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PRICE STABILITY IN PERIODS OF NEGATIVE INTEREST RATES

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Abstract
The connections between the ECB's unconventional "negative interest rate" measure and the overall goal of price stability are analyzed. Here there is a particular focus on the effectiveness of the measure during the Negative Interest Rate Period (NIRP) and the effectiveness in times of skyrocketing inflation. We will continue to examine whether the ECB's measures work in both the short run and the long run. The result is that the "negative interest rate" measure worked very well. It has been proven to contribute to price stability. In times of skyrocketing inflation, the ECB's control mechanisms via the interest rate still work. We proved this using the quantity theory of money, which applies both, in the long term and in the short term, and both during the NIRP and during positive interest rate structure phases.

Keywords: *negative interest rate policy; equation of exchange; price stability.*

JEL Classification: *E44, E51, E58, G17*

I. INTRODUCTION

The European Central Bank (ECB) plays a critical role in maintaining price stability within the euro area, a task that necessitates reliable and harmonized measures of consumer price levels across member states. One of the primary tools for this purpose is the Harmonized Index of Consumer Prices (HICP), which Eurostat, the statistical office of the European Union, calculates and publishes monthly. The HICP, constructed as a Laspeyres-type index, provides a consistent and comparable measure of inflation, essential for the ECB's monetary policy and for assessing economic convergence within the Economic and Monetary Union (EMU).

This article delves into the intricate mechanisms behind the HICP and its significance in the broader context of the ECB's monetary policy strategy, particularly focusing on the period characterized by the Negative Interest Rate Policy (NIRP). During this phase, the ECB implemented various measures, including the adjustment of key interest rates, to steer inflation towards the targeted 2% mark. The effectiveness of these measures is critically analyzed using comprehensive data from Eurostat, national statistics offices, and the ECB itself.

The analysis incorporates several key economic indicators and methodological approaches. Specifically, it examines the HICP, inflation rates, and monetary aggregates (M1, M2, M3), along with the ECB's deposit facility rate. These elements are scrutinized through correlation analysis, one-sided t-tests, and a synthesis of relevant literature to understand their interplay and impact on price stability. Furthermore, this research situates its findings within the theoretical framework of the Equation of Exchange, offering insights into the relationship between money supply, velocity, price levels, and economic output (Diamond et., 2023). By exploring both the short-term and long-term effects of the ECB's monetary policies, particularly during the NIRP period, the article aims to provide a nuanced understanding of how these policies influence inflation dynamics and overall economic stability.

The results indicate a significant correlation between the ECB's policy measures and the stabilization of inflation rates, demonstrating the effectiveness of the NIRP in achieving the desired price stability. However, the analysis also highlights the complexities and potential limitations of such unconventional monetary policies, especially in transitioning phases to a positive interest rate environment (Bernanke, 2019; Ikeda et al., 2024). This comprehensive examination not only underscores the pivotal role of the HICP in the ECB's monetary policy framework but also contributes to the ongoing discourse on the efficacy and sustainability of negative interest rate policies in modern economic management. Through robust data analysis and theoretical exploration, the article provides valuable insights for policymakers, economists, and scholars interested in the dynamics of monetary policy and price stability within the euro area.

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II. DATA AND METHODS

Used data bases for this article are Eurostat, National Statistics Offices and data of the European Central Bank (ECB). Analyzed are data components HICP, Inflation, Monetary Aggregates (M1, M2, M3), deposit facility rate and the Equation of Exchange. The research includes Correlation Analysis, One-Sided T-Test and literature synthesis.

Research Figure Harmonized Index of Consumer Prices

Since the Eurosystem is obliged to guarantee price stability throughout the euro area, a common price index is required. This so-called Harmonized Index of Consumer Prices (HICP) is determined by Eurostat, the statistical office of the European Union and published monthly. The HICP is calculated as a Laspeyres-type index, which is defined as follows:

$$p^{0,t} = \sum \frac{p^t}{p^0} * w^{0,b} \quad (1)$$

On the one hand, it serves as an indicator when assessing price convergence with regard to a country's possible accession to Economic and Monetary Union (EMU). Furthermore, it is fixed as the measure of price stability for the purposes of the monetary policy strategy of the ECB. The calculations are carried out individually in each country and are based on a uniform and legally prescribed method, which can be found in Regulation (EU) 2016/792 of the European Parliament and of the Council. A representative "shopping basket" with selected, differently weighted goods and services is compiled at national level, the composition of which is updated every five years. The price changes in the shopping basket result in the changes in the consumer price level, which in turn are mapped in the respective national price index. These results are combined in weighted form in the overall HICP index for the euro area.

