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MONEY SUPPLY AND INFLATION IN THE EURO AREA

Bachelor's thesis
Programme Applied Economics

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I hereby declare that I have compiled the thesis independently
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has not been previously presented for grading.
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ABSTRACT

This thesis explores recent dynamics of inflation and the relationship of inflation and the money growth in the euro area. A long-standing economic stagnation and low inflation have become a new reality of Europe. Different monetary approaches have been used to boost the market growth and increase inflation to its inflation target, but to no avail.

A number of scientists make an attempt to explain the reasons of this phenomenon. Two hypotheses have been chosen based on the previous research.

Hypothesis 1: There is a strong positive correlation between inflation and the growth rate of the money supply;

Hypothesis 2: Money growth affects the inflation rate indirectly by increasing the effect of labour force bargaining power on inflation.

A time-series data apprloach and Ordinary Least Squares (OLS) regression have been employed in the research. The results of the analysis do no support the propositions and make it possible to conclude that the effect of the money growth on inflation has disappeared. Oil price changes, the growth of imports and other monetary and fiscal factors appear to have a much stronger impact on inflation, thus reducing the influence of the money supply (MS) on the inflation rates. Therefore, further research is necessary.

The present paper might be of interest both to professionals and not professionals who are involved in the problem of economics.

Keywords: Inflation dynamics, money supply, wage share, euro area, determinants of inflation, Quantitative Easing, OLS.

INTRODUCTION

The present thesis is an attempt to study the recent trends in inflation in the euro area. Inflation is the "loss in purchasing power of a currency unit such as the dollar, usually expressed as a general rise in the prices of goods and services" (The Library of Economics and Liberty)[1].

The choice of the subject for research has been dictated by its topicality. Low inflation hit the euro area economy following the Great Recession (2007-2009), and, since then, in spite of the efforts of the European Central Bank (ECB) and the central banks of the Member States to provide the inflation rate stability, Europe's economic growth remains depressed, and the inflation rate is still significantly below the European two-per cent inflation target (ECB *The definition of*... 2021).

The aim of the thesis is to investigate what some of the reasons for low inflation in the euro area might be.

The tasks set in the paper have determined its structure. It consists of three sections and a conclusion. Section One gives a short survey of the theory of inflation, describes the ECB actions during the economic crises of 2007-2009 (The Great Recession), 2008-2012 (the European Sovereign Debt Crisis) and 2020-nowadays (the Covid-19 Recession), and their influence on the MS. Section Two gives an overview of the data used for the model and describes empirical methods employed during the analysis. Section Three examines two hypotheses, which are as follows:

Hypothesis 1: There is a strong positive correlation between inflation and the growth rate of the money supply;

Hypothesis 2: Money growth affects the inflation rate indirectly by increasing the effect of labour force bargaining power on inflation.

[1] https://www.econlib.org/library/Topics/HighSchool/Inflation.html

Hypothesis 1 is based on the monetarist theory of Milton Friedman (1970, 24), who claimed that inflation is purely a monetary creation. Hypothesis 2 is suggested by Hung and Thompson (2016) that the effect of MS increase on inflation is mediated by working-class power.

The sample period covers 1999Q4-2019Q4 and includes periods of recessions and prosperities. However, 2020 is not added to the sample, as the reasons of this crisis differ from the previous financial crises, thus making the consequences of this recession more unpredictable.

The primary data sources are the Organisation for Economic Co-operation and Development (OECD) and ECB databases. Quantitative research methods have been used throughout the paper. The conclusion summarises the results of the research. A list of references and 19 appendices complete the thesis.

1. THEORY OF INFLATION

The section is divided into three subsections. The first subsection analyses some of the causes of inflation fluctuations. The second subsection describes the ECB actions during crises. The third subsection deals with monetary and fiscal determinants of inflation and suggests possible reasons for low inflation in the euro area for the last decade.

1.1. Causes of inflation fluctuations.

There is a well-known inverse relationship between inflation and unemployment, which was first pointed out by Irving Fisher (1926). He described a noticeably high correlation between price changes and unemployment rates in the US. The idea behind this phenomenon is the following: when the price level is rising, companies find their nominal revenues increasing in the short run due to the general rise of prices. However, the expenses do not react to the price changes at the same pace, as some of the firm's costs might be contractually fixed, such as interest rates for debt obligations; or rents or salaries – the last are usually fixed for several months or years. As the revenue shows quicker changes than expenses, the business can enjoy its higher profits and decide to employ more people. Hence, employment is stimulated – for a while (Fisher 1926).

By contrast, when the price levels downfall, nominal revenues react to the changes at the same pace as usual – they immediately plunge. Expenses, however, need time to adopt for the reasons mentioned above. So, as profits decline, companies have nothing more to do than reduce costs, whether by using less labour or ending production and going bankrupt (*Ibid.*).

In his report, Fisher (1926) concluded that unemployment could be substantially prevented by controlling inflation. Government can use contractionary fiscal policies such as tax increases or government spending cuts in the boom period. That way, aggregate demand decreases, and an inflationary impact on the economy declines decreasing unemployment. The contrary actions should be taken during recessions: tax rates should be decreased, government spending should rise to stimulate aggregate demand. Inflation starts growing, and unemployment reduces (Keynes 1936).

Nowadays, the reversed relation between inflation and unemployment is known as the Phillips curve, named after William Phillips (1958), who observed almost a century of British data and found the same patterns described above. The curve has faced many transformations, so as to adapt to new realities, but the relation is still observed even today (Banbura, Bobeica 2020; Gagnon, Collins 2019; Mazumder 2018).

Many scientists criticised the Phillips curve. Friedman (1963; Friedman, Schwartz 2008) claimed that the Phillips curve could explain unemployment-inflation relation only in the short run. In the long run, unemployment always returns to its natural rate, which is named as a non-accelerating inflation rate of unemployment (NAIRU). As long-run unemployment equals to its NAIRU rates, the Phillips curve is no more a curve but a straight vertical line (Friedman 1963).

Milton Fridman (1970, 24) claimed that inflation is purely a monetary creation. The Quantity Theory of Money (QTM) first introduced by Fisher (1911) and then developed by Friedman's researches states that according to the formula, $M \times V = Y \times P$, keeping velocity (V) and the national income in the constant prices (Y) constant, if the money growth changes, the price level would change in the same direction. Federal Reserve Bank defines the velocity of money as "the frequency at which one unit of currency is used to purchase domestically- produced goods and services within a given time period"[2].

Still, Fisher (1926) concluded that the high or low price levels do not affect employment, but the rapid changes in the price levels do. If the price level is stable for an extended period, then there is no cause for inflation and employment changes. However, as soon as the price levels start growing or sinking, the inflation or deflation phenomenon appears, which impacts employment (Fisher 1926).

1.2. The European union during recent crises

The European Union faced three significant crises during the last 14 years, which are the Great Recession (2007-2009), the European Sovereign Debt Crisis (2008-2012) and the Covid-19 Recession (2020-nowadays). Figure 1 represents the dynamics of the EU Gross Domestic Product (GDP) growth, inflation and unemployment rates at the 2000-2020 timeframe. Recovered from the Dot Com Bubble (2000-2002), the EU economy showed signs of prosperity. The inflation rates

[2] https://fred.stlouisfed.org/series/M2V

were stable; the GDP growth showed positive results over 3% of annual growth at its peak in 2006-2007. Unemployment was declining as the economy was booming, and firms needed more labour to maintain the growth.

Figure 1. GDP growth, inflation and unemployment in the EU, 2000-2019
Source: The World Bank database. Prepared by the author from the data in appendix 1.

It was not long before the market found itself in the midst of a crisis. Firstly, the Great Recession started in the US and spread globally, severely affecting the EU economy (EP 2019). The GDP growth rate went down, showing -4% at the trough. Unemployment increased, and inflation declined. However, according to the Phillips curve, the economy should have shown much deeper deflation (Gagnon, Collins 2019). The competence of the Phillips empirical regularity was questioned one more time.

The deflation puzzle during the Great Recession was actively studied, and according to recent research, the Phillips curve exists in the modern European economy but with appropriate changes and specificities (Banbura, Bobeica 2020; Gagnon, Collins 2019; Mazumder 2018; Ball, Mazumder 2020). It is a big challenge to find a suitable model for the research. For example, Gagnon and Collins (2019) concluded that the Phillips curve could still be used to forecast inflation, but since the 1990s, the prevailing versions of the curve have failed to do so. Mazumder (2018), in his work about inflation in Europe after the Great Recession, mentioned that while using adaptive expectations of inflation, then the Phillips curve does not explain euro area inflation

dynamics. However, the model performs much better if, instead of adaptive expectations, to use forecasts from the ECB's Survey of Professional Forecasters (Mazumder 2018). The conclusion proves that there are still possibilities to use a Phillips curve model, but finding a suitable model and correct variables is challenging.

While every Member State felt the impact of the crisis, its spread was unequal. One adverse effect of the crisis was a reduction of interbank lending and the closing of credit lines, which are especially valuable during deep recessions, as firms need liquidity to bail out their businesses. Another effect was price reductions for assets, which decreases population wealth, and as a result, investment downfalls and savings increase. Also, unemployment grew, affecting mostly construction, manufacturing and utility sectors (EP 2019).

The Sovereign Debt Crisis was triggered by the previous financial crisis, as the Member States run up an enormous debt to save their economies from the previous recession. Countries started showing signs of default as soon as the yields demanded by investors for the high risk became unaffordable. The first country to suffer was Greece in 2009, which triggered similar reactions in other countries like Spain, Ireland, Portugal and Cyprus. The consequences of the two crises were catastrophic, and the recovery was slow. There was a high risk of deflation and economic stagnation, and it took five years for the EU to return to its before-crisis results (*Ibid.*)

The ECB faced a real challenge after the second crisis. Economies were under pressure, there was a deflation risk, and central banks were operating near a zero lower bound (ZLB). Traditional recovery tools were fully deployed, and still, the economy was not responding (Valiante 2017; Hohberger *et al.* 2019). The ECB had little option but to establish the Asset Purchase Programme (APP) or, in other words, the quantitative easing QE. The programme started in March 2015, and the monthly purchase pace was €60 billion. That pace lasted for a year, and from April 2016, monthly purchases increased to €80 billion. Later the ECB decided to reduce its purchases, first back to €60 billion till December 2017, then to €30 billion from January 2018 till September 2018, and at the end to €15 billion till December 2018, whereas the maturing bonds were still reinvested (ECB, *Asset purchase programme* 2021).

