The relationship of liquid money and selected price indices in the USA

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Abstract: The aim of this paper is to assess the relationship between the development of liquid money and selected price indices in the US economy in 1961–2018. The Engle-Granger cointegration test and Granger causality are used to calculate the relationships. Cointegration was not demonstrated in any of the cases. Therefore, this study's contribution lies in confirming the conclusions of mostly newer studies concerning the invalidity of the quantitative theory of money under current conditions. However, short-term Granger-causal relationships were demonstrated in almost all cases. Thus, we can predict consumer prices and the prices for bonds and real estate based on the development of the amount of liquid money. It is also possible to predict the development of the amount of liquid money based on how all these price indicators develop. So central banks can still to some extent affect significant prices in the economy by influencing the money supply.

Keywords: liquid money; CPI; consumer price index; bond prices; stock prices; real estate prices; US economy; Engle-Granger cointegration.

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1 Introduction

In the present day, most central banks in developed countries use inflation targeting and have backed away from monetary aggregate targeting, which was used in the past. In addition to greater transparency, this was due to the ambiguity of the ties between the behaviour of the selected monetary aggregates and the inflation rate. One explanation could lie in the implementation of financial innovations and deregulation, with economic entities holding money in a form other than those contained in the monetary aggregate. The money of zero maturity (MZM) monetary aggregate was defined in conjunction with this; it includes the liquid component of money on the market. A number of central banks have been monitoring this aggregate, some of them using it as their primary one. As our starting point for this paper, we used liquid money defined in this way, which should be more closely tied into market prices.

Considering that the huge increase in liquid money in significant developed economies has largely not been reflected in consumer prices, we have used this paper to examine other important prices in the economy. We investigated MZM's relationship to stock and bond prices as important prices on the financial markets. Moreover, we also examined real estate prices, a frequently addressed subject.

With regards to the current conception of the money supply as endogenous, we investigated reciprocal relationships between the money supply and the selected price aggregates. We have focused on the US economy, which is both the largest and most important in the world. Moreover, its circumstances entail an available time series for the given variables that is sufficiently long and credible.

Therefore, the goal of this paper is to assess the relationship between the behaviour of liquid money and the selected price indices for the US economy from 1961 to 2018. The selected period covers a relatively long time period preceding the global financial crisis, which erupted in 2007, as well as the period after it. In conjunction with the crisis, a number of thoughts have arisen concerning the change in how monetary policy is approached and its effects. Mishkin (2017) summarises the approach to monetary policy before the crisis, which amounts to understanding inflation as a monetary phenomenon, as put forth by Friedman. Central banks were primarily focusing on achieving price stability or supporting economic growth. Financial markets were already showing volatility in this period; nonetheless, this volatility was not as striking as in the present day nor were the financial markets were so strongly interconnected. In conjunction with the financial crisis, Mishkin summarised that the basic approaches to monetary policy do not change. Still, he outlines that what must be taken into consideration when implementing monetary policy in the present day. This is given by the fact that developments on the financial markets can have a more significant effect on economic activity in individual countries than central banks previously realised. Specifically, he states that before the financial crisis, central banks did not have financial market volatility included in their economic models, even though this is one of the main causes of fluctuation in the economic cycle. This resulted in the dichotomy between monetary policy and financial stability policy, which has these two types of policy being conducted separately. As Mishkin (2011) states, the recent financial crisis supports systemic regulation, with central banks becoming a suitable choice for the role. The benefit of coordinating monetary policy and macroprudential policy is another reason why central banks should take on the role of system regulator. The global financial crisis led both economists as well as central bankers to approach the implementation of monetary policy differently. It is necessary to realise that some areas must be reevaluated, and there should be a focus on inflation and monetary policy's reaction to the possible appearance of asset price bubbles. It is further necessary to concentrate on the dichotomy between monetary policy and financial stability policy. Not least, there should also be greater international cooperation on monetary policy in order to be better able to cope with volatility on the financial markets. He further recommends more extensive use of forward guidance.

This paper's goal is to add to scientific discussion on the relationship between the money supply (represented by the liquid money aggregate, which has not often been used as a standard monetary aggregate) and the behaviour of selected prices, i.e., to determine whether an increase in the money supply is manifested not only in increasing consumer prices but also in other significant prices in the economy. At the same time, it makes sense to specify the degree to which central banks are currently able to influence these prices' behaviour when the money supply is considered to be endogenous.

The paper is structured as follows. The issue is outlined in the Section 1, followed by research from important articles in the given field, presented in Section 2. Section 3 describes the data used and briefly depicts the analytical methods. Next follows Section 4, which lists the results of the analysis. The results are then examined from economic and financial viewpoints in Section 5, which includes a comparison between them and the cited studies. A substantial summary is provided in Section 6.

2 Theoretical background

In this paper, the monetary aggregate that we used as our starting point is money of zero maturity. Poole (1991) was the first to define the fundamentals of this aggregate and to give it a name. In his construct, he uses findings from a study by Motley (1988), and he lists the reasons why the M1 and M2 monetary aggregates are imprecise. He concludes that it would be better for the creators of monetary policy to monitor money without a fixed term, as in the M3 aggregate. According to his measurements, the demand for money defined like this should be more stable and more sensitive to interest rates than for the commonly studied M2 aggregate. Standard aggregate M1 includes funds that are readily accessible for spending. M1 consists of currency outside the US Treasury, Federal Reserve Banks, and the vaults of depository institutions; traveller's checks of nonbank issuers; demand deposits; and other checkable deposits. M2 includes a broader set of financial assets held principally by households. M2 consists of M1 plus: savings deposits (which include money market deposit accounts; small-denomination time deposits (time deposits in amounts of less than $100,000); and balances in retail money market mutual funds. M3 includes currency, deposits with an agreed maturity of up to two years, deposits redeemable at notice of up to three months and repurchase agreements, money market fund shares/units and debt securities up to two years. However, we use MZM because MZM better expresses economists' ideas about the nature of money and the money supply within the economy. The logic behind defining an aggregate in this way is to measure the liquid money supply on the market. MZM's value consists of the size of the M2 aggregate minus time deposits and with the addition of the amount of money in money market funds (Federal Reserve Bank of St. Louis, 2017). Carlson and Keen (1996) emphasise the importance of MZM. They state that deregulation and financial innovation have significantly influenced the relationship between the traditionally defined monetary aggregates and economic activity and interest rates. According to their research, the MZM aggregate is not significantly influenced in this way, because it demonstrated a relatively stable relationship to nominal GDP over the 20 years included in the study. MZM is also immune to investment fund innovation, which has led to the M2 aggregate 'relinquishing' its position. They start with the fundamental role money plays across economic sectors, and they emphasise the importance of liquid money and its utility for transaction purposes. Studies by a number of authors (Teles and Zhou, 2005; Serletis and Gogas, 2014; Barnett et al., 2013; Belongia, 1996) have also used the alternative aggregate MZM in addition to standard monetary aggregates. They investigated the aggregates' relationships to the macroeconomic variables with which they should theoretically be tied.

