European Research Studies Journal
Volume XXVII, Issue 3, 2024

pp. 69-81

The Role of Money Supply in Shaping Poland's Gross Domestic Product

Submitted 20/06/24, 1st revision 30/06/24, 2nd revision 14/07/24, accepted 24/07/24

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Abstract:

Purpose: *The main aim of this study was to evaluate changes in money supply measured by the monetary aggregate and the relationship between money supply and Poland's economic growth measured by the gross domestic product (GDP). We used the GDP measured in current prices (nominal GDP). It is proved that in the short period the money supply has an impact on GDP, but in the longer term, the money supply only has an effect on price growth. The supply of money is endogenous.*
Design/Methodology/Approach: *Data for the study were obtained from the National Bank of Poland and the Polish Financial Supervision Authority. The analyzed data covered the period from December 1996 to January 2024, which produced 326 observations. Data were analyzed using the generalized autoregressive conditional heteroskedastic (GARCH) model. The second method used in the paper was ordinary least squares (OLS) to measure the impact of M0-M3 aggregates on minimal GDP measured in current prices (nominal GDP). We used average yearly data to measure the impact of M0-M3 aggregates on GDP.*
Findings: *The study revealed increased monetary aggregates M0-M3 and the GDP. In 2023, Poland's GDP exceeded PLN 3 trillion. The analyses demonstrated a strong relationship between money supply expressed by monetary aggregates M0-M3 and Poland's GDP. The M2 aggregate had impact on GDP, what points out the significant role of government bonds. More of countries GDP in Polish and other countries' economies is caused by debt. The most liquid money, M0-M1, has the strongest but negative impact on GDP.*
Practical implications: *The study contributes important information about the role of money supply in the economy, and the presented findings can be used in the process of shaping the Central Bank's financial policy.*
Originality/Value: *The new information about changes in the aggregate supply of money and correlations with GDP*

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Keywords: *Monetary aggregates, supply changes, financial policy, GDP.*

JEL codes: *F10, F13, F17.*

Paper type: *Research article.*

Conflict of interest: *The authors declare that there is no conflict of interest regarding the publication of this manuscript.*

Acknowledgments: *The results presented in this paper were obtained as part of a comprehensive study funded by the Minister of Science under „the Regional Initiative of Excellence Program". University of Warmia and Mazury in Olsztyn, Faculty of Agriculture and Forestry, Department of Agrotechnology and Agribusiness (Grant. No 30.610.012-110).*

1. Introduction

Money supply influences the performance of national economies, the inflation rate, and other economic indicators. The economic growth of a country is determined by the total volume of money available in the economy at a given time. Money is generally in short supply, which limits a country's economic growth. The money supply is the total amount of money in circulation (Thalassinos and Stamatopoulos, 2015).

Barter was the earliest system of exchange, where goods and services were traded directly for other goods and services without the involvement of money. This system was simple, but it was often unfair and unprofitable for one of the parties. The development of commerce and services prompted the search for other means of payment that would not be susceptible to the effects of time, would be easy to transport, and could be divided into smaller units.

Over time, metals such as iron, nickel, and bronze, as well as precious metals such as gold and silver, known as bullion, became the accepted forms of payment. Bullion displaced other means of payment because it was durable, resistant to air and water, had a high value, and was divisible. Precious metals were ideally suited to serve as a means of payment.

However, bullion degrades over time and has several disadvantages, which is why coins were invented. Over the years, coins were replaced by paper money and, subsequently, by digital money.

Monetary policy significantly affects the main economic indicators, including the GDP, inflation, and unemployment (Thalassinos and Hakim, 2022. The amount and availability of money determines a country's economic performance and the

emergence of financial crises such as the global financial crisis 2008 2010 (Hsing, 2013). Monetary policy was also influenced by the COVID-19 pandemic; state authorities imposed restrictions on many sectors of the economy and provided the affected businesses with financial support. Specific channels of monetary transmission operate through the effects of Poland's monetary policy on the money market and interest rates (Kapuściński and Pietryka, 2019).

