0.961814 |
| 1987:1–1995:4 | $0.78^{***}$ (20.19) | $2.46^{***}$ (4.29) | $3.42^{***}$ (3.24) | 0.972266 |
| 1988:1–1995:4 | $0.77^{***}$ (22.14) | $2.33^{***}$ (4.57) | $3.45^{***}$ (3.24) | 0.975755 |

Table 7: Robustness of the Taylor-type rule

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