Concerning the traditionally conceived relationship between the behaviour of the money supply and the rate of inflation, it is impossible to start elsewhere than with the idea of monetarism and its main proponent Milton Friedman (1968), who defended the opinion that each significant recession in the USA has been produced by monetary restrictions and each important hike in inflation has been caused by monetary expansion. This means that Friedman posited that there is a direct connection: the growth of the money supply influences inflation. However, he no longer defended such an unequivocal opinion in later phases of his economic thinking. Lucas (1980) presented empirical evidence of the quantity theory of money – that a specific change in the money supply's growth rate causes a corresponding change in the inflation rate. Trecosi and Vega (2002) as well as Bruggeman et al. (2005) also state that an increase in the money supply has a causal effect on other economic variables, mainly on the inflation rate.

Kaufmann and Kugler (2010) came to the conclusion that it is necessary to take into consideration M3 money's growth rate in order to predict inflation, because their calculations showed that an increase in the money supply significantly influences the inflation rate. Gerlach and Svensson (2003) focused on the role the European Central Bank puts on the broad monetary aggregate in its monetary policy. They concluded that the money indicator can be appropriate to use in combination with other indicators to form an estimate of future price development. Holtemöller's (2004) fundamental contribution posited that inflation is a long-term monetary phenomenon, because inflation and the growth of money are cointegrated. De Grauwe and Polan (2005) concluded that there is a strong positive relationship between long-term inflation and the growth of the money supply for countries with high inflation rates or hyperinflation. Conversely, they concluded that this relationship is weak for countries with low inflation rates. Jílek (2015) stated that monetary aggregate growth results in both a higher inflation rate as well as higher real GDP roughly at a 1 : 1 ratio. In other words, growth of the money supply by x% effected an increase in price levels of 1/2 of x% and the growth of real GDP by 1/2 of x%. A smaller fixed part of money supply's growth also had an impact on decreasing the velocity of money. Conversely, Estrella and Mishkin (1997) concluded that monetary aggregates cannot correctly and directly predict inflation and nominal production, so they should not be used by those who set monetary policy in the sense of targeting the behaviour of monetary aggregates to influence real macroeconomic variables. According to Alvarez et al. (2009), rapidly increasing the money supply has a slow impact on inflation. Černohorská and Maléř also came to the conclusion that present day monetary policy is ineffective when it focuses on targeting M3 with the intention of influencing inflation in this way. Using cointegration analysis as their basis, they state that there is no long-term relationship between M3's behaviour and the inflation rate. Among other things, Dreger et al. (2019) investigated whether it is possible to improve inflation rate prognosis using the behaviour of monetary aggregates. They came to the conclusion that it is not. Gertler and Hofmann (2018) investigated the relationship between monetary aggregate growth and inflation for 46 economies over the long term. They concluded that there is a significant decline for this relationship; specifically, they indicated that this relationship is stronger for environments characterised by high inflation and low financial liberalisation. These results suggest that price stability and financial liberalisation could have implications for monetary analysis that go beyond the weakening of the link between money growth and inflation that was indicated by previous studies. As Borio (2014) confirmed for economies with lower inflation and credible central banks, unsustainable economic and financial expansions appear to manifest themselves not primarily in inflationary pressures but instead in excessive credit growth and asset price booms that ultimately usher in financial crises. In dealing with whether the quantitative theory of money is still valid, Teles and Uhlig (2016) came to a similar conclusion. They stated that the interconnection between the money supply and inflation is the least in countries with low inflation. Their conclusion states that adopting inflation targeting shows considerably less variability concerning inflation, disrupting the one-to-one relationship between money growth and inflation.

Concerning money supply's influence on the other given price indices, Becker (2007) asserted in his analysis that because the growth of liquidity has barely shown up in headline or core consumer price inflation, it is often said that it must have swept into asset markets and thus has boosted asset rather than consumer price inflation. He said that 'excess' liquidity has likely contributed to overheated real estate markets in the USA and the UK. In his analysis, he concluded that surplus liquidity swept into asset markets (mainly bonds, stocks, and real estate) and thus has led to asset rather than consumer price inflation. Nonetheless, he recognised the importance of other factors, such as strong profitability growth and improved corporate balance sheets. In his other studies, Mishkin (2001) confirmed money supply's effect on real estate prices, though he denied that it affects the price of stocks. Patelis (1997) stated that monetary policy variables are a significant factor for predicting future returns from stocks. According to his results, restrictive monetary policy brings with it lower returns from stocks and the opposite. Flannery and Protopapadakis (2002) determined that stock prices are significantly correlated with the growth of the money supply in circulation. Nonetheless, they determined that a total of 17 variables influence stock price returns and volatility with three nominal price factors standing out: the consumer price index (CPI), the producer price index, and monetary aggregates. Results by Ioannidis and Kontonikas (2008) indicated that changes in monetary policy significantly influence stock prices or financial assets in general. According to them, central banks can influence movement on the financial markets by setting interest rates and thereby implicitly influencing the money supply in circulation. Bjørnland and Leitemo (2009) concluded that there is reciprocal interdependence between the US monetary policy and the value of the S&P500 stock index. Specifically, their results state that real stock prices drop at an interval of 7–9% under the influence of monetary policy shock in the form of increasing the federal fund rate by 100 base points. On the other hand, shock in the form of increasing the real price of stocks by 1% results in an increase in interest rates by 4 to 7 base points. Chen (2007) investigated the effects of monetary shocks on stock prices in the USA. He determined that restrictive monetary policy has a strong negative impact on stock prices. Chebbi and Derbali (2019) investigated the impact of US monetary policy surprises on the volatility of stock market returns for euro area countries. He found that US monetary policy surprises exerted a strong influence on market volatility. Similarly, John et al. (2019) investigated the relationship of the amount of money and stock prices on the example of extensive demonetisation in the Indian economy. However, this government intervention led to greater volatility in banks' stocks – especially the private. So both papers did not show any clear relationship. Goodhart and Hofmann (2008) analysed how the money supply, loans, real estate prices, and economic activity are interconnected. They concluded that there is a close and significant interconnection between real estate prices and monetary aggregates, primarily for the period of 1985 to 2006. Stronger effects occur primarily during periods of rapidly increasing real estate prices. Nonetheless, they also defined a number of other factors influencing real estate prices in conjunction with the macroeconomic cycle. Hofmann and Peersman (2017) show that, in the USA, the effects of monetary policy on credit and housing markets have become considerably stronger relative to the impact on GDP since the mid-1980s, while the effects on inflation have become weaker. Macroeconomic stabilisation through monetary policy may therefore have become associated with greater fluctuations in credit and housing markets. The stronger impact of monetary policy on credit is driven by a much higher responsiveness of mortgage credit and a larger share of mortgages in total credit since the 1980s. Ahearne et al. (2005) stated that housing prices are procyclic and that important central banks also take real estate prices into consideration as a significant indicator. Taylor (2007) demonstrated that the period where interest rates were significantly low when compared with the Taylor rule in 2003 and 2004 significantly contributed to increasing demand for real estate and thereby to its price growth spiral. Once interest rates returned to their normal levels, the demand for real estate rapidly dropped; therefore, real estate prices also dropped. On the other hand, Mishkin (2007) stated that standard models are limited in their ability to explain the housing market's behaviour – including prices – and warns of uncertainty linked to 'housing-related' channels of the monetary transmission mechanism.