In Germany, the category "Apartment, Water, Gas and Fuels" is weighted most heavily in the shopping cart with 32.5 percent. It should be noted, however, that in addition to price changes for water, gas and fuel, only the rental price changes from existing and constant leases are taken into account. Increased rental prices for the first occupancy of a newly created apartment, rent increases for new re-letting of existing living space as well as rental price increases after renovation measures on a rented existing property are not taken into account. It should also be noted that only price developments of consumer goods and services are included, those of the assets such as purchase prices of real estate or shares are not included in the shopping cart (Hafemann & Tillmann, 2020; Boucinha et al., 2020; Ehrmann, 2015; Ruge-Murcia, 2014).

Research Figure Money Supply

The monetary policy strategy of the Eurosystem gives the development of the money stock an important role. Within the framework of the monetary analysis, the development of the monetary aggregates (M1, M2 and M3) as well as the determining factors opposing them in the balance sheet context are examined.

The focus is on the growth of the money stock M3, for which a reference value of 4.5% per year has been set as a benchmark. The money stock M3 contains the entire money stock M2 plus repurchase agreement transactions (limited transactions based on a repurchase agreement) and money market fund units (investment funds that invest in bank deposits and liquid money market instruments), money market papers (short-term securities) and bank bonds with an original term of up to two years. Bank bonds are fixed-income securities that are issued by credit institutions.

The money supply M3 serves the ECB as a central control variable and as an indicator for assessing the monetary development (Gerdesmeier, 2009; Wang, 2020; Giannone et al., 2019; Eggertson & et. al., 2019; Kashyap & Stein, 2023).

III. RESULTS AND DISCUTIONS

Results for NIRP Phase

The deposit facility is one of three key ECB rates. Banks can invest up to the beginning of the next business day at the current interest rate with the ECB. It is therefore considered to be the key interest rate for the short term and has a control and signaling effect for the banks 'liabilities to customers and thus indirectly also for the banks' credit interest rates.

As previously described, a negative interest rate was charged for the deposit facility for the first time in 2014. This interest rate was increased in tenths of a step until it reached the lowest value rate of -0.5% at the end of 2020. This interest rate control in the negative range serves to increase the amount of money in circulation and thus to increase inflation. The ECB is trying, among other things, to use this method to develop inflation towards the targeted 2%-mark.

If this is an effective instrument, then there should be a connection between the negative adjustment of the

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interest rate and a stable development of inflation towards the 2% mark.

The research question is: How effective is NIRP in achieving ECBS objective of price stability?

The test to answer this question is carried out through own data collection and data analysis. For this purpose, data from the ECB are used, which are processed and evaluated. The data period covers the years from 2013 to 2022 in half-year steps (see *Table 1*). The characteristics are deposit facility, HICP, M3 and HICP objective (2%).

Table 1. Raw Data of deposit facility, HICP, M3 and ECB's HICP objective in time period of NIRP;

Indicator	**Dez 13**	**Jun 14**	**Dez 14**	**Jun 15**	**Dez 15**	**Jun 16**	**Dez 16**	**Jun 17**	**Dez 17**
Deposit facility	0,00%	-0,10%	-0,20%	-0,20%	-0,20%	-0,40%	-0,40%	-0,40%	-0,40%
HICP_euroarea	1,40%	0,50%	0,40%	0,50%	0,20%	0,00%	0,20%	1,30%	1,50%
M3_euroarea	1,00%	1,50%	3,60%	5,00%	4,70%	4,30%	5,00%	5,00%	4,60%
HICP_objective	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%
Indicator	**Jun 18**	**Dez 18**	**Jun 19**	**Dez 19**	**Jun 20**	**Dez 20**	**Jun 21**	**Dez 21**	**Jun 22**
Deposit facility	-0,40%	-0,40%	-0,40%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%	-0,50%
HICP_euroarea	2,00%	1,80%	1,30%	1,20%	0,30%	0,20%	1,90%	5,00%	8,60%
M3_euroarea	4,40%	3,80%	4,50%	5,00%	9,20%	12,30%	8,40%	7,30%	5,60%
HICP_objective	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%	2,00%

Source: ECB data

An obvious consideration would be to research the correlation over time between the independent variable "deposit facility" and the dependent variable "Harmonized Index of Consumer Prices (HICP)". The point, however, is to achieve a stability of the HICP close to 2% by lowering the interest rate. The independent variable therefore moves into the negative area, while the dependent variable should remain constant. However, this cannot be mapped using the correlation. An intermediate step must therefore be introduced.