The Covid-19 crisis that started in spring 2020 is different from other crises. Even if banks were much better prepared, having a higher level of capital and liquidity, economic stress was still overwhelming (Altavilla *et al.* 2020). The effect of the crisis can be seen from Figure 1, where the EU GDP showed a negative growth of -6% – the deepest plunge of the 21st century. The ECB

showed a quick reaction, reducing bank collaterals, so in that way, commercial banks could have more liquidity to face the demand of loans from the market. New refinancing operations were introduced, namely pandemic emergency longer-term refinancing operations and pandemic emergency purchase programme. The older programmes like the APP and targeted longer-term refinancing operations (TLTROs) were also implemented, increasing liquidity and flooding countries' economies with money. Only under the TLTRO III programme in June 2020, EUR 1.3 billion was borrowed by banks (Altavilla *et al.* 2020).

The aggressive money inflow during the last five years could not happen without any impact on economies. The ECB bought government bonds from central and commercial banks, and banks used available cash to buy equity and foreign assets and provide loans to households and firms. Collateral requirements were also reduced, forcing commercial banks to borrow even more from their central banks and lend to firms. Besides, as interest rates were near the ZLB, the ECB purchase programmes encourage private investors to reallocate their capital from local bonds to equities or foreign bonds. As a consequence of these actions, cash started outflowing and foreign currency (mainly USD) appreciated with respect to euro, boosting European exports as goods became cheaper to foreign customers (Hohberger *et al.* 2019).

The APP is a new phenomenon for Europe, and its effects on the economy should be thoroughly examined. Still, there is empirical evidence that QE is a strong lever during crises as it showed the ability to calm markets (Valiante 2017) and give firms liquidity to keep employment (Altavilla *et al.* 2020), hence reducing the adverse effects of downturns. Besides, QE decreased bond yields (Valiante 2017; Hohberger *et al.* 2019), so the ECB should be cautious and not use QE when there are no severe market pressures.

1.3. Monetary and fiscal determinants of inflation

Understanding inflation determinants is crucial, as it gives an insight into the inter-relationship between inflation and economic factors. This knowledge and appropriate actions can help policymakers stabilise inflation at its target rates (Lim, Sek 2015).

After observing 14 years of the European economy, we see a significant trend: even if the amount of money in the economy surged, the APP and refinancing operations had a minor effect on inflation and GDP growth (Valiante 2017; Hohberger *et al.* 2019).

The observation of the weak short-run relation between the MS and inflation is not unique. During the Great Recession, the US and EU increased fiscal and monetary stimuli to stop the deep fall of their economies. These actions could have brought the largest economies to hyperinflation (Ferguson 2011, Weale 2013 cited by Hung and Thompson 2016). However, no signs of severe inflation occurred. The EU inflation even showed near-zero results during 2014-2016 (see Figure 1) and was persistently below the ECB target of 2%. While observing this pattern, Hung and Thompson (2016) studied other determinants of inflation that might have a more significant influence than the MS. They conducted research using cross-section data for 23 OECD countries from the 1960-2009 period and concluded that labour and capital power distributions could better explain inflation dynamics than monetary and fiscal policies. Strong labour unions force capital to steadily increase wages, which in turn increase price levels. However, if labour unions are weak, workers' salaries show slow or no growth, which weakens inflation (Hung, Thompson 2016).

Another reason why the QE programmes have a low impact on inflation is the decreasing velocity of money. For example, only in July 2020, the M3 annual growth rate showed 10.2%, which is more than two times higher than usual due to the crisis's policy reactions (ECB 2020). Still, inflation has not become higher. There might be many reasons for this phenomenon, like the one that inflation needs time to adapt. In their research, Hung and Thompson (2016) concluded that inflation shows a better response to the MS changes only after a year. In other words, Europe will eventually face higher inflation, but some time should pass.

Alternatively, another idea is that the consumption basket during the pandemic has changed, so the inflation rates should be measured differently (Cavallo 2020). However, Dreger and Wolters (2009) explain low inflation in the euro area as a consequence of a reduction of velocity. Figure 2 shows the dynamics of the velocity of M2 money stock in the US from the Federal Reserve Economic Database (FRED). The US data are an example of a global trend in the developed world; thus, the trend is topical to the European market.

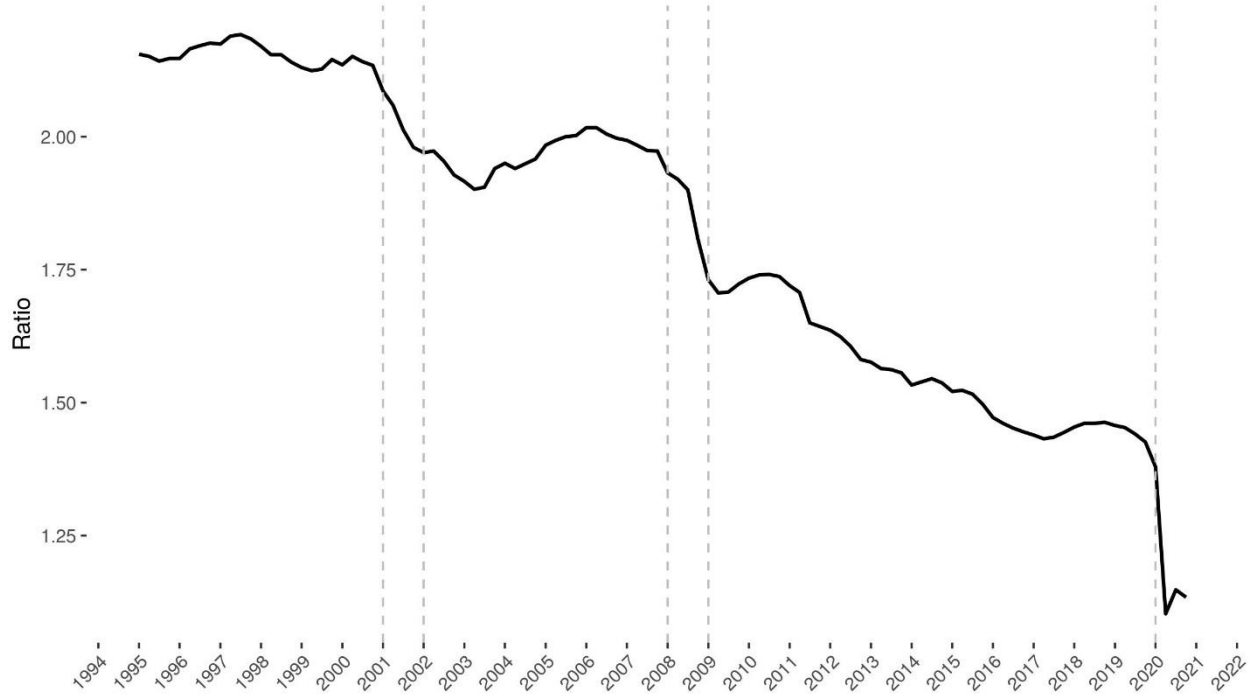

Figure 2. The velocity of M2 Money Stock in the US, 1994-2021
Source: The Federal Reserve Economic Data database. Prepared by the author from the data in Appendix 2.

There is a visible downtrend of velocity for the US, which should not be a unique phenomenon and should have the exact representations in other developed countries of the globe. The grey dashed lines show periods of global recessions (Dot-Com bubble, the Great Recession, the Covid-19 crisis). The end of the last crisis is unknown. The graph demonstrates that the velocity of money has been moving down, showing deep plunges during crises. However, it does not increase even during more stable times such as 2012-2019. As we see from Figure 2, velocity showed a strong downtrend during 2012-2019.

One of the reasons for such dynamics is asset price inflation. Equities have been showing high growth, provoking investors to bring more money to the market and keep it there, promising high yields. Inflation in assets was also spurred by QE programmes which decreased bond yields and made investors search for riskier assets (Valiante 2017, Hohberger *et al.* 2019). Another reason for low velocity is that companies and people are unwilling to spend during unstable times and prefer to keep money safe until a situation stabilises. Therefore, deep plunges during crises occur. Even though there might be other reasons for the downfall of velocity, the consequence of this trend on inflation should come from the QTM formula, $M \times V = Y \times P$. If M shows high growth and V

represents a deep decline, then that might be why the average price of all goods (P) is not reacting to the changes in the money inflow, thus keeping inflation low.

Another factor that should evoke reactions but seems to have lost its influence on inflation is the interest rate. As there is an inverse relationship between interest rates and inflation, if nominal interest rates are low, more people are willing to use credit to consume, and fewer people would like to keep their money deposited, as it does not bring enough yield. Consequently, more money comes to economies due to cheap loans, which trigger price increases, causing inflation. However, although Europe has been operating near the ZLB for several years already, inflation still does not seem to change, showing the aggregated average annual result of 0.575% in 2020, while expected inflation in two years is 1.4% (ECB *HICP Inflation forecasts* 2021).

One of the reasons for low interest rates and low inflation are zombie firms and zombie credit. In their research, Acharya *et al.* (2020) state that one of the harmful effects of the ZLB is that more companies are operating with high leverage. Researchers identify zombie firms as those that a) show interest coverage ratio below the country-sector median, b) show leverage ratio above the country-sector median. A critical feature of these firms is that they would not exist without cheap credit as they are less competitive than the rest of the market. The authors of the work suggest that without cheap loans starting from 2012, the EU would have annual inflation higher by 0.45 percentage points from 2012 to 2016 (*Ibid.*).

The ECB cannot increase interest rates as business, and even the Member States rely on cheap credit. Especially after the Sovereign Debt Crisis. Still, increased interest rates would remove uncompetitive firms from the market, which show a disinflationary effect on the economy (*Ibid.*).

The framework of the thesis does not allow to discuss all the inflation determinants, but many other factors such as oil prices, imports of goods and services (Lim, Sek 2015), de-anchoring of inflation from expectations of future inflation (Mazumder 2018) could have influence inflation in the EU and the euro area. Even if, according to the monetarist theory, inflation is mainly determined by monetary changes, the list of non-monetary determinants for inflation variations can be very long. For example, inflation behaviour can be influenced by corruption, as corrupt governments rely on inflation tax as a crucial additional revenue source (Al-Marhubi 2000). It can be influenced by fiscal deficits (Campillo, Miron 1997; Catao, Terrones 2005). Countries with high government expenses or those struggling to collect usual taxes make heavier use of the inflation tax as the additional source of revenue (Campillo, Miron 1997).