3 Data and methodology

To represent the amount of liquid money, we used MZM as published in the FRED databases (Federal Reserve Bank of St. Louis, 2019c) for the years 1961 to 2018. Regarding the fact that our goal was to investigate the selected variables' long-term relationships, we used such a long time series given the understanding that the crisis occurred during this period as well as various developments for these variables. Specifically, cointegration analysis, as described below, is able to judge whether there is a balanced state (equilibrium) for concrete variables toward which a given system is drawn. A system is never in equilibrium in reality, because it is exposed to constants shocks (e.g., the influence of crises and other economic variables). However, a system can be in what is called long-term equilibrium, i.e., in a state that converges to a balanced position over time. Cointegration is the type of state in which time series are in long-term equilibrium even though they may deviate from each other over the short term, but not past a certain point. These methods are currently used in a number of studies analysing the relationship of financial time series, e.g., Lauenstein (2017), Kumar (2010), Tsaurai and Odhiambo (2012), and Suresh Babu and Prabheesh (2008).

MZM is calculated as M2 less small-denomination time deposits plus institutional money funds. Consumer prices are represented by the standard CPI (Federal Reserve Bank of St. Louis, 2019a), stock prices (P_S) are represented by the Dow Jones Industrial Average index (Federal Reserve Bank of St. Louis, 2019b), bond prices (P_B) are expressed by the price of 10-year US Treasury bonds (Bloomberg, 2019), and real estate prices (P_R) are represented by the Residential Property Prices index for the USA (Federal Reserve Bank of St. Louis, 2019a). We worked with monthly values that were seasonally adjusted. We used quarterly values only for real estate prices. For the calculations, we used values that had undergone logarithmic transformation, which is in line with financial time series analysis. In this step, we made sure that the time series had log-normal distribution. At the same time, thanks to the series' logarithmic transformation, stabilisation was achieved with regards to variance (Arlt and Arltová, 2003). The Engle-Granger cointegration test and Granger causality testing were used for calculating the relationships. These methods have the advantage of being able to analyse nonstationary time series. If traditional statistical methods were used, spurious regression could occur. Essentially, the method of cointegration analysis explains long-term relationships for two or more economic variables allowing for an interpretation of their economic relationship that includes these variables deviating from each other to some degree for various reasons over the short term. Over time, these short-term deviations disappear. Granger causality tests give information about whether the development of one economic variable is able to improve prediction of other economic variables, which is an important aspect of economic relationships and their study in reality.

The first step was to select the criteria for determining the appropriate model with regards to optimal lag length. One of the most frequently used methods is to employ information criteria. A number of authors, including Ivanov and Kilian (2005), came to the conclusion that for VAR models with monthly data, it is most appropriate to apply Akaike's information criteria (AIC).

The second step was to conduct the cointegration analysis. We carried out cointegration analysis in the form of the Engle-Granger method using the following four steps:

- testing the time series for stationarity and determining the order of integration
- estimating the regression relationship between the time series
- testing the stationarity of the residual component from the regression model
- interpreting the estimated regression function and estimating the error correction model.

The stationarity test is conducted using the augmented Dickey-Fuller test (ADF test), i.e., a unit root test. In this paper, we conducted testing using a 0.05 level of significance. We tested the hypothesis H_0, i.e., that the time series are not stationary (if $p > 0.05$). In the next process, we stationarised the data by taking the difference.

The following step is to estimate the regression relationship between the time series. We used the least squares method, and the equation resulting from the standard cointegration test regression (see Hendl, 2012). Testing for the stationarity of the estimated regression model's residual components is also conducted using the ADF test. We tested the hypothesis that the time series are not cointegrated. The hypothesis is true when $p > 0.05$. This means that there is no unit root present and H_0 is not rejected, which means that there is no cointegration relationship. If there is a unit root present ($p < 0.05$), the null hypothesis is rejected, and we can say that the residuals from the cointegration equation are stationary and the time series y_t and x_t are cointegrated. The hypotheses is defined as follows:

$$H_0 : \epsilon_t \sim I(d) \ldots \text{ the time series are not cointegrated,}$$
$$H_1 : \epsilon_t \sim I(0) \ldots \text{ the time series are cointegrated.} \quad (1)$$

If the third step concluded that the time series were cointegrated, we then used the error correction model, by which we get an idea of the long-term relationship as well as the short-term dynamic. This model is expressed by the following equation

$$\Delta Y_t = \alpha + \beta_0 \Delta X_t + \delta(Y_{t-1} - \rho_2 X_{t-1}) u_t \quad (2)$$

where $\delta(Y_{t-1} - \rho_2 X_{t-1})$ is the error correction coefficient, representing the explained variable's deviation from the long-term equilibrium; β_0 is the short-term reaction between changes *Y* and *X*; and δ is the speed of adaptation to the equilibrium over time. In these equations, the parameter ρ_2 interests us as it measures the long-term dependence between *Y* and *X*.

If we did not conclude that the time series were cointegrated, we tested for Granger causality. These tests explain the causal relationship between the investigated variables. The logic of Granger causality is that if series X effects series Y, then series X should help improve prediction of series Y (Arlt, 1999). In his method, Granger used VAR models and compared the individual models' residuals, which differ in their number of lags. Then, the lowest AIC value is recommended as the most suitable. The next procedure is defined according to Arlt and Arltová (2003) and Hušek (2007).

As part of Granger causality testing, we tested the following hypotheses:

$$H_0 : \textit{the variable X does not Granger} - \textit{cause the variable Y}$$
$$H_1 : \textit{the variable X does Granger} - \textit{cause the variable Y} \quad (3)$$

This calculation uses stationarised time series. Granger (1969) derived the testing equations listed below, which are based on VAR models and serve to determine the validity of the above-listed conditions:

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{p} \beta_i X_{t-i} + u_t, \quad (4)$$

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + u_t, \quad (5)$$

where α_i and β_i are the variables' coefficients; X_t and Y_t are the variables' time series; *p* is lag length; and u_t is the random error term.