The result is therefore viewed in reverse order, i.e. from the final result (HICP) to the individual components of the control by the ECB (NIR, money supply M3). First of all, it will therefore be checked whether there is a significant interrelation between actual inflation, measured by the HICP, and the intended inflation of 2% in the years between the end of 2013 and mid-2022. For this purpose, a one-sided t-test was used to check whether the mean value of the actual inflation differs from the specified target value. The result -5.85 means that the mean value of the actual inflation does not differ from the target value with a confidence level of 97.5%. There is a significant connection. All of the measures taken by the ECB have therefore worked successfully, despite time-related fluctuations. The HICP is moving relatively steadily towards the 2% mark. However, this does not say anything about the effectiveness of the individual measures. So far, it has only been proven that the measures are effective. However, whether the adjustment of the deposit facility also contributed causally is the next question.

The deposit facility affects the money supply, because negative interest rates make it unprofitable for banks to remain the money at the central bank. Banks have to get it circulated. As a result, the ECB should have steadily increased the money supply through its interest rate policy, which is the case. Between 2014 and 2022, the money supply increased steadily. It is questionable whether there is a causal relationship over time between the money supply M3 and the deposit facility. This applies after evaluating the statistics. There is a strong negative correlation at -0.737 (see *Table 2*). This means that the more the deposit facility was lowered, the more M3 rose. Thus, the step of the ECB was successful.

Table 2. Correlation between deposit facility and money stock M3, and result of one-sided-t-test between HICP and ECB's HICP objective;

Correl_df_M3	-0,7365003
t-test_HICPreal_HICPobjective	-5,8499047

Source: ECB data

As a result, the following indirect deduction can be made: the lowering of the deposit facility caused the money stock M3 to increase. The increased money supply increased inflation causally. And by demonstrating the correlation between actual inflation and the 2% target, it can be indirectly said that there is a causal link between the lowering of the deposit facility and the stable convergence of inflation towards the 2% target.

The research question can therefore be answered as follows: The NIR policy leads, among other measures, to an effective control of the inflation rate by the ECB. This is to be rated very positively.

In this article it was shown that the ECB since the introduction of the European common currency, the euro, is responsible for monetary policy in the monetary union. Within the scope of this mandate, it is the task of the

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ECB and the Eurosystem to operate independently of monetary policy on the basis of the two-pillar strategy with the aid of monetary policy instruments, for example via the control of interest rates to be implemented by the state in such a way that the primary goal of price stability in the eurozone is reached. Price stability is considered a fundamental factor for a favorable economic environment and a high level of employment. As of the definition valid until the beginning of July 2021, this goal was met when the annual inflation rate measured by the HICP in the euro area is close to, but just under, two percent in the medium term.

In the years between 2013 and mid-2022, the HICP was well close to the 2% mark, targeted by the ECB. The measures taken by the ECB also appear to make a causal contribution to price stability. The research, as to whether this was done via the adjustment of interest rate levels, can be derived via the money supply. The negative deposit facility starts with the fact that it was unprofitable for banks to park money at the ECB. Money was also created via the interest rate channel, particularly via the cost of capital effect. In addition, the interest rate reduction has a positive effect on the transfer of money through the credit channel (Bauer et al., 2023). The result was an increase in the money supply. The M3 money supply and the reduction of the deposit facility into negative territory show a strong negative correlation. An indirect conclusion can be drawn from this: the increase in the deposit facility leads to an increase in the money supply M3. The increased money supply usually increases inflation. And as the link between actual inflation and the 2% target is shown, it can be indirectly said that there is a causal link between the reduction in the deposit facility and the stable convergence of inflation towards the 2% target. The research has demonstrated a causal connection between the increasing reduction in the deposit facility into negative territory and the achievement of the strategic goal of price stability.

The hypothesis, wheather ECBs NIRP leads significantly to effective control of the inflation rate, can be clearly agreed. The NIR policy leads, among other things, significantly to effective control of the inflation rate by the ECB.