Other non-monetary determinants of inflation that have deflationary effects on the economy are economic openness and political stability (Campillo, Miron 1997), an increase in the relative number of elderly people (Lis *et al.* 2020), and a past experience of hyperinflation in developed countries. The last factor is heavily related to some EU countries such as Germany, which faced hyperinflation of its Deutsche mark, and has had low inflation ever since (Campillo, Miron 1997). To conclude, there are many controversial factors influencing inflation. Still, it seems that the latest inflation in the euro area shows low reactions to any monetary and fiscal changes. As Gagnon and Collins (2019) wrote, inflation rates should have met deflation as a response to high unemployment during the Great Recession. However, in a few years after the crisis, a new notion in Europe appeared – a "missing inflation puzzle". Due to the Sovereign Debt Crisis and Europe's QE programmes, inflation should have shown much higher rates (Acharya *et al.* 2020). Even so, we see that mid-term and long-term inflation expectations are still below the target (ECB *HICP Inflation forecasts* 2021). So, the question of whether inflation still correlates with money growth is relevant.

2. DATA AND METHODOLOGY

The data for research have been merely obtained from the OECD and ECB databases for the 1999Q4-2019Q4 period. Descriptive statistics and data visualisation are used to identify the characteristics of the samples.

2.1. Hypotheses and data description

The relationship between inflation and the MS is being examined in this paper. Therefore, the first proposition of the thesis is based on the monetarist theory of Milton Friedman and is as follows:

Hypothesis 1: There is a strong positive correlation between inflation and the growth rate of the money supply.

It includes the following variables: a) a quarterly percentage change of a consumer price index (CPI) data as a proxy for inflation; b) a quarterly broad money (M3) growth as a proxy for the MS growth. M3 consists of M2 and specific marketable instruments such as repurchase agreements, fund shares and debt securities, whereas M2 comprises M1 (currency and overnight deposits) in addition to deposits up to two years. The M3 is seasonally adjusted. In the empirical model, the inflation rate has been taken as a dependent variable.

The second proposition is based on the research of Hung and Thompson (2016), who claim that the wage push inflation is one of the main reasons for the prices changes, and even if the direct relationship between inflation and the MS could have weakened, still the money growth pushes salaries up, hence influencing inflation indirectly.

Hypothesis 2: Money growth affects the inflation rate indirectly by increasing the effect of labour force bargaining power on inflation.

An employee compensation by activity, which is a ratio of all salaries and social contributions paid by employers divided by gross value added, is used as a proxy for wage share to estimate the labour force bargaining power. The analysis includes control variables that have an impact on

inflation, according to the existing literature. For example, oil price changes, imports of goods and services (Campillo, Miron 1997; Catao, Terrones 2005) and economic growth (Hung, Thompson 2016) are expected to positively affect inflation. For this analysis, a percentage change of seasonally adjusted real GDP from a quarter earlier has been used as a proxy of economic growth. Seasonally adjusted imported value of goods for the euro area has been used as a variable of imports. Price changes of a Brent crude oil 1-month Forward free on board per barrel have been chosen as a variable of oil price changes.

A German Stock Index (DAX – Deutscher Aktienindex) has been added as a proxy of equity growth in the euro area, which the ECB's QE programmes have boosted. The growth should have stimulated investors to keep more money in equities for high returns (Valiante 2017, Hohberger *et al.* 2019). As a result, consumption and the velocity of money should have reduced, negatively affecting the inflation rates (Dreger, Wolters 2009). Still, there might be a reverse causality between inflation and equities, as a rise of the first can bring short-term revenue increases to the equity market, thus affecting the stock prices. Therefore, the gross saving rates of households as a ratio of adjusted gross disposable income have been added as an additional control variable, as with an increase of saving rates consumption and inflation downfalls.

Variables, which were in nominal terms (oil prices, total imports of goods for the euro area, and DAX values), have been transformed into a value change in per cent for every subsequent period. In addition, a cubic spline interpolation has been used for wage share to obtain a quarterly frequency, as the original data were annual. Variables have been obtained from the OECD, ECB FRED and Yahoo Finance databases. The data are quarterly for the 1999Q4-2019Q4 period, and the total number of observations for each variable is 80. See Appendices 2-10 in a Google Drive link.

2.2. Data visualisation and descriptive statistics

This subsection starts withs an overview of the data and recent trends of inflation. Figure 3 represents the average inflation rates in 2020 for the European and neighbouring countries. According to the Eurostat (Annual inflation stable… 2021) report and database, the euro area showed -0.3% and the EU 0.3% annual inflation in December 2020. The minimum rate for the EU was in Greece (-2.4%), and the maximum rate was in Poland (3.4%). All three Baltic States showed

negative inflation, where Estonia had the lowest rate of -0.9%, Latvia had -0.5% and Lithuania -0.1%.

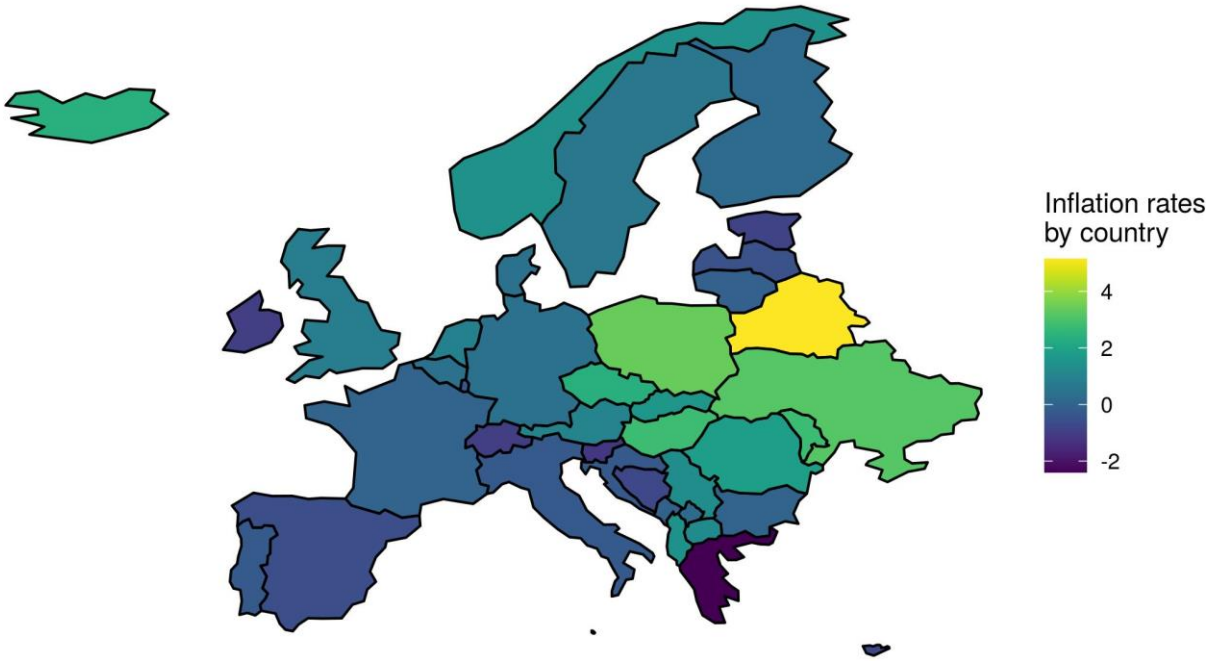

Figure 3. Inflation rates for the EU and neighbouring countries in 2020.
Source: The Eurostat database. Prepared by the author from the data in Appendix 11.

The report and the map show that the highest inflation rates were in the Member States, not in the euro area. For example, in Czech Republic, Hungary, Romania and Poland. Moreover, it shows that the Member States with their currencies are more subject to inflation than the eurozone.

In the next step, a normal distribution of the data has been studied. Figure 4 represents the quantile-quantile (QQ) plots for the MS, CPI and wage share. The QQ plot is a probability plot where the theoretical and sample quantiles have been set against each other. The black dots are the intersection points of two quantiles. The QQ graph helps to indicate whether variables have been normally distributed. It is noticeable that the intersection points of the CPI and the MS growth have been spread near the normality, but still some fluctuations occur. However, the wage share variable has a different spread. Some points are precisely on the line, and other points have been distributed below and above normality.

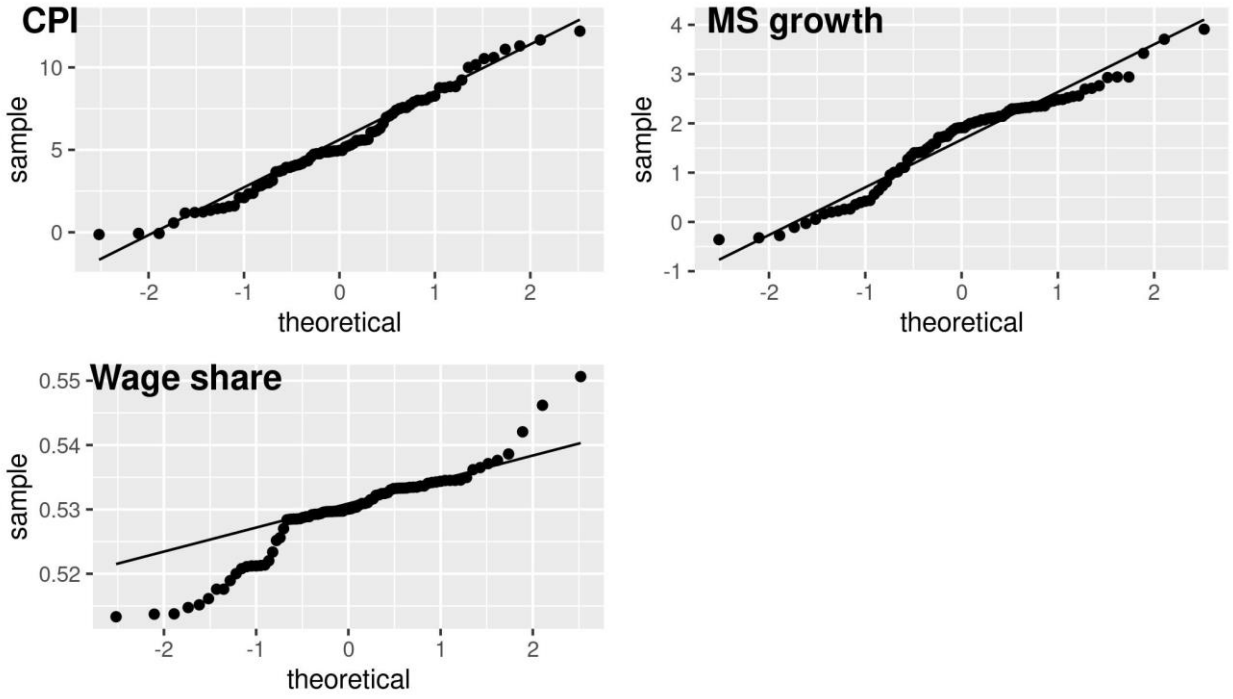

Figure 4. The QQ plot for the MS, CPI and Wage share.
Source: Data from Appendices 2-10. Prepared by the author in RStudio software.