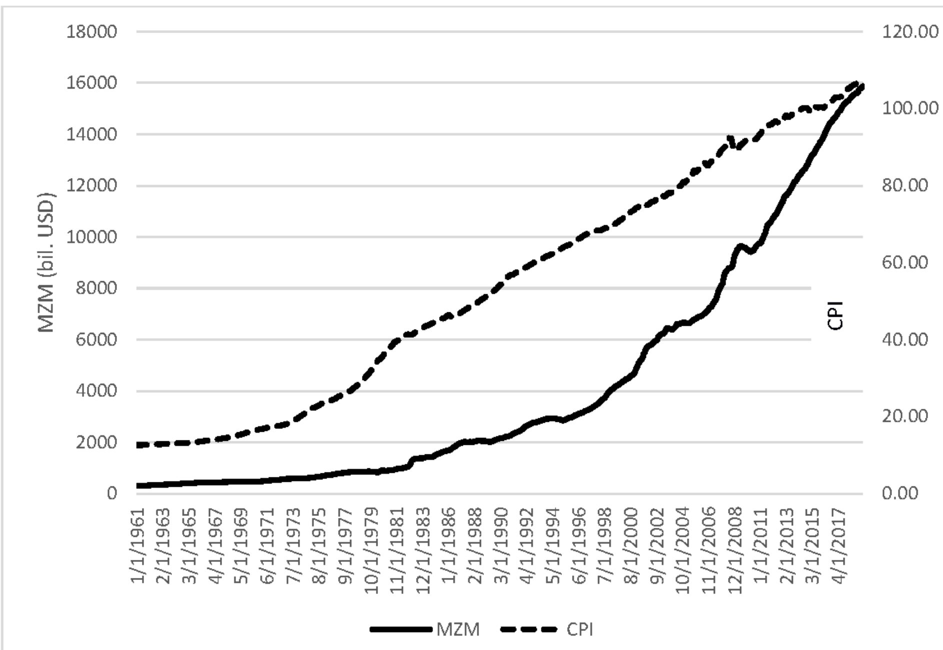
4 Empirical results

Before we proceed to the analysis itself, let us demonstrate and briefly describe the analysed variables' behaviour, which is always the relationship between the behaviour of

MZM and the variable being considered, i.e., the CPI, stock prices, bond prices, and real estate prices. A graphic depiction has been provided.

As the graph shows, the money supply in circulation is constantly growing, at an average rate of 7% for the given period. Annual *MZM* growth averaged under 6% up until the 1980s, it has grown more rapidly since the 80s, and *MZM* has primarily grown at an even more marked tempo (more than 8% annual growth) in the 21st century. Naturally, this is dependent on the growth of the US economy and global trade. In contrast to this, the CPI has grown with a roughly linear trajectory, at an average of 3.8% annually. According to current thinking, this represents a higher inflation rate than corresponds to price stability. Nonetheless, it is necessary to take into consideration the more marked growth of the US economy – primarily during the years we examined from the 20th century, to which the growth of the price level generally corresponds (Figure 1).

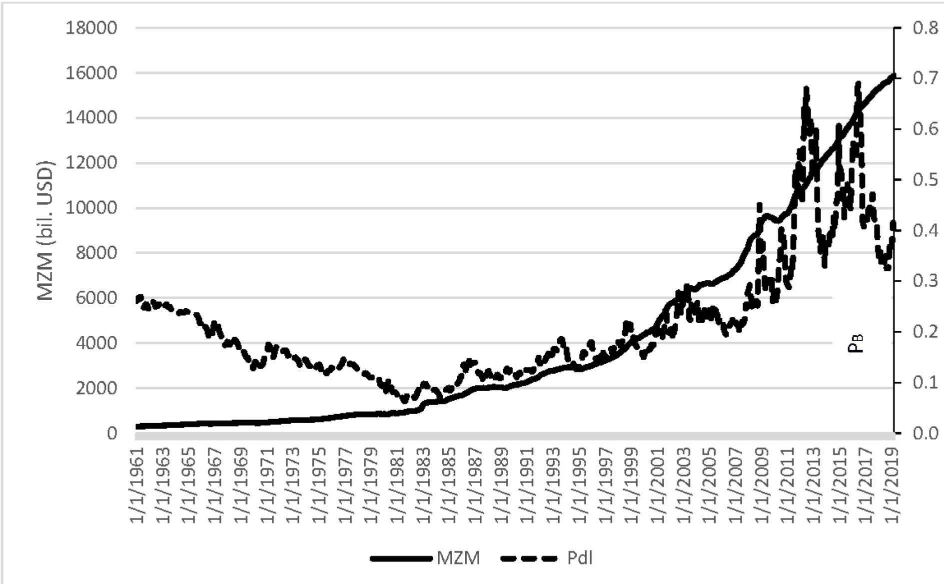
Figure 1 The development of *MZM* and *CPI*



Source: Federal Reserve Bank of St. Louis (2019a, 2019c)

In contrast to the growth of *MZM*, bond prices grew only slightly from the long-term perspective, specifically at an annual average of 0.7%. Nonetheless, it is necessary to divide the values' behaviour into two periods. Up to 1982, bond prices were dropping significantly – at an average of 6.3% annually, primarily influenced by increasing bond yields. Afterwards, the bond prices grew significantly – at an annual average of 4.7%. The main factor was a significant drop in bond yields, which were reacting to economic development and to the yields of financial and investment substitutes. Since the financial crisis in 2007, stronger volatility has been seen for prices and bond yields – primarily on account of increased uncertainty on the financial markets (Figure 2).

Figure 2 The development of *MZM* and bond prices



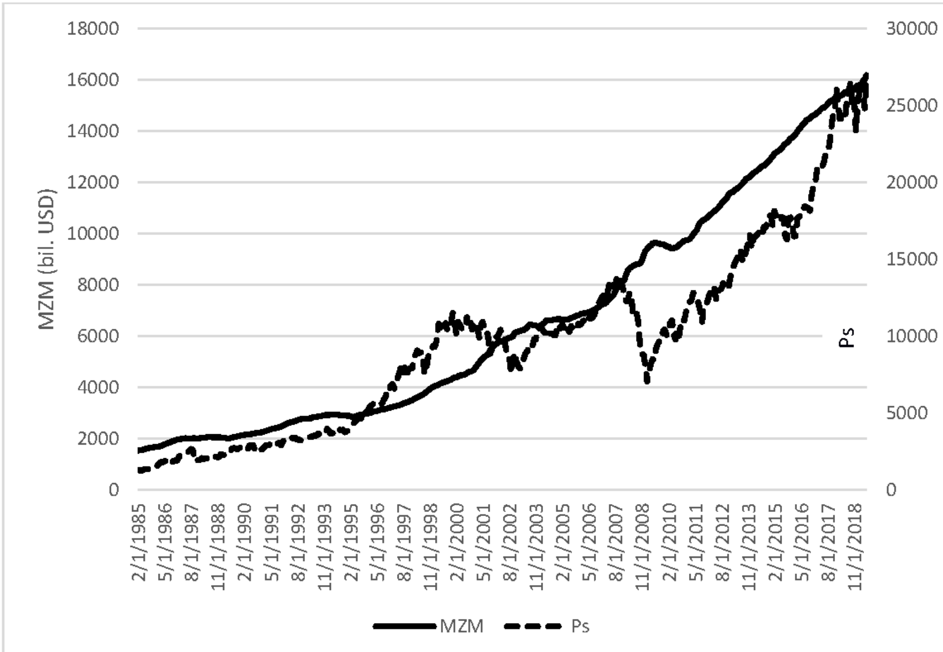
Source: Federal Reserve Bank of St. Louis (2019c) and Bloomberg (2019)

On average, stock prices grew annually at an even greater rate than *MZM*, at 9.1%. At certain points, dips were naturally unavoidable – in conjunction with the dot-com bubble in 2001 or the financial crisis after 2007. However, during other periods, stock prices grew, thus confirming the long-term growth trend for prices of this type of asset (Figure 3).