The future target of inflation of two percent, deviating from the previous "below, but close to two percent", leaves the ECB further leeway to accept temporary excesses. In this way, measures can be applied over the long term in the future.

The authors now consider these findings in the overall context of the Equation of Exchange. This provides clues about the relationship between money and goods transactions within an economy and is interpreted through quantity theory. It describes a causal dependence of the price level on the money supply.

$$M * V_Y = P * Y \tag{2}$$

While the right part of the equation (P * Y) represents the value of the goods produced (nominal gross domestic product), the left side (M * V) reflects the monetary payments required to purchase these goods/services, but taking into account the now changed velocity of circulation as a result of the tautological modification of the quantity equation, through the exchange of transactions with the real gross domestic product and the resulting disregard of financial market transactions and intermediate consumption values.

Velocity of money measures how quickly money circulates in the economy and is calculated as the ratio of nominal GDP to the money supply. It reflects the frequency with which a unit of currency is used to purchase domestically produced goods and services within a given period. The velocity of money is crucial to understanding the dynamics of inflation and economic activity.

The authors have observed and statistically proven the effectiveness of negative interest rates in the short term as well as in the long term over the entire duration of the NIRP.

Results for Post-NIRP Phase

It is undisputed that the equation of exchange applies in normal interest rate structure times in the long term. However, the authors experienced an interest rate shock from the ECB when the NIRP ended. This meant a significant increase in interest rates in a short period of time. The authors question whether the equation of exchange is also valid in the short term and in a positive interest rate structure.

There is a theory in research that unconventional monetary policy measure negative interest only works in special times and only in the short term (Ikeda et al., 2024). Therefore, the authors now examine the long-term effects of NIRP and the validity of the equation of exchange in the transition phase to the normal interest rate structure in a positive interest rate phase.

Next, we examine the previously carried out analyzes in the post-NIRP. The test for correlation between HICP and the 2% inflation target is rejected. There is no correlation in the post-NIRP, which is due to exponentially increased inflation. We then check the correlation between the M3 money supply and the deposit facility rate. Here too you have to reject it. The money supply remains relatively constant, while the deposit facility rate increases sharply from 2022 to 2024. In addition, in the spirit of the Equation of Exchange, the correlation between the money supply M3 and output Y (GDP of the Euro states) was checked. Here, too, there is no relevant statistical connection.

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Therefore, a literature analysis is now carried out in the form of a synthesis. For this purpose, relevant papers by 10 authors are analyzed. In addition, the results are supported by statistics from official bodies.

First, the core theses from the synthesis analysis are summarized:

- Negative interest rate policy has limited effectiveness compared to Quantitative Easing (QE). The necessary scale of NIRP to achieve desired economic outcomes is often impractically large.
- There are complex interactions between QE, NIRP, and Forward Guidance (FG). The simultaneous use of these tools can amplify their individual effects but also introduces new dynamics and potential unintended consequences.
- To generate the same output response, the requisite interventions for NIRP and forward guidance need to be twice as large as a conventional policy shock, indicating practical limitations.

The latter section serves as a transition to the question of whether the Equation of Exchange in the post-NIRP is valid in the short run and in the long run. Regarding NIRP there was an increasing money supply, constant price levels, constant output and falling velocity.

After the pandemic, the euro area's M1 money supply (cash in circulation and overnight bank deposits) increased by over 30% and inflation rose from 1.2% to 9.1%, reaching a peak of 10.6% in October 2022. This situation sparked a debate about the connection between the two monetary growth and inflation. Some analysts saw this as a confirmation of the quantity theory of money, while others viewed the correlation as insignificant (see Figure 1).