A natural log has transformed estimated variables to reach a normal distribution. 100% and a minimum value of a sample have been added to every number before taking a natural log to avoid taking a logarithm from a negative value. The results are available in Figure 5. The QQ plots for logged variables show that the natural log had no effect on a wage share distribution but had increased fluctuations in the CPI and MS. As a result, it has been decided not to use a natural logarithm in the empirical model despite the practice of Hung and Thompson (2016), as the variables have been showing near-normal distribution without any interventions.

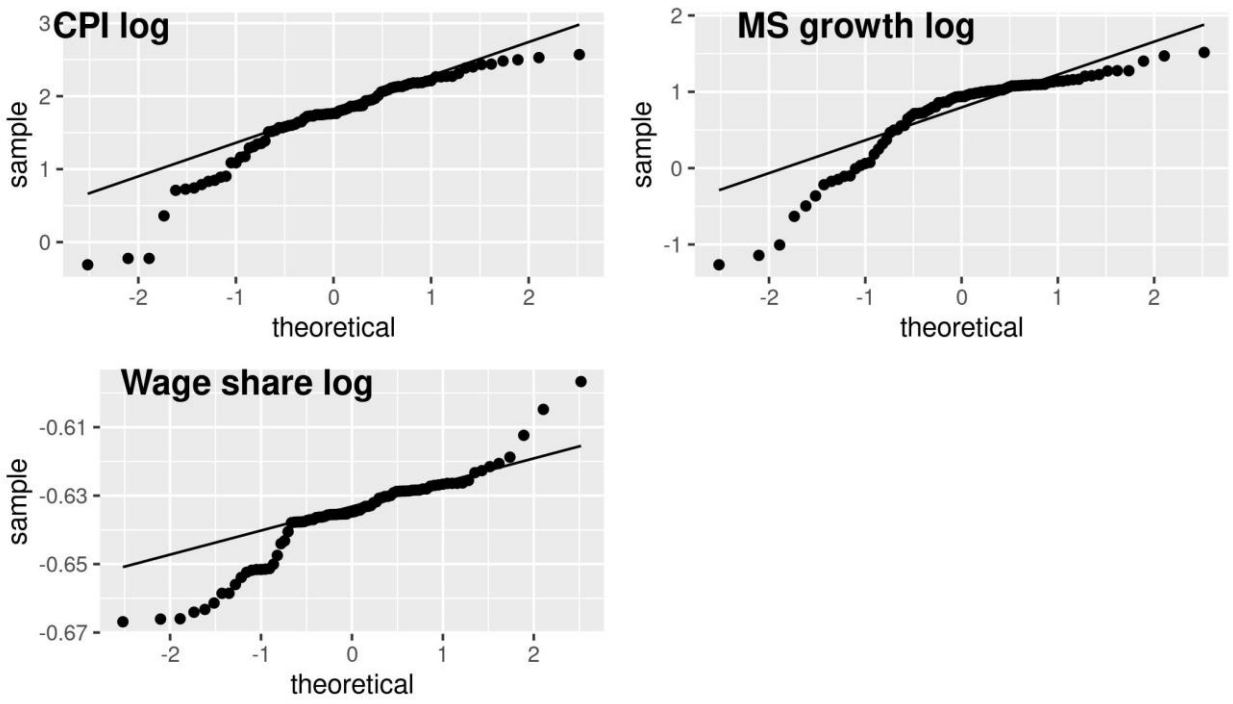

Figure 5. The QQ plot for the MS, CPI and Wage share.
Source: Data from Appendices 2-10. Prepared by the author in RStudio software.

Descriptive statistics for all variables are available in Appendix 12. The mean inflation for the euro area at the period of 1999Q4-2019Q4 was 1.674%. The maximum inflation was 3.911% and occurred in 2008Q4 during the Great Recession. The minimum value of inflation equalled -0.359% and happened in three quarters after a maximum rate. Figure 6 shows the histogram graphs for every variable used in the model. There is a left tail in the CPI data, which means that more data are distributed at the beginning of the graph. The skewness of the CPI equals -0.357 and kurtosis -0.351; thus, the CPI is left-skewed. As normally distributed data have skewness and kurtosis equal to zero, the range from -1 to 1 is near-normal. Therefore, it proves the normality of the dependent variable.

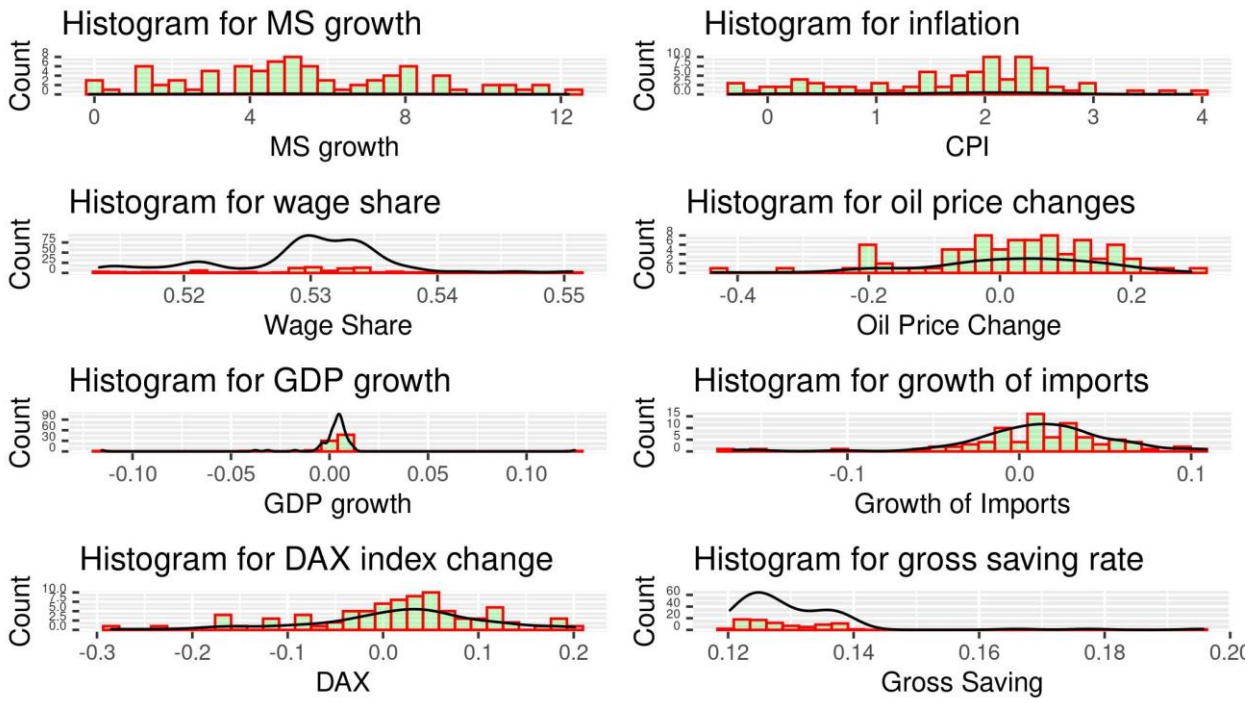

Figure 6. Histograms of variables.
Source: Data from Appendices 2-10. Prepared by the author in RStudio software.

The maximum and minimum values for the MS growth were 12.200% in 2007Q4 and -0.1333% in 2010Q1. The range is very high, and the standard deviation of the data is 2.948%. Still, the data is close to normality, as kurtosis and skewness are within the near-normal range. The median and the mean values of the sample are 4.967% and 5.373%, respectively. A smaller median than the mean value demonstrates that the MS has been positively skewed. Figure 7 shows the dynamics of the MS growth time series. Dashed lines represent periods of global recessions. Two horizontal lines are a median and a mean of the time series. It is visible that the MS showed its peak growth exactly before the Great Recession, then it was decreasing for two years and was even negative at the trough. In 2015 when the first APP programmes were initiated, the MS growth showed stable median results.