As the graph shows, real estate prices grew significantly (at an annual average of 4.2%) – most dramatically during the period of 2000 to halfway through 2006 (at an annual average of 10.9%) and then from the start of 2012 up until the present (at an average of 6%). Conversely, the time between these periods shows a distinct decline in real estate prices (at an annual average of 7.2%). Real estate prices are distinctly connected with economic development. In this case, the initial impetus for the financial crisis was the crisis on the American mortgage market. The downturn in this market was the result of previous marked growth in real estate prices, which was caused by a preceding drop in interest rates and the disproportionately generous provision of mortgages. As soon as problems appeared on the real market, it reacted with a significant decline in prices (Figure 4).

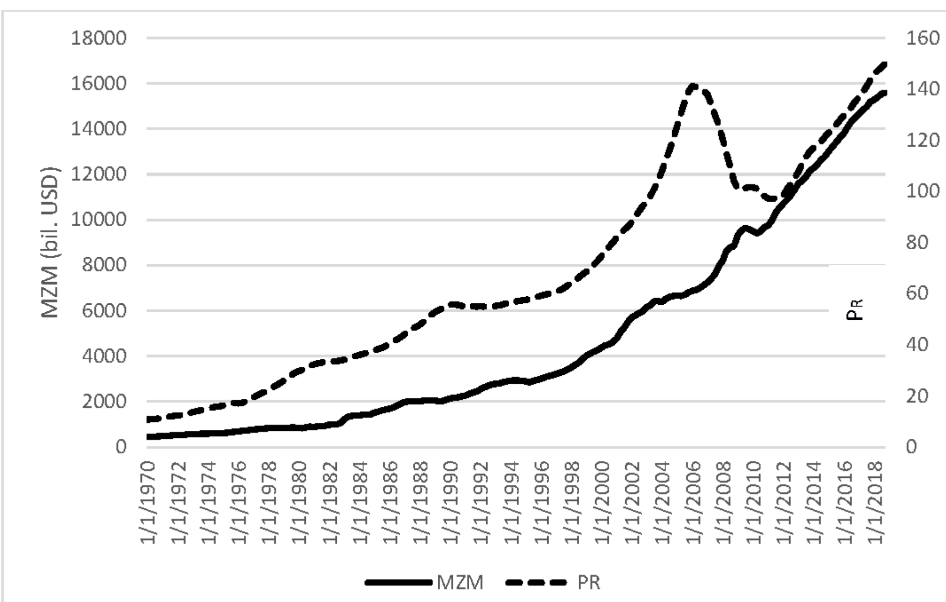
Concerning the actual analysis of the relationships between the variables under consideration, we first calculated the optimal lag length of the variables in the VAR model for the monthly values, and for quarterly values. We took the tests' resulting values, selected the lowest value, and used the corresponding lag length in the following step. At the same time, we selected the type of test to be used. We used 16-month optimal lag length and a test with a constant and a trend for MZM and CPI. We used 16-month optimal lag length and a test with a constant for MZM and bond prices. For MZM and stock prices we used the same test but with a 2-month lag. We used an optimal lag length of six quarters and a test with a constant and a trend for MZM and property prices.

Figure 3 The development of *MZM* and stock prices



Source: Federal Reserve Bank of St. Louis (2019b, 2019c)

Figure 4 The development of *MZM* and real estate prices



Source: Federal Reserve Bank of St. Louis (2019c, 2018d)

The next step in the cointegration analysis was testing for the time series' stationarity. In this paper, we tested the hypothesis for whether the time series are nonstationary using a 0.05 level of significance. In all calculations, we confirmed that the original log-transformed time series are nonstationary. We achieved stationarity by taking the first difference. So the results of the ADF tests confirmed the assumption for cointegration analysis testing, i.e., that the original time series are nonstationary. We next continued to the Engle-Granger cointegration test. In this test, we tested for the time series' residuals. When the residuals were nonstationary, then the time series were not cointegrated – see (1). We did not reject this hypothesis when $p > 0.05$. Cointegration relationships are able to work in both directions. For this reason, it is necessary to conduct cointegration tests for *MZM* as an independent variable and successively for *CPI*, P_B, P_S, and P_R as dependent variables – as well as for *MZM* as a dependent variable and *CPI*, P_B, P_S, and P_R as independent variables.

The results of the Engle-Granger cointegration test for the given time series are listed in Table 1. When testing, the above-listed optimal lag was used along with the above-listed type of test – either with a constant or a constant and a trend.

Table 1 The results of the Engle-Granger cointegration test

Time series	*p-value of the residuals*	H_0 *of the residuals*	*Relationship*
MZM – CPI (CPI is dependent)	0.9554	Not rejected	No cointegration
CPI – MZM (MZM is dependent)	0.3293	Not rejected	No cointegration
MZM – P_B (P_B is dependent)	0.5067	Not rejected	No cointegration
P_B – *MZM (MZM* is dependent)	0.3668	Not rejected	No cointegration
MZM – P_S (P_S is dependent)	0.4017	Not rejected	No cointegration
P_S – *MZM (MZM* is dependent)	0.6050	Not rejected	No cointegration
MZM – P_R (P_R is dependent)	0.2631	Not rejected	No cointegration
P_R – *MZM (MZM* is dependent)	0.1459	Not rejected	No cointegration

Source: Calculations by the author in the program Gretl

From the residuals' p-values, which are higher than the 0.05 level of significance, we can conclude that the time series are not cointegrated, i.e., there are no long-term relationships between them.

The last step of this analysis is the Granger causality test. The tests are based on (4) and (5), and we have used them to test the hypothesis that the *X* value does not Granger-cause the *Y* variable. This test also needed to be conducted by eventually switching the dependent and independent variables. This means that *MZM* is the independent variable in the first step with *CPI*, P_B, P_S, and P_R successively becoming the dependent variables. In the second step, *MZM* is dependent and *CPI*, P_B, P_S, and P_R become the independent variables in succession. The results for the variables' Granger causality are listed in the following tables. The first column lists the dependent variable and its lag in months. These are stationary time series, and for example, *d_l_CPI_1* denotes the first difference of the *CPI* variable after logarithmic transformation with a time delay of 1 month. The first difference of *CPI* after logarithmic transformation time series actually expresses the relative growth rate of this indicator, in this case the rate of inflation. The left side of the table contains the dependent variable *CPI;* the right side of the table lists the dependent variable *MZM*. The second column contains the calculated p-value. Using stars, the third column specifies the significance coefficient at 0.01 (***), 0.05 (**), and 0.10 (*) levels of significance. In our case, values less than the selected level of significance 0.05, i.e., two stars or more, are of interest. The last column lists whether or not the null hypothesis was rejected, i.e., that the variable *MZM* does not influence the variable *CPI* (left side of the table) or that the variable *CPI* does not influence *MZM* (the right side of the table).