Bank operations affect the money supply. By granting loans, banks influence economic growth and the GDP. The cost of money, namely the interest rate charged by banks on the loaned money, is an important consideration (Stola, 2009; Thalassinos *et al.*, 2022). Banks borrow money from the National Bank of Poland (NBP), which controls bank operations and is responsible for the supply of money on the domestic market. Both a shortage and a surplus of money can have negative implications for the money market (Hsing and Hsieh, 2012).

Money supply and the demand for money influence the performance of all markets. Money is exchanged for goods and services on all markets. The law of supply and demand also applies to the money market. Financial crises decrease the money supply due to lower consumer spending and higher interest rates (Machaj, 2012).

The money market is considerably affected by crises. The financial crisis of 2008-2010 exerted a negative influence on the money market, and many people lost their savings. The financial giant Lehman Brothers Holdings Inc. filed for bankruptcy on 15 September 2008, which led to a crisis in the mortgage market and the market of high-risk investments prompting general panic in the stock market. Between July 2007 and February 2009, the Warsaw Stock Exchange General Index (WIG) decreased by 69%, and the S&P 500 index decreased by 57% (Hsing and Hsieh, 2012).

The problem with the supply of money and inflation has been measured in the literature. The most common approach analysis of this relationship is that changes in the money supply can cause inflation. The theoretical basis for this position is the quantitative theory of money (Jędruchniewicz, 2011). Grabia (2010) analyzed the relationship between the money supply based on Friednam's work.

According to the analysis, the initial increase in income is the effect of an increase in the money supply and is primarily related to the development of production increases, but only after 12-18 months with increasing prices. In short periods (three to ten years) changes the quantity of money mainly affected the volume of production.

In a long period over ten years, changes in the money supply have had an impact on the prices (Grabia, 2010). Ogunmuyiwa and Ekone (2010) found in Nigeria that although the supply of money is positively correlated with growth, in terms of GDP

growth rates, the result is irrelevant when choosing between a contracting or expansionary money supply.

The literature does not discuss this issue extensively, and little attention was paid to the impact of the money supply measured by aggregates M0-M3 on nominal gross domestic product (GDP) measured in current prices. The authors of the paper intended to fill in the existing gap in the literature.

2. Aim of the Study and Methodology

The study's main aim was to analyze Poland's supply of money measured by monetary aggregate M0-M3. The detailed research objectives were to:

1. Check the stationarity of the time series of monetary aggregates M0, M1, M2, and M3.
2. Determine the correlations between monetary aggregates and Poland's GDP.

Data for the analysis were obtained from the NBP and the Polish Financial Supervisory Authority. The analyzed period was December 1996 to January 2024. Monetary aggregates (M0-M3) were analyzed between December 1996 and January 2024. Poland's GDP was analyzed between 2000 and 2003. A total of 326 monthly observations of monetary aggregates M0-M3 were analyzed. The long time series supported the application of statistical models and methods.

Changes in money supply and Poland's GDP were determined with the use of generalized autoregressive conditional heteroskedastic (GARCH) models. Autoregressive conditional heteroskedastic (ARCH(p)) models were initially applied, but their main disadvantage is that high values of *p* are required for a good fit. This problem can be resolved by applying the GARCH model, which accounts for lagged conditional variances in the representation of σ 2 t. In 1986, Bollerslev proposed the GARCH model with the formula:

$$yt = \mu t + \epsilon t \, , \, \epsilon t \sim N(0, \sigma 2 \, t) \tag{1}$$

$$\sigma \, 2 \, t = \omega + \alpha 1 \epsilon \, 2 \, t-1 + \ldots + \alpha P \, \epsilon \, 2 \, t-P + \beta 1 \sigma \, 2 \, t-1 + \ldots + \beta Q \, \sigma \, 2 \, t-Q \tag{2}$$

where $\omega > 0$, $\alpha p \geq 0$ and $\beta q \geq 0$.

GARCH models are widely used to describe and predict variance as a measure of uncertainty. Conditional variance or conditional standard deviation is a measure of uncertainty in GARCH models (Fiszeder, 2009).