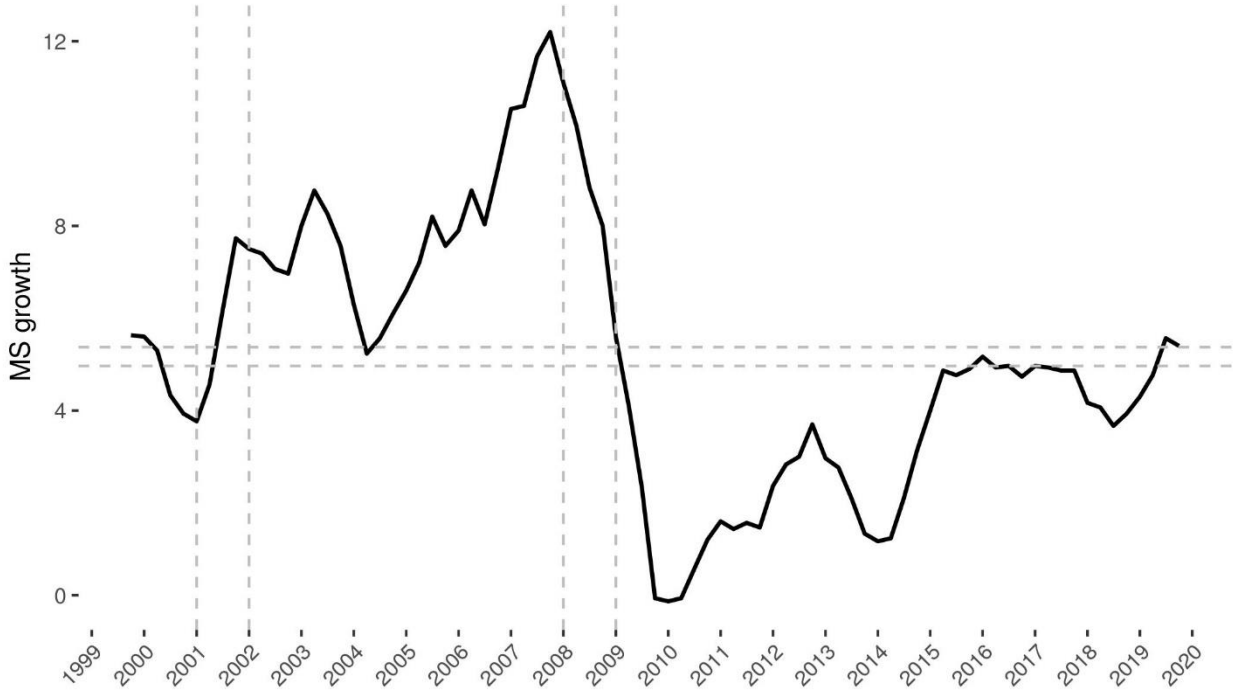

Figure 7. Dynamics of broad money M3 for the euro area, 1999-2019.
Source: Data from Appendices 2-10. Prepared by the author in RStudio software.

The wage share data have the lowest standard deviation of the sample and are near the normal distribution. The range between a maximum value (55.1%) and a minimum (51.3%) is only 3.73%, which shows that the variable has been stable throughout the estimated period.

There are three variables, whose distribution is far from normal: GDP growth, the growth of imports and the gross saving of households. All three variables are leptokurtic. In addition, the growth of imports is left-skewed, and the gross saving of households is right-skewed. The histogram graphs from Figure 6 illustrate the skewness.

2.3. Analysis methodology

A correlation and regression analyses have been used to estimate the causation among variables. Correlation measures an association between two parameters and a correlation matrix is used when more than two constants are studied. The value of the correlation coefficient ranges from -1 to 1, where the coefficient means the magnitude of the units. The value near 1 means that there is a strong positive correlation, or in other words, the pair moves monodirectional. The value near -1

means that variables move in opposite directions. The value, which equals 0, means that there is no correlation between estimators.

Regression analysis makes it possible to explain changes in one variable by the movements of other variables. Thus, it can be said that regression models deal with the estimation and description of a dependent variable through independent variables. The most straightforward relationship among parameters is linear (Gujari 2004, 5).

Pearson correlation and OLS regression in a Gretl software have been used to test the relationships among independent variables and inflation in the following model.

An OLS method minimises the sum of square differences between observed and predicted variables. A regression model has the following shape (Gujari 2004, 58-59); see formula 1:

$$Y = \alpha + \beta X + \varepsilon \quad (1)$$

where

Y is a dependent variable

α is a constant

X is a matrix of independent variables

β is a vector of regression coefficients

ε is a random variable

There are pros and cons of linear regression. It is easy to compile a model using statistical software and then to analyse results. However, a very high explanatory power obtained among variables might sign an autocorrelation in regression, which can ruin all results (Gujari 2004, 441-442). One way to detect autocorrelation is a Breusch-Godfrey test, where a null hypothesis indicates the absence of autocorrelation. The presence of autocorrelation might be caused due to a connection of the same variables in different periods or because a critical parameter is missing in the model. If a model is autocorrelated, heteroscedasticity and autocorrelation consistent (HAC) robust standard errors are used, which result in effective, unbiased and efficient estimates (Gujari 2004, 441-487).

Another problem, which might occur in a regression model, is heteroskedasticity. In this case, the model results are no longer reliable, as the model does not explain an independent variable enough. One of the reasons for heteroskedasticity is the absence of a vital variable. The detection of heteroskedasticity attempts to test whether there is a statistically significant relationship between residuals and any of the independent variables. White's test is often used for this purpose and has been employed in the regression models of the author. The null hypothesis of White's test states that the data are homoskedastic. Should heteroskedasticity be present in the regression, HAC robust standard errors are also used to run the model, providing reliable estimates in the presence of both autocorrelation and heteroskedasticity (Gujari 2004, 387-417; 484).

Multicollinearity can occur if there is a linear relationship among independent variables. The reason for multicollinearity might happen when different independent variables measure the same phenomenon. There are several ways to reduce multicollinearity: a) to remove one of the explanatory variables, which measure the same occasion; b) to aggregate similar variables; c) to increase the sample size. In order to identify multicollinearity, a Variance Inflation Factors (VIF) method can be used, where the VIF value higher than ten can indicate a presence of multicollinearity (Gujari 2004, 341-364).

A normal distribution can be tested using the Doornik-Hansen test, where the null hypothesis means that residuals of the model are normally distributed, while the alternative hypothesis indicates the opposite. If residuals obey normality, then the OLS estimators are not biased and have minimum variance. The non-normality of residuals can be caused due to influential observations, which usually occur during crises. Another reason might be the absence of a critical parameter (Gujari 2004, 109-112). The null hypothesis of the test states that residuals are normally distributed.

The non-stationarity of variables is also a problem for a regression model. Time-series variables can change their statistical properties during the observed period, making it difficult to predict them; hence, the model results can be wrong. One way to identify the non-stationarity is a unit root testing using the Augmented Dickey-Fuller (ADF) test (Gujari 2004, 817-369). If a variable is non-stationary, a first difference of the parameter can be taken and used in the regression.

One more test, which evaluates the shape of the model, is the Ramsey RESET test. The test adds squares and cubes of a dependent variable to the model and re-estimates the results. The null

hypothesis indicates that the model has a correct shape, and the alternative hypothesis means that there are missing variables in the model or the shapes of estimators are wrong (Gujari 2004, 521).

3. EMPIRICAL ANALYSIS

This section verifies the hypotheses of the paper and meets the objective of the thesis. The author analyses the results obtained and makes conclusions of the empirical research at the end of the section.

3.1 Correlation analysis

As the first step of the empirical analysis, a correlation among variables has been studied. Figure 8 represents scatterplots of the M3 growth, CPI and wage share. According to the graphs, i) a relationship between the MS and inflation is not strong; ii) a connection between the wage share and inflation in the euro area seems to be stronger than the one between the MS and inflation rate, but the graph shows a negative relation between the wage share and inflation, which looks like an anomaly and does not support the proposition of Hung and Thompson (2016). The correlation between the MS and wage share is also negative and strong. Multiple scatterplots for all variables used in the model are available in Figure 9.

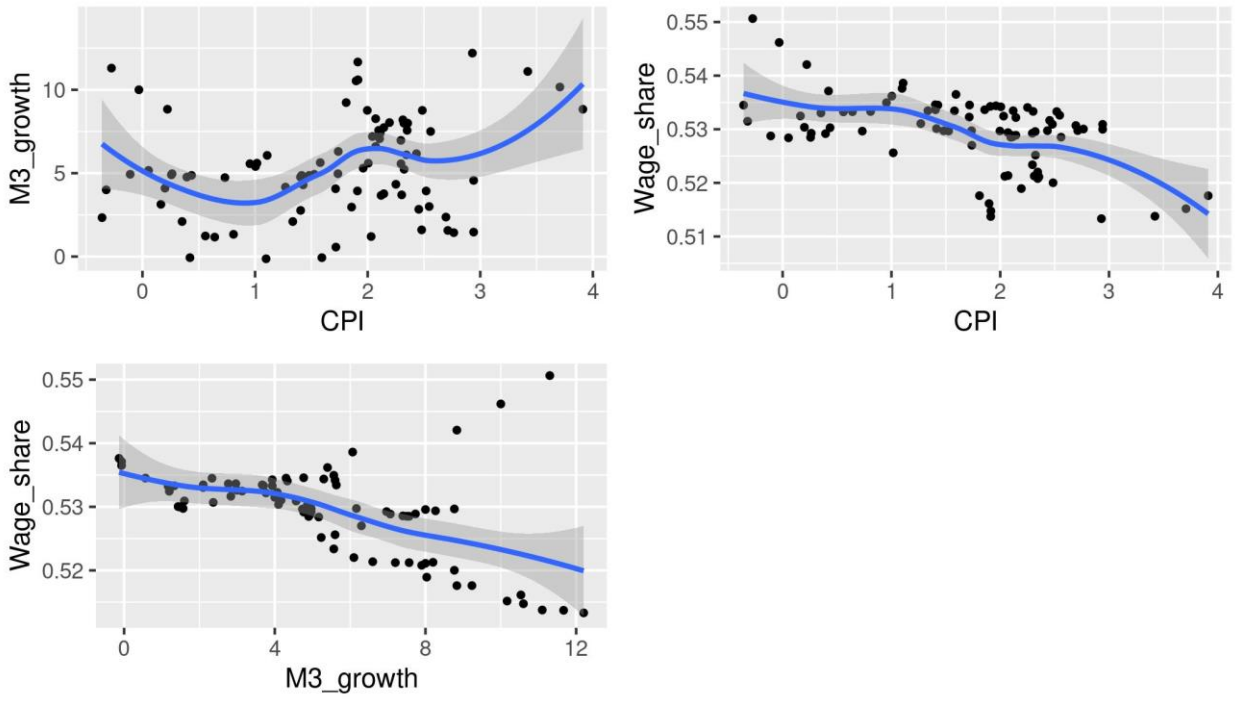

Figure 8. Correlation between the MS, CPI and wage share.
Source: Data from Appendices 2-10. Prepared by the author in RStudio software.