Table 2 The results of Granger causality for *MZM* and *CPI*

Lags	*p-value*		H_0	*Lags*	*p-value*		H_0
d_l_CPI_1	4.03×10^{-24}	***	Rejected	*d_l_MZM_1*	$2,88 \times 10^{-68}$	***	Rejected
d_l_CPI_2	0,9413		Not rejected	*d_l_MZM_2*	0.0004	***	Rejected
d_l_CPI_3	0.5835		Not rejected	*d_l_MZM_3*	0.0128	**	Rejected
d_l_CPI_4	0.1888		Not rejected	*d_l_MZM_4*	0.0456	**	Rejected
d_l_CPI_5	0.6720		Not rejected	*d_l_MZM_5*	0.0157	**	Rejected
d_l_CPI_6	0.5275		Not rejected	*d_l_MZM_6*	0.1064		Not rejected
d_l_CPI_7	0.2994		Not rejected	*d_l_MZM_7*	0.4500		Not rejected
d_l_CPI_8	0.9566		Not rejected	*d_l_MZM_8*	0.0284	**	Rejected
d_l_CPI_9	0.0264	**	Rejected	*d_l_MZM_9*	0.2883		Not rejected
d_l_CPI_10	0.2039		Not rejected	*d_l_MZM_10*	0.1234		Not rejected
d_l_CPI_11	0.0032	***	Rejected	*d_l_MZM_11*	0.0400	**	Rejected
d_l_CPI_12	0.0017	***	Rejected	*d_l_MZM_12*	0.2065		Not rejected
d_l_CPI_13	0.6503		Not rejected	*d_l_MZM_13*	0.4843		Not rejected
d_l_CPI_14	0.7704		Not rejected	*d_l_MZM_14*	0.0136	**	Rejected
d_l_CPI_15	0.0019	***	Rejected	*d_l_MZM_15*	0.0219	**	Rejected
d_l_CPI_16	0.9438		Not rejected	*d_l_MZM_16*	0.4000		Not rejected
d_l_CPI_17	0.8741		Not rejected	*d_l_MZM_17*	0.5289		Not rejected
d_l_CPI_18	0.1815		Not rejected	*d_l_MZM_18*	0.4768		Not rejected

**d_l_CPI_x*…means the first difference of the *CPI* variable after logarithmic transformation with a time delay of *x* month, *d_l_MZM_x*…means the first difference of the *MZM* variable after logarithmic transformation with a time delay of *x* month.

Source: Calculations by the author in the program Gretl

Table 2 shows that the variable *MZM* Granger-causes the variable *CPI* at 1, 9, 11, 12, and 15 month lags. In order to be able to say that the variables Granger-cause each other, it is enough to reject the null hypothesis at least once. In our case, this means that using the *MZM* variable can improve prediction of *CPI* development when using the given lags. We can also state that the variable *CPI* Granger-causes *MZM* at 1–5, 8, 11, 14, and 15 month lags. This means that using the variable *CPI* can improve the prediction of *MZM*'s development at the given lag lengths.

Table 3 lists the results of Granger causality for P_B and *MZM*. The dependent variable P_B is shown on the left side of the table; the dependent variable *MZM* is on the right.

Table 3 The results of Granger causality for *MZM* and P_B

Lags	*p-value*		H_0	*Lags*	*p-value*		H_0
$d\_l\_P_B\_1$	0.0871	*	Not rejected	*d_l_MZM_1*	9.14×10^{-70}	***	Rejected
$d\_l\_P_B\_2$	0.0028	***	Rejected	*d_l_MZM_2*	0.0006	***	Rejected
$d\_l\_P_B\_3$	0.3463		Not rejected	*d_l_MZM_3*	0.0220	**	Rejected
$d\_l\_P_B\_4$	0.6946		Not rejected	*d_l_MZM_4*	0.0542	*	Not rejected
$d\_l\_P_B\_5$	0.0485	**	Rejected	*d_l_MZM_5*	0.0157	**	Rejected
$d\_l\_P_B\_6$	0.1067		Not rejected	*d_l_MZM_6*	0.1149		Not rejected
$d\_l\_P_B\_7$	0.1336		Not rejected	*d_l_MZM_7*	0.4395		Not rejected
$d\_l\_P_B\_8$	0.4427		Not rejected	*d_l_MZM_8*	0.0211	**	Rejected
$d\_l\_P_B\_9$	0.3352		Not rejected	*d_l_MZM_9*	0.2651		Not rejected
$d\_l\_P_B\_10$	0.9818		Not rejected	*d_l_MZM_10*	0.1024		Not rejected
$d\_l\_P_B\_11$	0.0702	*	Not rejected	*d_l_MZM_11*	0.0516	*	Not rejected
$d\_l\_P_B\_12$	0.6391		Not rejected	*d_l_MZM_12*	0.2011		Not rejected
$d\_l\_P_B\_13$	0.0169	**	Rejected	*d_l_MZM_13*	0.5030		Not rejected
$d\_l\_P_B\_14$	0.9262		Not rejected	*d_l_MZM_14*	0.0111	**	Rejected
$d\_l\_P_B\_15$	0.4605		Not rejected	*d_l_MZM_15*	0.0198	**	Rejected
$d\_l\_P_B\_16$	0.6746		Not rejected	*d_l_MZM_16*	0.3437		Not rejected
$d\_l\_P_B\_17$	0.9911		Not rejected	*d_l_MZM_17*	0.5749		Not rejected
$d\_l\_P_B\_18$	0.9598		Not rejected	*d_l_MZM_18*	0.4867		Not rejected

*$d\_l\_P_B\_x$…means the first difference of the P_B variable after logarithmic transformation with a time delay of *x* month.

Source: Calculations by the author in the program Gretl

Table 3 shows that the variable *MZM* Granger-causes the variable P_B at lags of 2, 5, and 13 months. We can also state that the variable P_B Granger-causes the variable *MZM* at lags of 1, 2, 3, 5, 8, 14, and 15 months.

Table 4 lists the Granger causality results for P_S and *MZM*. The dependent variable P_S, is on the left side of the table; the right side shows the dependent variable *MZM*.