Another method used in the analysis was ordinary least squares (OLS). It is a linear least squares method for choosing the unknown parameters in a linear regression model using the principle of least squares. It is a very common statistical tool that

aims to measure the individual impact of selected independent variables on a dependent variable. The dependent variable was gross domestic product (GDP). The independent variables were: aggregates M0, M1, M2, and M3.

3. Results and Discussion

The total volume of money in the economy can be measured with the use of monetary aggregates M0-M3. Monetary aggregates are a key tool for economists and analysts who seek to understand and forecast changes in the economy. They cover the different types of money in circulation and play a vital role in monitoring and controlling the money supply.

Table 1. *Monetary aggregates in Poland*

M0	**M1**	**M2**	**M3**
Non-cash money from commercial banks on accounts with the central bank	Non-cash money from commercial banks on accounts with the central bank	Non-cash money from commercial banks on accounts with the central bank	Non-cash money from commercial banks on accounts with the central bank
Banknotes and coins in circulation	Banknotes and coins in circulation	Banknotes and coins in circulation	Banknotes and coins in circulation
	Current deposits with banks (available on request)	Current deposits with banks (available on request)	Current deposits with banks (available on request)
		Deposits, bank deposits, savings bank accounts with a notice period of up to 3 months, treasury bonds, deposits, and other financial instruments with a notice period of up to two years	Deposits, bank deposits, savings bank accounts with a notice period of up to 3 months, treasury bonds, deposits, and other financial instruments with a notice period of up to two years
			Savings bank accounts, treasury bonds, and other debt financial instruments with a notice period of up to and including two years
			Long-term bank deposits and other long-term funds maturing up to and including two years

Source: *National Bank of Poland.*

Understanding these concepts is essential for economists, investors, and anyone interested in the functioning of the economy (Table 1). The money supply is represented by the following aggregates (M0-M3):

- Aggregate M0 is the amount of liquid cash in circulation, including currency notes and coins held by the public and banks. Currency in circulation is the most liquid monetary aggregate because it is the most available and readily exchanged for goods and services (Stola, 2009).
- Aggregate M1 includes both currency in circulation and demand deposits in banks. Demand deposits are bank accounts where clients hold their money. These deposits are also highly liquid because money can be withdrawn at any time. Aggregate M1 is a broader aggregate than M0 because it includes money deposited in banks.
- Aggregate M2 is a broader measure that represents aggregate M1 and other financial instruments with higher liquidity than demand deposits. Aggregate M2 includes savings accounts in banks, government bonds, and other debt instruments. These instruments are less liquid than cash and demand deposits, but they can be easily converted to cash.
- Aggregate M3 is the broadest measure of money supply that combines monetary aggregates M0, M1, and M2, as well as other less liquid financial instruments, such as long-term deposits and other long-term assets. M3 is the broadest monetary aggregate that covers most types of money and marketable liabilities https://mfiles.pl/pl/index.php/Agregaty_pieni%C4%99%C5%BCne).

The value of all aggregates increased between December 1996 and January 2024 (Figure 1). The value of aggregate M0 decreased from PLN 423,947.1 million in September 2021 to PLN 390,496.3 million in October 2021. The value of aggregate M1 decreased from PLN 1,584,060.8 in September 2022 to PLN 1,570,605.5 in November 2022.

The value of aggregates M0 and M1 decreased as a consequence of the COVID-19 pandemic which had a detrimental impact on the Polish economy and the world economy. It also points out negative impact of war in Ukraine.