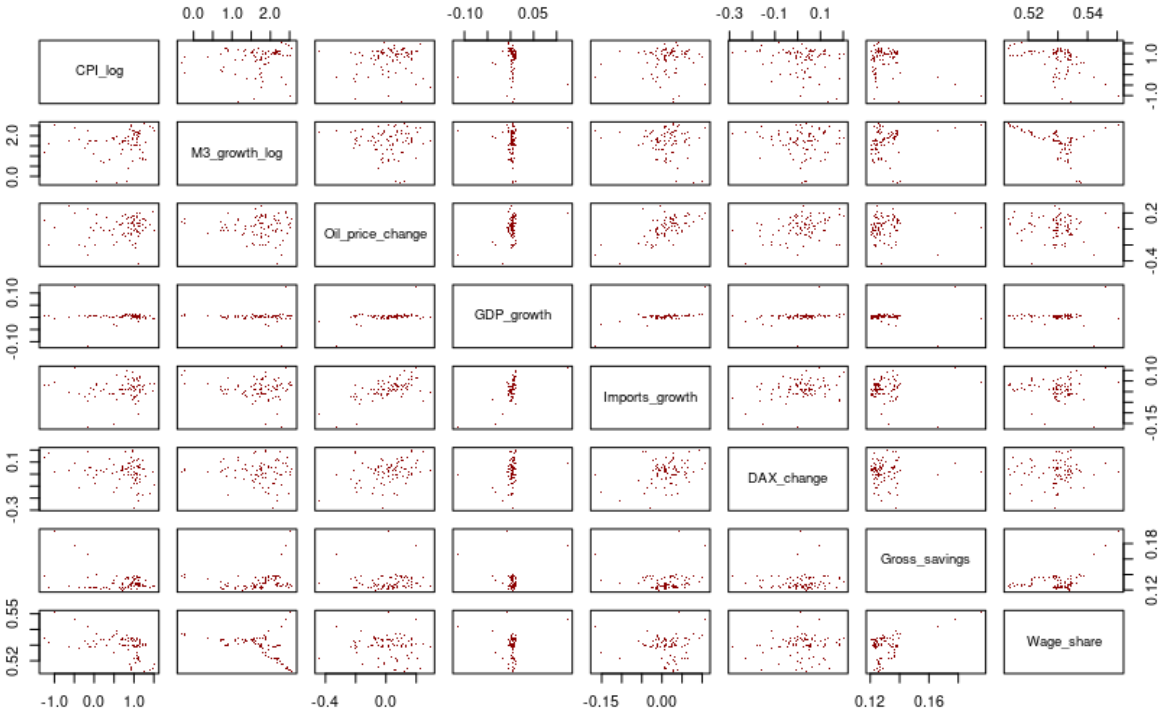

Figure 9. Multiple scatterplots of all variables.
Source: Data from Appendices 2-10. Prepared by the author in RStudio software.

As the next step, the stationarity of the data has been studied. Time-series plots, which have been built to identify non-stationarity in the variables, are available in Appendix 13. The graphs of the CPI, money growth and wage share did not seem to be stationary during the estimated period, while the other did. The ADF tests with a constant and a trend have been employed to examine the stationarity of the variables. The descriptive statistics can be found in Table 1. The tests prove that the CPI, MS growth and wage share are non-stationary, as the p-values are over a significance level of 5%. After taking the first difference, the data became stationary.

Table 1. ADF test and p-values.

Element	P-value	Conclusion	1. difference	Conclusion
CPI	0.1045	non-stationary	<0.05	stationary
MS growth	0.2749	non-stationary	<0.05	stationary
Oil price changes	<0.05	stationary		

GDP growth	<0.05	stationary		
Growth of imports	<0.05	stationary		
DAX index change	<0.05	stationary		
Gross savings	<0.05	stationary		
Wage share	0.6884	non-stationary	<0.05	stationary
$Wage\ share \times MS\ growth$	<0.05	stationary		

Source: Author's calculations in a Gretl software.

One more variable – an interaction between the stationary MS and wage share – has been added in order to test the second hypothesis. The ADF test showed the stationarity of the sample, so no additional transformations have been employed.

A Pearson correlation matrix for all variables has been built (see Appendix 14) after obtaining the stationarity of the data. A 0.22 coefficient represents a significant correlation between variables for the sample size equalling 80. The correlation matrix demonstrates that the MS growth, DAX index change and gross savings have no significant connection with inflation, as the coefficients are significantly below 0.22. On the contrary, oil price changes and growth of imports show the most substantial relation with inflation. The strongest correlation between independent variables is between the GDP growth and growth of imports (0.67) and between wage share and $Wage\ share \times MS\ growth$ (-0.67).

3.2 Regression analysis

Regression analysis has been done in the Gretl software. Four model specifications have been tested to estimate the hypotheses of the thesis. A White's test, which controls heteroskedasticity of the model; a Ramsey RESET test, which estimates the correctness of the shape of the model; a Doornik-Hansen test, which controls the normality of residuals of the model; a Breusch-Godfrey test, which evaluates the autocorrelation of the model; and a VIF method to identify multicollinearity have been used in every regression. See the estimations and the test results in Appendices 15-18.

The first two models consist of the MS growth and control variables. A wage share and a $Wage\ share \times MS\ growth$ variable have been added to Model 3 and 4. Model 1 and 3 use lagged MS growth, GDP growth and imports' growth to four quarters, as according to the theory,

these variables affect inflation with a delay. Models 2 and 4 consist of the explanatory variables without lags. See the summary of regression results in Tabel 2, where a first number represents a coefficient of an estimator and a star near the coefficient means a significance of the result (* indicates significance at the 10% level, ** at the 5% level and *** at the 1% or below level). A number in parenthesis represents a standard error of the estimator.

The goodness of fit index (R^2) has been added to see how well the sample regression line fit the data. However, R^2 cannot be used while comparing models with a different number of estimators (Gujarati 2004, 81-82). Therefore, an adjusted R^2 has been added to the table to better overview the results.

Two more parameters have been added to the table: i) a sample size, ii) a Durbin-Watson test, as a representation of a level of autocorrelation in the model, where a number near 2 means that the estimation lacks autocorrelation.

In the first model specification (Table 2, Column 1), three explanatory variables are significant: the oil price changes, GDP growth lagged to four quarters, and growth of imports lagged to four quarters. The model shows the lowest adjusted R^2 and risk of autocorrelation. Therefore, HAC robust standard errors have been employed before regression to get reliable results.

The second model specification (Table 2, Column 2) has been tested with the same set of explanatory variables, but this time not lagged. The results of the model state that the oil price changes and growth of imports are statistically significant if using a significance level of 5%. The adjusted R^2 of the model is 0.5027.

The third specification (Table 2, Column 3) includes a wage share and an interaction of the wage share and the MS growth. The model uses lagged parameters and shows three significant explanatory variables: the oil price changes, growth of imports and a wage share. The adjusted R^2 of the model equals 0.4792.

The fourth specification (Table 2, Column 4) consists of the same explanatory variables that are in Model 3 but without lags. The oil price changes and the growth of imports show a strong impact and the wage share demonstrates a weak but still significant impact on inflation. Model 4 shows the highest adjusted R^2 of 0.5137;

Tabel 2. Parameters of regression. Models 1-4[3].

	Model 1	Model 2	Model 3	Model 4
Constant	0.7880 (0.8404)	0.4176 (0.8103)	1.1079 (0.9436)	0.6479 (0.8410)
MS growth		0.0353 (0.0472)		-0.0140 (0.0541)
MS growth $_{t-4}$	-0.0011 (0.0599)		0.0112 (0.0562)	
Oil price change	1.8497*** (0.3624)	1.0412*** (0.3579)	1.8651*** (0.3149)	1.0819*** (0.3546)
GDP growth		4.0516 (8.6839)		-3.0346 9.5186
GDP growth $_{t-4}$	21.5419** (9.3621)		12.2598 (9.0558)	
Imports growth		5.9525*** (1.4439)		5.9565*** (1.4497)
Imports growth $_{t-4}$	-5.1249*** (1.7852)		-4.9336*** (1.3291)	
DAX change	-0.1123 (0.3812)	-0.6365 (0.4203)	-0.3665 (0.4518)	-0.5546 (0.4233)
Gross savings	-6.5309 (6.5571)	-4.0570 (6.2995)	-8.8048 (7.3365)	-5.7194 (6.5817)
Wage share			-128.8380*** (41.5348)	-77.8783* (42.2765)
$Wage\ share\ \times MS\ growth$			-12.9913 (31.0317)	-10.9953 (27.1919)
R^2	0.4192	0.5405	0.5348	0.5629
Adjusted R^2	0.3687	0.5027	0.4792	0.5137
Sample size	76	80	76	80
Durbin-Watson	1.4983	2.0188	1.8047	1.9546

Source: Author's calculations using Gretl software.

In contrast to the first model specification, the rest of the specifications pass all the tests and are homoskedastic, lack autocorrelation, have a correct shape, and their residuals are normally distributed. In addition, all models lack multicollinearity, which has been tested with a VIF method.

[3] "t-4" at the end of a variable means that it has been lagged to 4 quarters before regression.

3.3. Empirical results' interpretation

The main goal of the thesis was to study inflation dynamics of the euro area and examine a relationship between inflation and the MS to find out whether the money growth has an impact on inflation. The research period covered 1999Q4-2019Q4. The author used eight variables and one interaction between variables. The data have been transformed into stationary before regression.

All four model specifications demonstrate significant causation among oil prices, imports of goods and inflation. Furthermore, coefficient signs for oil price changes are positive, which means that inflation will grow with oil prices. The results coincide with other empirical researches (Campillo, Miron 1997; Catao, Terrones 2005) and confirm the results from Section 3.1, where a correlation matrix showed a significant correlation between oil and inflation.

Growth of imports demonstrates positive coefficients in Model 2 and 4 and negative coefficients in Model 1 and 3, where imports have been lagged to one year. Empirical research (Campillo, Miron 1997; Catao, Terrones 2005) suggests that imports positively affect inflation. However, the analysis has demonstrated that the relationship is not so straightforward, and the effect from the growth of imports on inflation changes with times.

GDP growth significantly affects inflation in Models 1, while being lagged to one year. All other models showed an insignificant effect of GDP growth on inflation. The coefficient sign is positive, hence confirms the previous results of Hung and Thompson (2016).

The DAX index and gross saving of households cannot explain the inflation changes despite the author's expectations, as their p-values are above a significance level of 5% and even 10%.