Table 4 The results of Granger causality for *MZM* and P_S

Lags	*p-value*	H_0	*Lags*	*p-value*		H_0
$d\_l\_P_S\_1$	0.7076	Not rejected	*d_l_MZM_1*	1.01×10^{-26}	***	Rejected
$d\_l\_P_S\_2$	0.3649	Not rejected	*d_l_MZM_2*	0.8126		Not rejected
$d\_l\_P_S\_3$	0.6766	Not rejected	*d_l_MZM_3*	0.0171	**	Rejected
$d\_l\_P_S\_4$	0.4840	Not rejected	*d_l_MZM_4*	0.2742		Not rejected
$d\_l\_P_S\_5$	0.3656	Not rejected	*d_l_MZM_5*	0.2993		Not rejected
$d\_l\_P_S\_6$	0.1068	Not rejected	*d_l_MZM_6*	0.3689		Not rejected
$d\_l\_P_S\_7$	0.1965	Not rejected	*d_l_MZM_7*	0.1130		Not rejected
$d\_l\_P_S\_8$	0.8444	Not rejected	*d_l_MZM_8*	0.0288	**	Rejected

Table 4 The results of Granger causality for *MZM* and P_S (continued)

Lags	*p-value*	H_0	*Lags*	*p-value*		H_0
$d\_l\_P_S\_9$	0.3265	Not rejected	*d_l_MZM_9*	0.9209		Not rejected
$d\_l\_P_S\_10$	0.9096	Not rejected	*d_l_MZM_10*	0.4735		Not rejected
$d\_l\_P_S\_11$	0.4979	Not rejected	*d_l_MZM_11*	0.0058	***	Rejected
$d\_l\_P_S\_12$	0.4913	Not rejected	*d_l_MZM_12*	0.5042		Not rejected
$d\_l\_P_S\_13$	0.8413	Not rejected	*d_l_MZM_13*	0.0438	**	Rejected
$d\_l\_P_S\_14$	0.5377	Not rejected	*d_l_MZM_14*	0.0006	***	Rejected
$d\_l\_P_S\_15$	0.8979	Not rejected	*d_l_MZM_15*	0.2147		Not rejected
$d\_l\_P_S\_16$	0.4234	Not rejected	*d_l_MZM_16*	0.4842		Not rejected
$d\_l\_P_S\_17$	0.8101	Not rejected	*d_l_MZM_17*	0.0422	**	Not rejected
$d\_l\_P_S\_18$	0.5632	Not rejected	*d_l_MZM_18*	0.0642	*	Not rejected

*$d\_l\_P_S\_x$…means the first difference of the P_S variable after logarithmic transformation with a time delay of *x* month.

Source: Calculations by the author in the program Gretl

Table 4 shows that the variable *MZM* does not Granger-cause the variable P_S. Conversely, we can state that the variable P_S Granger-causes the variable *MZM* at lags of 1, 3, 8, 11, 13, 14, and 17 months.

Table 5 lists the Granger causality results for P_R and *MZM*. The dependent variable P_R is on the left side of the table; the right side shows the dependent variable *MZM*.

Table 5 The results of Granger causality for *MZM* and P_R

Lags	*p-value*		H_0	*Lags*	*p-value*		H_0
$d\_l\_P_R\_1$	6.54×10^{-27}	***	Rejected	*d_l_MZM_1*	4.02×10^{-10}	***	Rejected
$d\_l\_P_R\_2$	0.7150		Not rejected	*d_l_MZM_2*	0.0211	**	Rejected
$d\_l\_P_R\_3$	0.3672		Not rejected	*d_l_MZM_3*	0.0137	**	Rejected
$d\_l\_P_R\_4$	0.0139	**	Rejected	*d_l_MZM_4*	0.0206	**	Rejected
$d\_l\_P_R\_5$	0.0020	***	Rejected	*d_l_MZM_5*	0.0004	***	Rejected
$d\_l\_P_R\_6$	0.2151		Not rejected	*d_l_MZM_6*	0.0038	***	Rejected
$d\_l\_P_R\_7$	0.9426		Not rejected	*d_l_MZM_7*	0.0770	*	Not rejected
$d\_l\_P_R\_8$	0.3703		Not rejected	*d_l_MZM_8*	0.0476	**	Rejected

*$d\_l\_P_R\_x$… means the first difference of the P_R variable after logarithmic transformation with a time delay of *x* quarter.

Source: Calculations by the author in the program Gretl

Table 5 shows that the variable *MZM* Granger-causes the variable P_R at lags of 1, 4, and 5 quarters. Conversely, we can say that P_R Granger-causes the variable *MZM* at lags of 1–6 and 8 quarters.

5 Discussion

The motivation for dealing with this subject is to evaluate whether increase in amount of money in the economy is related to the growth not only of consumer prices but also of the other important economic prices we selected. At the same time, it makes sense to specify the degree to which central banks are able to influence the behaviour of the investigated prices in the present day under the assumption that the money supply is endogenous. Specifically, the paper's goal was to assess the relationship between the development of liquid money and the selected price indices for the US economy for 1961 to 2018.

On the basis of the Engle-Granger cointegration test results, there are not long-term relationships between liquid money and the other price indices – the CPI, stock prices, bond prices, and property prices. We can therefore state that growth in the amount of liquid money is not reflected in an increase in the given prices over the long term. We believe that a decrease in brokering, finance innovation, and time delay are fundamental factors causing the currently standard transmission mechanism for monetary policy to be less effective and predictable. A drop in brokering means a relative decrease in the significance of banks as financial brokers in favour of other financial market institutions. This results in a partial drain of money away from bank management towards other institutions on the financial market. Financial innovation also ties into this, where an ever-decreasing relative share of money is kept in traditional transaction accounts and more sophisticated banking and financial products are being used. These effects were the result of financial liberalisation – as presented by Gertler and Hofmann (2018) – which reduces the empirical connection between an increase in the money supply and inflation. Conversely, the result is an increase in the risk of a financial crisis. Namely, the financial innovations that were part of advanced countries' financial liberalisation have been indicated to be significant drivers of the demand for money. Within the current understanding of the money supply as endogenous, this is essential for influencing the money supply in circulation. At the same time, the sharper changes in the demand for money happening at present have caused the tempo of monetary circulation to change, which further blurs the relationship between the money supply and inflation. Also regarding these products' complicated nature, it is impossible to give a precise estimate of how long a delay before monetary policy's effects can be seen on the real and financial markets; therefore, this effect can be dispersed across a given time period. Furthermore, the money supply has been having a distinctly diminished effect on the behaviour of inflation over time as a result of changing monetary policy regimes. As Teles and Uhlig (2016) stated, this is because a number of central banks have adopted the regime of inflation targeting over money supply targeting. This has resulted in inflation becoming less variable, which has weakened the connection between the money supply's behaviour and inflation. Mostly, this conclusion is valid for countries with low inflation rates and credible central banks. Other factors, primarily contemporary ones, include a decrease in the price of raw materials and overhead costs in conjunction with greater use of modern technology.