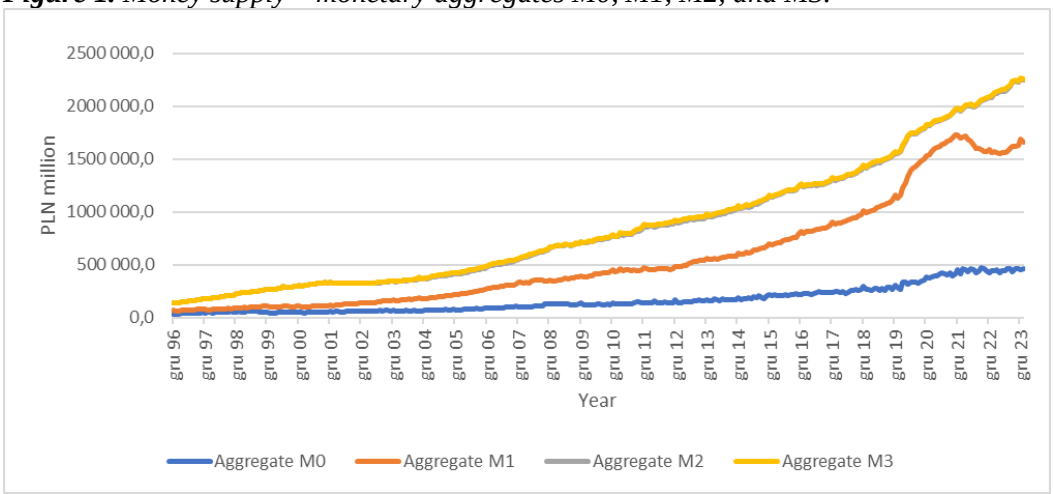
The value of money increased between December 1996 and January 2024. This increase reached 410% for aggregate M0, 2436% for aggregate M1, 1602.8% for aggregate M2, and 1607.4% for aggregate M3 (Figure 1).

The descriptive statistics for monetary aggregates M0, M1, M2, and M3 are presented in Table 1. The analysis covered the period from December 1996 to January 2024, which produced a total of 326 monthly observations.

As shown in Table 2, the highest coefficient of variation was noted for aggregate M1 (0.88191), followed by aggregates M0 (0.75019), M2 (0.68160), and M3 (0.67779).

Aggregates M0 and M1 were also characterized by the highest positive value of skewness. Kurtosis was negative for aggregates (M1-M3).

Figure 1. *Money supply – monetary aggregates M0, M1, M2, and M3.*



Source: *Own elaboration based on data obtained from the National Bank of Poland.*

Table 1. *Descriptive statistics for the analyzed time series (mln PLN) (1996/12 – 2024/01)*

Variable	Mean	Median	Minimum	Maximum	Standard deviation	Coefficient of variation	Skewness	Kurtosis
Aggregate M0	164515.5	126 235.1	32 391.1	473 697.9	131 536.3	0.75019	1.1128	0,1748
Aggregate M1	564461.5	414 885.3	63 663.0	1 726 455. 3	497 800.0	0.88191	1.0646	-0.0604
Aggregate M2	864 300.5	735 385.4	138 755.5	2 259 343.5	589 110.5	0.68160	0.7516	-0.5246
Aggregate M3	873 241.5	743 020.5	139 333.9	2 268 269.3	591 880.5	0.67779	0.7358	-0.5416

Source: *Own elaboration based on data obtained from the National Bank of Poland.*

GARCH models are widely used to evaluate the volatility of financial instruments. These models support empirical analyses of financial time series. GRACH models can be also easily extended, and their parameters are easy to estimate (Fiszeder, 2009).

The GARCH model for dependent variable M0 is estimated in Table 2. The *p*-value was below 0.05 for all modeled parameters, which implies that the model is statistically significant.

The GARCH model for 326 monthly observations of aggregate M1 is shown in Table 3. The *p*-value was below 0.05 for the constant and alpha(1), which indicates that the model is statistically significant.