The MS growth showed no significant causal relationship between inflation, which confirms the correlation results from Section 3.1, but contradicts the monetary theory of Milton Friedman. Hypothesis 1 has found no evidence, and the alternative hypothesis has been confirmed that there is no significant relationship between the MS growth and inflation.

A wage share shows a significant connection with inflation in Model 3 and Model 4. A sign of the coefficient is negative, which is against the results of Hung and Thompson (2016) but confirms the results from Section 3.1. Although the size of the coefficient looks like an abnormality and should not be linearly interpreted, the outcome suggests that the previously researched positive correlation in the 20th century (*Ibid.*) might have vanished or even changed to a negative correlation in the 21st century.

Trade unions from developed countries feel pressures caused by the Asian market, where labour is much cheaper (Ferguson 2006 cited by Hung and Thompson 2016). Thus, employers have less motivation to increase salaries, especially if the working process can be offshored to emerging markets. Also, due to globalisation and market openness, cheaper labour can move to emerged economies and increase competition, keeping wages stagnated. Consequently, a connection between the wage share and inflation found from the older data could have vanished in the new century.

As the $Wage\ share \times MS\ growth$ variable is insignificant in both Model 3 and Model 4, the second hypothesis – money growth affects the inflation rate indirectly by increasing the effect of labour force bargaining power on inflation – has been rejected, and the alternative hypothesis has been confirmed. The results desprove empirical research of Hung and Thompson (2016).

As all the variables are in a percentage change, an increase of an independent variable by 1 percentage point should result in a change of inflation in "β" percentage points. For example, according to Model 4, an increase of oil prices by 1 percentage point will increase inflation by approximately 1.0819 percentage points.

Further research should be carried out with a broader sample, panel data approach and with more complicated econometric methods, such as a Vector autoregression (VAR) method, which is commonly used in the similar studies. Furthermore, other variables should be tried, as the regression results might change with different proxies. For instance, Hung and Thompson (2016) used a trade union density and unemployment rates as additional control variables of the wage share. However, the union density data, which can be found in the OECD database, have a low frequency (annual) and is not up-to-date, as the last year available is 2018. In addition, the data have been measured only for a small portion of the EU countries. Therefore, it could not be used in the present thesis.

Thus, it can be concluded that the relation between money growth and inflation seems to disappear, as the correlation matrix and the regression models showed no significant relationship between these variables. The MS growth is not the leading cause of inflation, which contradicts the theory of Milton Friedman (1970, 24), who claimed that inflation is purely a monetary creation.

CONCLUSION

A missing inflation puzzle in the euro area, which occurred since the Great Recession, is still a popular topic of disputes. The inflation rates have been below the target for many years despite the different monetary stimuli from the ECB.

Due to this fact, the thesis aimed to investigate some of the reasons for low inflation in the euro area and test the hypothesis based on the monetarist theory of Milton Friedman that there is a positive correlation between inflation and the growth rate of the money supply.

Another hypothesis proposed by Hung and Thompson (2016) stated that money growth indirectly affects the inflation rate by increasing labour force bargaining power on inflation.

In order to test both hypotheses and reach the goal of the work, correlation and regression analyses have been employed. A research period was 1999Q4-2019Q4, so as to include in the model a series of economic ups and downs. 2020 has not been added as this crisis differs from others and has unpredictable effects on the economy.

The CPI index as a proxy of inflation has been chosen as a dependent variable. A broad M3 money growth, a wage share (a ratio of all salaries and social contributions paid by employers divided by gross value added), and the intervention of these variables have been used as independent estimators. In addition, several control variables have been added to the empirical model, which have been chosen on the basis of the previous empirical research.

After visualising analysing the descriptive statistics of the data, the author used an Augmented Dickey-Fuller test to examine the stationarity of the variables. The result showed that the CPI, wage share and money growth have been non-stationary, so the first difference of these variables has been taken and used in the analysis.

A correlation matrix and four regression model specifications have been employed in the analysis. A heteroskedasticity, autocorrelation, correctness of the shape of the model, normality of the residuals and multicollinearity have been tested in every model specification.

Research has shown that the growth rate of the money supply has no statistically significant effect on inflation, which disproves Hypothesis 1. Neither it has an indirect effect, as the interaction of the MS and wage share show statistically insignificant causation between inflation. This result rejects Hypothesis 2.

The wage share shows a strong relationship with inflation, however the correlation and regression coefficients are negative, which is a new phenomenon and does not support the research of Hung and Thompson (2016).

Oil price changes and the growth of imports showed the most substantial effect on inflation among all independent variables supported by previous analyses.

One model specification had a risk of autocorrelation; therefore HAC robust standard errors have been used before regression to get unbiased estimates. The other models lacked heteroskedasticity and autocorrelation, showed a correct shape of the model and demonstrated no multicollinearity. That is why it can be concluded that the estimates are credible and unbiased.

The results of the thesis show that money growth has had no effect on inflation and other factors influence the inflation rate fluctuations. For instance, according to the theory, the increase of zombie firms (Acharya *et al.* 2020), population ageing (Lis *et al.* 2020) and decreasing velocity of money (Dreger, Wolters 2009) have a deflationary effect on the euro area, which as a result could efface the impact of the money growth on inflation.

The author suggests using a vector autoregression model instead of the ordinary least squares method for further research, as it is commonly used in similar studies. In addition, other variables could be tested as there are many other factors, which might have strong inflation or deflation effects and thus weaken the impact of the money growth on the inflation rates. Moreover, a negative correlation between the wage share and inflation might indicate a change of the trend for this pair, which should be tested in further research.

KOKKUVÕTE

RAHAPAKKUMINE JA INFLATSIOON EUROALAL

Artur Dragunov

Madal inflatsioon tabas euroala majandust pärast suurt majanduslangust (2007-2009) ning sellest ajast alates on Euroopa Keskpanga ja liikmesriikide keskpankade jõupingutustest inflatsioonimäära stabiilsuse tagamiseks hoolimata Euroopa majanduskasv endiselt madal ja inflatsioonimäär on endiselt märkimisväärselt madalam Euroopa kaheprotsendilisest inflatsioonieesmärgist.

Lõputöö eesmärk on uurida, millised võivad olla euroala madala inflatsiooni mõned põhjused, ning kontrollida Milton Friedmani monetaristlikul teoorial põhinevat hüpoteesi, et inflatsiooni ja rahapakkumise kasvutempo vahel on positiivne korrelatsioon.

Teine hüpotees, mille idee on ammutatud Hung ja Thompson (2016) uuringust, väidab, et rahapakkumise kasv mõjutab kaudselt inflatsioonimäära, suurendades tööjõu läbirääkimispositsiooni inflatsiooni suhtes.

Valimiperiood hõlmab 1999 IV kvartal kuni 2019 IV kvartal ja katab nii majanduslanguse kui ka -õitsengu perioode. Kuid 2020. aasta ei ole valimisse lisatud, sest selle kriisi põhjused erinevad eelmistest finantskriisidest, mistõttu selle majanduslanguse tagajärjed on ettearvamatumad.

Esmased andmeallikad on Majandusliku Koostöö ja Arengu Organisatsiooni (OECD) ja Euroopa Keskpanga andmebaasid. Kogu töös on kasutatud kvantitatiivseid uurimismeetodeid.

Sõltuvaks muutujaks on valitud tarbijahinnaindeks kui inflatsiooni asendaja. Sõltumatute hindamisnäitajatena on kasutatud üldist M3-rahakasvu, palgaosa (kõigi tööandjate makstud palkade ja sotsiaalmaksete suhe, mis on jagatud brutolisandväärtusega) ja nende muutujate sekkumist. Lisaks on empiirilisse mudelisse lisatud mitu kontrollmuutujat, mis on valitud varasemate empiiriliste uuringute põhjal.

Näitajate mõju, tugevuse ja suuna kindlaksmääramiseks pidi autor koostama korrelatsioonimaatriksi ja viima läbi regressioonanalüüsi. Regressioonanalüüsi eelduseks on ka aegridade statsionaarsus, mis saavutati Augmented Dickey-Fulleri testi abil. Tarbijahinnaindeksi, palgaosaku ja rahakasvuindeksi aegridades esines mittestatsionaarsust, mistõttu nimetatud muutujate statsionaarsuse saavutamiseks võeti neist esimest järku diferents.

Analüüsis kasutati korrelatsioonimaatriksit ja nelja regressioonimudeli spetsifikatsiooni. Heteroskedastiivsust, autokorrelatsiooni, mudeli kuju hindamist, jääkliikmete allumist normaaljaotusele ja multikollineaarsust on testitud igas mudelispetsifikatsioonis.

Uuringud on näidanud, et rahapakkumise kasvutempol ei ole statistiliselt olulist mõju inflatsioonile, mis kummutab esimese hüpoteesi. Samuti ei ole sellel kaudset mõju, sest rahapakkumise ja palgaosa koostoime näitab inflatsiooniga statitistiliselt ebaolulist põhjuslikku seost. See tulemus lükkab ümber teise hüpoteesi.

Palgaosa näitab tugevat seost inflatsiooniga, kuid korrelatsiooni- ja regressioonikoefitsiendid on negatiivsed, mis on uus nähtus ega toeta Hung ja Thompson (2016) uuringut.

Naftahinna muutused ja impordi kasv näitasid kõigist sõltumatutest muutujatest kõige olulisemat mõju inflatsioonile, mida toetavad ka varasemad analüüsid.

Ühes mudeli spetsifikatsioonis oli autokorrelatsiooni oht, seetõttu on enne regressiooni kasutatud HAC robustset standardviga, et saada erapooletuid hinnanguid. Teistes mudelites puudusid heteroskedastiivsus ja autokorrelatsioon, mudeli kuju oli korrektne ja multikollineaarsus puudus. Seetõttu võib järeldada, et hinnangud on usaldusväärsed ja erapooletud.

Lõputöö tulemused näitavad, et rahakasv ei ole mõjutanud inflatsiooni, ja on olemas muud tegurid, mis mõjutavad inflatsioonimäära kõikumist. Näiteks on teooria kohaselt euroalal deflatsiooni põhjustav mõju zombifirmade arvu suurenemisel (Acharya et al. 2020), rahvastiku vananemisel (Lis et al. 2020) ja raha liikumise kiiruse vähenemisel (Dreger, Wolters 2009), mis selle tulemusel võib nõrgestada rahakasvu mõju inflatsioonile.