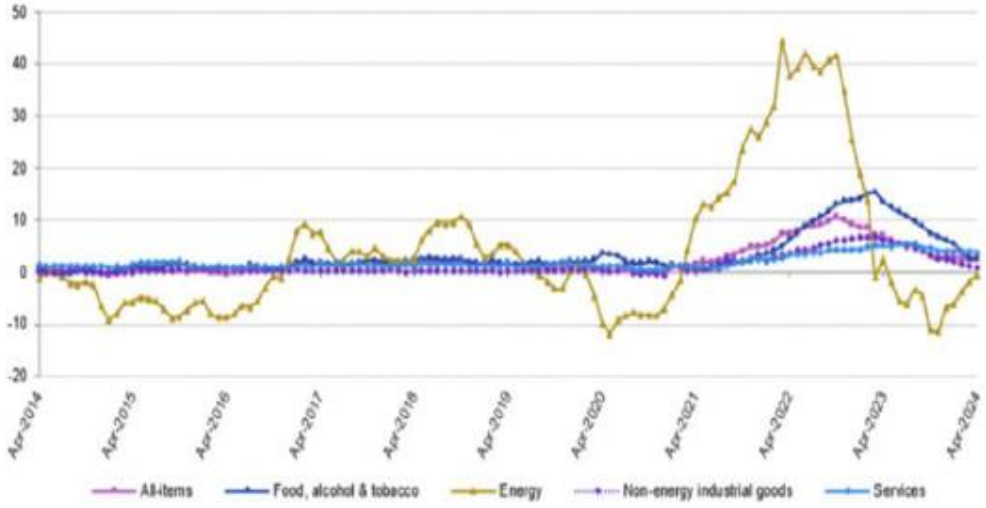

Figure 1. Euro area annual inflation and its main components – April 2014 – April 2024 (%)
Source: Own processing based on data extracted from Eurostat

We consider the role of money in explaining recent inflation in the euro area, the historical reasons why central banks have prioritized monetary analysis, and the impact of the monetary and fiscal responses to the pandemic. The discussion also highlights how the ECB's monetary tightening has supported disinflation.

The quantity theory of money postulates a long-term one-to-one relationship between money supply growth and inflation, based on long-term stable demand for real money stocks. Historically, this theory has been supported by empirical evidence showing that inflation and excess monetary growth often go hand in hand. However, this relationship weakened during periods of low and stable inflation.

Before the global financial crisis in 2008, the velocity of money remained relatively stable. This stability was due to the fact that the supply of central bank reserves was demand-driven and based on banks' cash circulation and reserve requirements. Therefore, the base money supply (M0) and the broad money supply (M3) expanded at similar rates.

However, the velocity of money began to decline measurably and sustainably after the launch of the ECB's Asset Purchase Program (APP) in 2015 and further during the pandemic when the Pandemic Emergency Purchase Program (PEPP) was introduced. This decline was due to the level of reserves being set by the Eurosystem, which resulted in reserves exceeding banks' liquidity needs.

The impact of quantitative easing on money velocity is complex. With QE, central banks buy securities and create new central bank reserves to finance these transactions. These reserves are part of the monetary base (M0), but can indirectly influence the growth of the broad money supply (M3). QE depresses long-term debt yields and stimulates credit demand and supply and economic activity. Lower interest rates make holding money relatively more attractive by reducing opportunity costs and thereby increasing the money supply M3. However, when proceeds from bond sales are used to repay loans or purchase foreign assets, the initial positive effect on the broad money supply is reversed.

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The situation has changed dramatically during the pandemic. Budget deficits soared as governments responded with large transfers to households and businesses, boosting broad money supply growth. Credit demand from businesses and households increased significantly, resulting in higher credit growth and sustained overall demand (Adelino et al., 2020). The monetary multiplier, which had previously fallen, remained stable, indicating a stronger transmission of monetary policy.

The significant money creation during the pandemic, fueled by the fiscal policy response, supported households' real disposable income and maintained aggregate demand (Dao et al., 2023). This resilience facilitated the transmission of cost shocks to consumer prices, as households were able to absorb significant price increases. The increase in liquid assets and total household wealth also contributed to sustained demand and credit growth (Dubyna, et al., 2021).

We observe a constant growth in the money supply M over the entire period of the NIRP (see *Figure 2*). At the same time, as previously researched, a constant price level and only a slightly increasing GDP remain. The velocity of circulation of money must therefore decrease. This is also what was previously described with increasing opportunity costs.