Table 2. *Estimation of the GARCH model for the dependent variable (Y): aggregate M0 in the analyzed time series (1996/12 – 2024/01) (N = 326)*

	Coefficient	*Std. error*	*z-statistic*	*p-value*	
Const	124736	1089.42	114.5	<0.0001	***
alpha(0)	9.50121e+06	5.65682e+06	1.680	0.0930	*
alpha(1)	0.560870	0.151272	3.708	0.0002	***
beta(1)	0.439130	0.144838	3.032	0.0024	***

Mean dependent var.	164151.7	SD dependent var.	123145.4
Log likelihood	−4043.656	Akaike info criterion	8097.312
Schwarz criterion	8116.246	Hannan-Quinn crit.	8104.868

Notes: *Standard errors were obtained from the Hessian matrix.*
Unconditional variance of the error term = 3.1655e+019
Source: *Own elaboration based on data obtained from the National Bank of Poland.*

Table 3. *Estimation of the GARCH model for the dependent variable (Y): aggregate M1 in the analyzed time series (1996/12 – 2024/01) (N = 326)*

	Coefficient	*Std. error*	*z-statistic*	*p-value*	
Const	351186	2915.43	120.5	<0.0001	***
alpha(0)	2.80991e+07	1.94801e+07	1.442	0.1492	
alpha(1)	0.924793	0.235583	3.926	<0.0001	***
beta(1)	0.0752072	0.223603	0.3363	0.7366	

Mean dependent var.	564455.8	SD dependent var.	497797.1
Log likelihood	−4470.177	Akaike info criterion	8950.354
Schwarz criterion	8969.288	Hannan-Quinn crit.	8957.910

Notes: *Unconditional variance of the error term = 2.5734e+020*
Standard errors were obtained from the Hessian matrix.
Source: *Own elaboration based on data obtained from the National Bank of Poland.*

The GARCH model for dependent variable M2 is shown in Table 4. The *p*-value was below 0.05 for the constant and alpha(1), which indicates that the model is statistically significant.

Table 4. *Estimation of the GARCH model for the dependent variable (Y): aggregate M2 in the analyzed time series (1996/12 – 2024/01) (N = 326)*

	Coefficient	*Std. error*	*z-statistic*	*p-value*	
Const	681151	5429.72	125.4	<0.0001	***
alpha(0)	4.22966e+07	3.43461e+07	1.231	0.2181	
alpha(1)	0.978502	0.414773	2.359	0.0183	**

beta(1)	0.0214983	0.402143	0.05346	0.9574	

Mean dependent var.	864304.3	SD dependent var.	589112.3
Log likelihood	−4604.157	Akaike info criterion	9218.314
Schwarz criterion	9237.248	Hannan-Quinn crit.	9225.870

Notes: *Standard errors were obtained from the Hessian matrix.*
Unconditional variance of the error term = 3.38644e+023
Source: *Own elaboration based on data obtained from the National Bank of Poland.*

The GARCH model for variable M3 is shown in Table 5. The *p*-value was below 0.05 for parameter alpha(1).

Table 5. *Estimation of the GARCH model for the dependent variable (Y): aggregate M3 in the analyzed time series (1996/12 – 2024/01) (N = 326)*

	Coefficient	*Std. error*	*z-statistic*	*p-value*	
alpha(0)	1.28683e+09	8.86535e+09	0.1452	0.8846	
alpha(1)	0.999998	0.0957258	10.45	<0.0001	***
beta(1)	2.11902e-06	0.0303886	6.973e-005	0.9999	

Mean dependent var.	873239.6	SD dependent var.	591876.3
Log likelihood	−4840.274	Akaike info criterion	9688.547
Schwarz criterion	9703.695	Hannan-Quinn crit.	9694.592

Notes: *Standard errors were obtained from the Hessian matrix.*
Unconditional variance of the error term = 3.8611e+020
Source: *Own elaboration based on data obtained from the National Bank of Poland.*

The GDP is measured by the sum of consumption, investment, net exports, and government spending. GDP data are easier to understand when presented in the domestic currency because they are not burdened by exchange rate fluctuations.