Nonetheless, on the basis of the Granger causality test results, we can state that short-term relationships are apparent and we can use MZM's behaviour to predict the development of consumer prices, bond prices, and real estate prices (not, however, that of stock prices). It is interesting to note that the behaviour of the money supply is not in anyway apparent on the US stock market. As Mishkin (2001) asserted, stock prices rather tend to reflect fundamental indicators of company economic activities and the economy as a whole. From this, it follows that central banks should not focus on influencing stocks in any way. Thus, the results of our study do not correspond with findings by Becker (2007), Patelis (1997), Flannery and Protopapadakis (2002), Ioannidis and Kontonikas (2208), or Bjørnland and Leitemo (2009). Our reasoning for this is that the situation in the economy and on the financial markets has changed since the time when these studies were made. In part, we support Mishkin's opinion that stock prices are created primarily by the results of given companies. Furthermore, psychological factors are currently manifested on the stock market more sharply, which influences stock market prices. When we take into consideration complex economic relationships, it is clear that stock and bond prices are influenced by a whole range of other factors, such as the economy's credibility and economic performance, fiscal policy formulation, the situation on the financial markets, the strength of the given currency, etc. For real estate prices, we are aware of its procyclicality, among other things.

Reverse relationships were also demonstrated – in that it was possible to use the behaviour of all the given prices to better predict the behaviour of money in the economy. Along with this, we can state that Granger causality is strongest in the direction of the given prices towards liquid money supply (in the sense of multiple Granger-causal relationships). This means that we definitely cannot consider money to be an exogenous variable, as is considered by many economic models, because it is dependent on the development of prices in the economy to a certain degree and thereby on the demand for money. We explain this by the fact that along with growing prices, economic entities demand more money for their transactions, with their amount increasing as loans are issued. This conclusion is significant from the perspective of enacting monetary policy in the wake of the financial crisis in the way that has been outlined by Mishkin (2017). Today, achieving financial stability has become another goal for central banks. In this case, it is appropriate for central banks to monitor and take into consideration the behaviour of important prices on the financial market in order to achieve their goals.

The prevailing opinion from the previously mentioned studies is that the money supply influences the rate of inflation. This relationship has been considered fundamental mostly by older studies (Friedman, 1968; Lucas, 1980; Holtemöller, 2004; Trecrosi and Vega, 2002; Bruggeman et al., 2005; Kaufmann and Kugler, 2010) which used data primarily or exclusively from the period when a central bank's goal was to influence the amount of money in circulation. Gerlach and Svensson (2003) acknowledged this relationship, although they stated that the behaviour of the money supply should serve as only one of the factors influencing the inflation rate. Conversely, newer studies have concluded either that there is currently no clear relationship between the money supply and inflation (Alvarez et al., 2009; Černohorská and Maléř, 2019; Dreger et al., 2019) or rather that the relationship between the money supply and inflation exists only for economies with a greater inflation rate and a low level of liberalisation on the financial markets (De Grauwe and Polan, 2005; Gertler and Hofmann, 2018; Borio, 2014; Teles and Uhlig, 2016). In contrast, the relationship between the money supply and inflation is not explicit for economies with low inflation rates and high degrees of financial market liberalisation. This second conclusion corresponds with our results for the US economy, where a long-term relationship between the examined variables was not confirmed; however, short-term relationships characterised by Engle-Granger causality were confirmed. This is given because in recent years, the prevailing goal of important central banks has been inflation targeting, where an aggregate expressing the money supply has become one of multiple indicators that the creators of monetary policy use when making decisions. In conjunction with this, certain studies warn that rather than being the only criteria, monetary aggregates should only be one of multiple criteria to be set when establishing the conditions for monetary policy. Estrella and Mishkin (1997) even state that it is impossible to use monetary aggregates (however standard) to correctly and directly predict the trend of inflation, which is in contrast to our Granger causality results.

Considering the findings that the behaviour of the money supply does not effect stock price, our results are in line with those of Mishkin (2001), who doubts the effectiveness of monetary policy regarding stock prices. On the other hand, we differ from the opinions of Flannery and Protopapadakis (2002), Ioannidis and Kontonikas (2008), and Bjørnland and Leitamo (2009), who have described its significant influence on stock price. Rather, we tend to agree with Becker (2007), who stated that excess liquidity tends to be seen more in an increase in the prices of bonds, stocks (not in our case), and housing.

Most authors (e.g., Goodhart and Hofmann, 2008, Ahearne et al., 2005; Taylor, 2007) also agree that monetary policy influences housing prices. In our case, even though cointegration did not emerge, it is still possible to improve prediction of real estate prices using MZM's behaviour. We positively agree with the fact that monetary policy is definitely not the only factor influencing housing prices, as Mishkin (2007) asserted. There are not many studies interested in analysing reciprocal relationships for the given variables; therefore, we consider our conclusions about their mutual influence to be fundamental. Our primary emphasis is on improving the ability of the given prices' behaviour to predict the development of the liquid money necessary for purchasing real or financial assets.

Naturally, we are aware that there are many factors active in the real economy affecting consumer, stock, bond, and housing prices as well as the money supply – ones that our calculations have not taken into consideration. Therefore, it is necessary to continue with this research.

6 Conclusion

This study contributes to the current state of scientific knowledge by confirming the conclusions of primarily newer studies regarding the invalidity of the quantitative theory of money under current economic conditions. This means that the relationship between the growth of money and the inflation rate is currently decreasing sharply. It refutes the classic conclusions of the quantitative theory of money, which were valid at the time of its conception. Nonetheless, the Engle-Granger causality test results demonstrate options for improving the prediction of inflation levels using the behaviour of the liquid monetary aggregate. What this means for the practical application of monetary policy is that this essential monetary policy indicator must always be taken into consideration by central banks. This is true despite central banks being able to influence it only indirectly, which is given by the current understanding of the money supply as endogenous.

The contribution consists of having demonstrated relationships that are the opposite of that which economic thinking considers standard, i.e., that we can predict the behaviour of liquid money in the economy more accurately by using the behaviour of all the prices under consideration. This is a fundamental idea for influencing central banks' decision making. We explain this by the fact that along with growing prices, economic entities demand more money for their transactions, with its amount increasing as loans are issued. As a next contribution, it would be possible to utilise money of zero maturity, a non-standard money supply indicator that reports only the liquid money available on the market and thus best expresses the actual amount of money available on the financial markets.

Because our study did not discover long-term relationships between the variables under investigation, it is clear that it is necessary for economic reality to take into consideration other macroeconomic indicators influencing the given prices. The results of this study thus indicate that the relationship between the money supply and inflation has indeed been weakened under the combination of the current economic conditions and a high degree of financial liberalisation and that the conclusions of the quantitative theory of money are not valid for the present day. These conclusions are valid rather for environments with low inflation. Nonetheless, it is possible to state that over the short term, that we can use liquid money's behaviour to improve prediction of the development of consumer, bond, and housing prices, although not stock prices. Thus, central banks should take liquid money's behaviour into account when making decisions. It is therefore possible to state that even with the current conception of the money supply as endogenous, we should not be forgot that an increase in the money supply has the tendency to lead to inflation. Underestimating this – even if the relationship is not entirely clear – can lead to inflationary problems in the future, mostly for economies with a higher inflation rate. Furthermore, this could lead to exaggerated and unwarranted growth of prices on the financial markets in the future and could thus trigger a financial crisis.

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