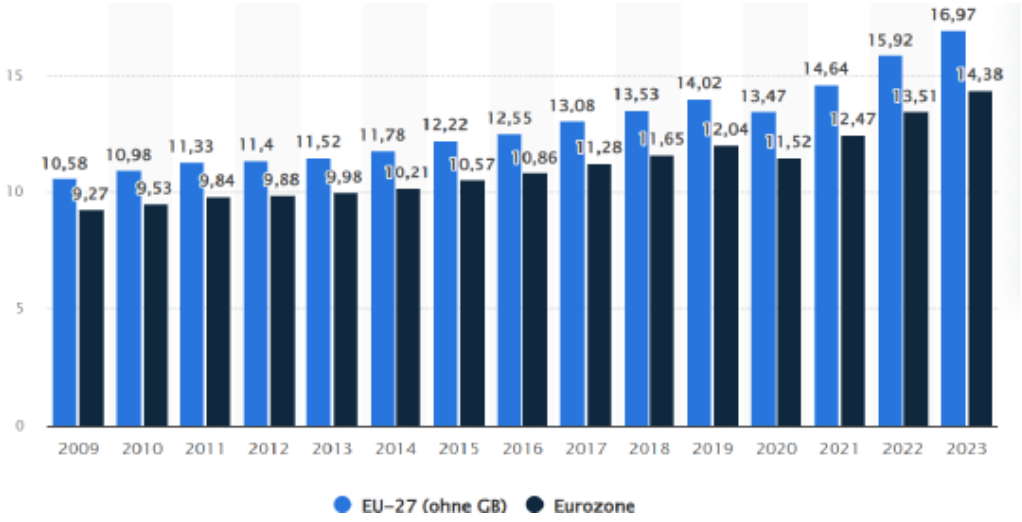

Figure 2. European Union & Eurozone: Gross domestic product (GDP) in current prices from 2009 to 2023 (billions of euros)

Source: Own processing based on data extracted from Statista 2024

Figure 3 illustrates the development of the M3 money supply in the eurozone from 1999 to November 2023, measured in billions of euros. It can be observed that the M3 money supply has steadily increased over the period, indicating a continuous expansion of liquidity in the eurozone economy.

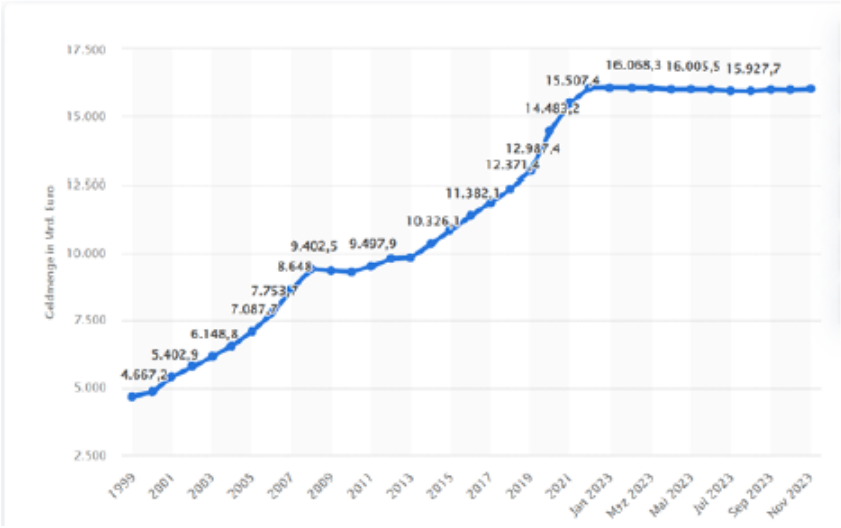

Figure 3. Development of the M3 money supply in the eurozone from 1999 to November 2023 (in billions of euros)

Source: Own processing based on data extracted from Statista 2024

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In 2022, we can observe a constant money supply M. The price level rises extremely, the output level remains relatively constant. In theory, the speed of circulation increases extremely. This also corresponds to the theory of declining opportunity costs in positive interest structure phases.

IV. Conclusion

The ECB's sharp tightening of monetary policy since July 2022, with significant interest rate increases and a reduction in the central bank's balance sheet, has had a significant impact on monetary dynamics and supported disinflation. Broad money supply (M3) growth has slowed and turned negative, while narrower money aggregates such as M1 are contracting at an unprecedented pace. This decline reflects a rebalancing of portfolios toward higher-yielding term deposits and other instruments rather than a decline in economic activity.

The velocity of money and its impact on overall money growth, economic activity and inflation are complex and state dependent. The events of the last three years have shown that monetary growth can have a significant impact on inflation, particularly in times of economic instability. While a stand-alone monetary pillar is no longer strictly necessary for the conduct of monetary policy, monetary analysis remains crucial for central banks when assessing risks to price stability.

In summary, this means that the quantity theory of money applies both in the long term and in the short term, and both during the NIRP and during positive interest rate structure phases. Based on his research, the authors reject all other hypotheses

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