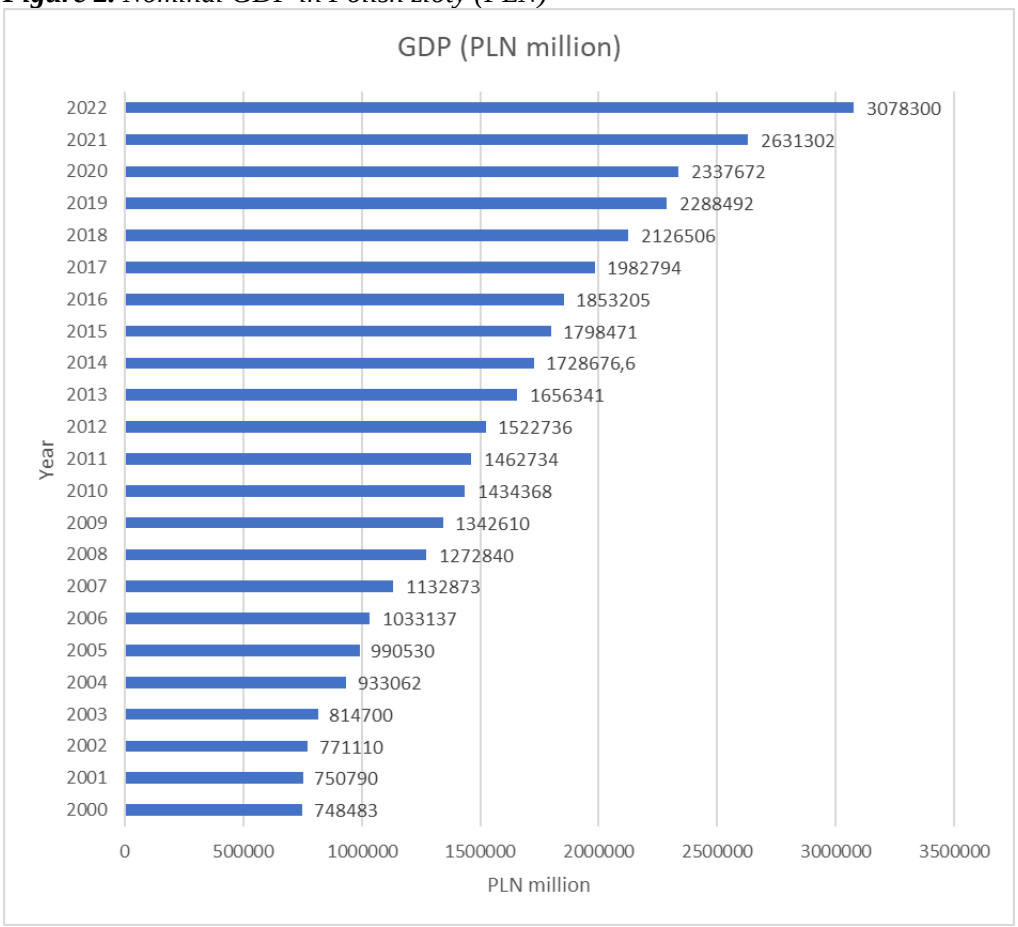
The Polish economy grew most rapidly in recent years, and the GDP exceeded PLN 3 trillion in 2022. These data indicate that Poland's economic output increased significantly in the analyzed period (Figure 2).

Money is a factor that impacts parts of the GDP such as: investment, consumption, net export and government spendings because its access determines theirs state. However, money is external to the GDP and has an indirect impact. Poland's GDP was strongly correlated with monetary aggregates M0-M3.

The value of Pearson's correlation coefficient describing the relationship between Poland's GDP (in PLN million) and monetary aggregates (in PLN million) reached 0.9745 for M0, 0.9665 for M1, 0.9903 for M2, and 0.9906 for M3.

The influence of monetary aggregates M0-M3 on Poland's GDP was evaluated with the use of a multiple regression model with the ordinary least squares (OLS) method. The analysis revealed that variable M1 exerted the greatest influence on Poland's GDP (Table 7). The coefficient of determination (R^2) reached 0.984292, indicating that the model fits well.

Figure 2. *Nominal GDP in Polish zloty (PLN)*



Source: *Own elaboration based on Statistics Poland data*.

The changes in money supply, exchange rate, and inflation were measured by Bukowski and Bukowska (2017). The authors found that the change in the M3 money supply resulted in a first decrease in the GDP growth rate in the second quarter and then a relatively small increase in the fifth quarter of 2008-2016.

The authors found that the impulse in the form of a change in the M3 aggregate was quite weak. The changes in interest rate and exchange rate had a stronger impact on GDP. Changes in the interest rate resulted in an increase in GDP in the first quarter.

It is difficult to explain the negative impact of aggregate M1 on GDP in Poland. The GDP was measured in real prices (nominal GDP). The most liquid money may have negative impact because it increases the shadow of the economy (grey market).

Operating the most liquid money encourages to buy product without invoice and not paying taxes for government. This sector should be shut down as soon as possible.

Table 7. *Estimation of the OLS regression model for 2000-2023 (N = 24) Dependent variable (Y): GDP in PLN million*

	Coefficient	*Std. error*	*t-statistic*	*p-value*	
Const	277864	65585.2	4.2370	0.0004	***
M0 (PLN million)	1.49783	2.06056	0.7269	0.4761	
M1 (PLN million)	−0.95445	0.43783	−2.1800	0.0420	**
M2 (PLN million)	1.58209	4.07598	0.3882	0.7022	
M3 (PLN million)	0.12539	3.95265	0.0317	0.9750	

Mean dependent var.	1628822	SD dependent var.	733232.8
The sum of squared resid.	1.60e+11	Residual SD	91898.18
R-squared	0.987024	Adjusted R-squared	0.984292
F(4, 19)	361.2978	F-statistic	1.23e-17
Log likelihood	−305.5336	Akaike info criterion	621.0672
Schwarz criterion	626.9575	Hannan-Quinn criterion	622.6299
Autocorrelation - rho1	0.576546	Durbin-Watson stat.	0.882353

Note: *OLS - ordinary least squares method.*
Source: *Own elaboration based on Statistics Poland data.*

Our research proved that aggregate M2 had the most significant positive and indirect impact on nominal GDP in Poland. The least liquid money, which is under control, has a positive but not strong impact on nominal GDP measured in current prices (Table 7).

The Government bonds are an important part of the M2 aggregate. They are a form of government credit. If the government bond increases, the GDP also increases. It means that the development of the economy is financed by credits. Thirty years ago, 1 dollar financed the 1 dollar growth of American gross domestic products. Nowadays, the 1 dollar GDP increase requires more than 3 dollars of debt. Similarly Polish economy imitates the behavior of the US economy and other more economically developed countries increasing its growth on credit.

4. Summary and Conclusions

This study aimed to determine the impact of the money supply, i.e., monetary aggregates M0-M3, on Poland's GDP. The study confirmed that the money supply is

correlated with Poland's GDP. The observed correlations were statistically significant.

Poland's money supply increased significantly during the period studied. The volume of monetary aggregates increased from PLN 34,196.2 million (M0), PLN 67,866.0 (M1), PLN 140,038.7 million (M2), and PLN 140,428.8 million (M3) in December 1996 to PLN 463,400.4 million (M0), PLN 1,653,213.4 million (M1), PLN 2,244,540.3 million (M2), and PLN 2,257,256.0 million (M3) in January 2024.

Between December 1996 and January 2024, aggregate M0 increased by 410%, aggregate M1 increased by 2436%, aggregate M2 increased by 1602.8%, and aggregate M3 increased by 1607.4%. These data clearly indicate that higher money supply contributed to the rapid growth of the Polish economy despite adverse events such as the global financial crisis of 2008-2010, the COVID-19 pandemic, or the war in Ukraine.

Poland's GDP increased from PLN 748,483 million in 2000 to PLN 3,078,300 million in 2023. Money supply significantly contributed to the observed increase in Poland's GDP. However the impact was indirect as monetary aggregates are external source of financing consumption, investment, net export and government spending.

The correlation analysis revealed a positive correlation between Poland's GDP and monetary aggregates M0-M3, which indicates that GDP growth was driven by the examined aggregates. The monetary aggregate that exerted the greatest influence on GDP measured in domestic currency (PLN million) was identified using the OLS method. It was found that aggregate M1 had the strongest impact on GDP, although the regression coefficient assumed a negative value.

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