Autor teeb ettepaneku kasutada edasistes uuringutes vähimruutude meetodi asemel vektorautoregressiivset analüüsimeetodit, kuna seda kasutatakse tavaliselt sarnastes uuringutes. Lisaks võiks testida ka teisi muutujaid, sest on palju muid tegureid, millel võib olla tugev inflatsiooni- või deflatsioonimõju ja mis seega nõrgestavad rahakasvu mõju inflatsioonimääradele.

Lisaks sellele võib negatiivne korrelatsioon palgaosa ja inflatsiooni vahel viidata selle muutujapaari suundumuse muutumisele, mida tuleks edasistes uuringutes testida.

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APPENDICES

Appendix 1. GDP growth, inflation and unemployment in the EU, 2000-2020.

Year	GDP growth (annual %)	Inflation, consumer prices (annual %)	Unemployment, total (% of the total labour force) (national estimate)
2020	-6.164	0.700	7.150
2019	1.552	1.400	6.717
2018	2.116	1.800	7.283
2017	2.806	1.600	8.158
2016	2.009	0.200	9.142
2015	2.295	0.100	10.067
2014	1.578	0.400	10.900
2013	-0.041	1.300	11.442
2012	-0.743	2.600	10.933
2011	1.840	2.900	9.933
2010	2.197	1.800	9.925
2009	-4.306	0.800	9.192
2008	0.637	3.700	7.258
2007	3.133	2.400	7.517
2006	3.459	2.300	8.692
2005	1.879	2.300	9.667
2004	2.524	2.500	9.942
2003	0.857	2.300	9.792
2002	1.055	2.700	9.050
2001	2.131	3.600	8.733
2000	3.868	3.150	8.983

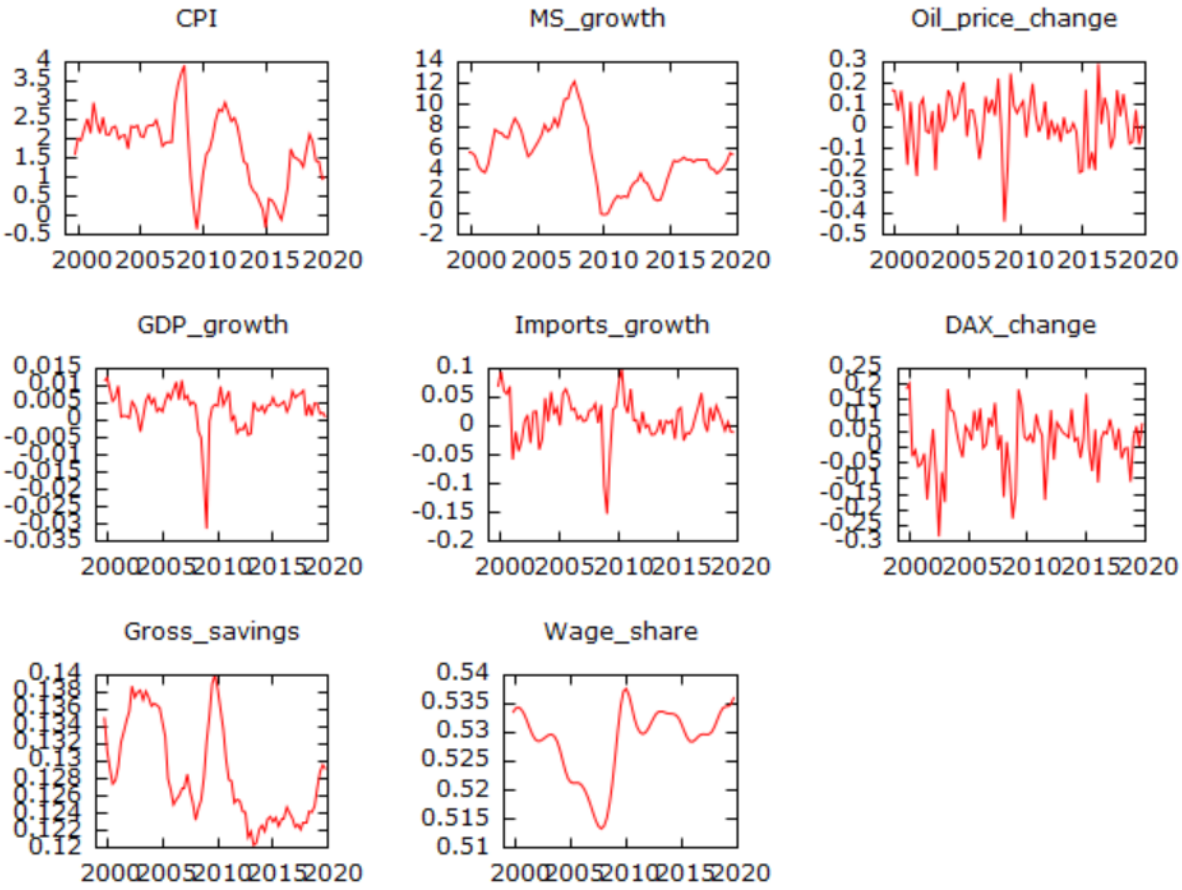
Source: The OECD database (2021)

Appendix 12. Descriptive statistics of all variables.

Element	CPI	MS Growth	Oil price change	GDP Growth	Growth of imports	DAX index change	Gross savings	Wage share
Mean	1.674	5.373	0.017	0.003	0.012	0.015	0.130	0.529
Median	1.912	4.967	0.031	0.004	0.011	0.027	0.127	0.530
Standard deviation	0.955	2.948	0.133	0.020	0.044	0.093	0.011	0.007
Kurtosis	-0.351	-0.464	0.863	30.849	4.383	0.916	16.503	0.959
Skewness	-0.357	0.246	-0.728	0.049	-1.267	-0.662	3.570	-0.306
Minimum	-0.359	-0.133	-0.439	-0.116	-0.166	-0.285	0.120	0.513
Maximum	3.911	12.200	0.291	0.125	0.109	0.201	0.196	0.551

Source: Data from appendices 3-11. Author's calculations.

Appendix 13. Time-series plots for all variables.



Source: Data from appendices 3-11. Author's calculations.

Appendix 14. Correlation matrix.

Element	CPI	MS Growth	Oil price change	GDP Growth	Growth of imports	DAX index change	Gross savings	Wage share	$Wage\ share \times MS\ growth$
CPI	1								
MS growth	0.11	1							
Oil price change	0.56	-0.12	1						
GDP growth	0.47	0.31	0.30	1					
Growth of imports	0.69	0.12	0.58	0.67	1				
DAX index change	0.15	0.07	0.32	0.37	0.31	1			
Gross savings	0.02	-0.14	0.15	-0.04	0.06	-0.03	1		
Wage share	-0.35	-0.58	-0.03	-0.58	-0.35	-0.10	0.03	1	
$Wage\ share \times MS\ growth$	0.33	0.43	0.09	0.52	0.40	0.06	-0.24	-0.67	1

Source: Data from appendices 3-11. Author's calculations.

Appendix 15. Regression with lagged variables, no wage share.

```
Model 3: OLS, using observations 2001:1-2019:4 (T = 76)
Dependent variable: d_CPI
HAC standard errors, bandwidth 3 (Bartlett kernel)

                     coefficient   std. error   t-ratio    p-value
  ---------------------------------------------------------------------
  const                0.788048     0.840411     0.9377    0.3517
  Oil_price_change     1.84965      0.362405     5.104     2.81e-06 ***
  GDP_growth_4        21.5419       9.36207      2.301     0.0244   **
  Imports_growth_4    -5.12489      1.78520     -2.871     0.0054   ***
  DAX_change          -0.112273     0.381229    -0.2945    0.7693
  Gross_savings       -6.53090      6.55712     -0.9960    0.3227
  d_MS_growth_4       -0.00112020   0.0598579   -0.01871   0.9851

Mean dependent var  -0.019942   S.D. dependent var   0.447428
Sum squared resid    8.720619   S.E. of regression   0.355508
R-squared            0.419182   Adjusted R-squared   0.368677
F(6, 69)             7.558926   P-value(F)           2.99e-06
Log-likelihood     -25.56769    Akaike criterion     65.13538
Schwarz criterion   81.45051    Hannan-Quinn         71.65569
rho                  0.248036   Durbin-Watson        1.498250

Excluding the constant, p-value was highest for variable 15 (d_MS_growth_4)

RESET test for specification -
  Null hypothesis: specification is adequate
  Test statistic: F(2, 67) = 1.26686
  with p-value = P(F(2, 67) > 1.26686) = 0.288375

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 34.373
  with p-value = P(Chi-square(27) > 34.373) = 0.155471

LM test for autocorrelation up to order 4 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 2.73683
  with p-value = P(F(4, 65) > 2.73683) = 0.0361186

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 3.82906
  with p-value = 0.147411

 Variance Inflation Factors
 Minimum possible value = 1.0
 Values > 10.0 may indicate a collinearity problem

 Oil_price_change    1.166
     GDP_growth_4    2.036
 Imports_growth_4    1.885
       DAX_change    1.217
    Gross_savings    1.216
    d_MS_growth_4    1.292

 VIF(j) = 1/(1 - R(j)^2), where R(j) is the multiple correlation coefficient
 between variable j and the other independent variables
```

Source: Author's calculations using a Gretl software.

Appendix 16. Regression without lagged variables nor wage share.

```
Model 4: OLS, using observations 2000:1-2019:4 (T = 80)
Dependent variable: d_CPI

                    coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------------
  const               0.417624     0.810334     0.5154   0.6078
  Oil_price_change    1.04124      0.357893     2.909    0.0048   ***
  DAX_change         -0.636491     0.420275    -1.514    0.1342
  Gross_savings      -4.05703      6.29948     -0.6440   0.5216
  d_MS_growth         0.0353124    0.0471674    0.7487   0.4565
  GDP_growth          4.05155      8.68387      0.4666   0.6422
  Imports_growth      5.95253      1.44385      4.123    9.79e-05 ***

Mean dependent var  -0.007191   S.D. dependent var   0.441243
Sum squared resid    7.068091   S.E. of regression   0.311164
R-squared            0.540464   Adjusted R-squared   0.502693
F(6, 73)            14.30929    P-value(F)           1.04e-10
Log-likelihood     -16.45763    Akaike criterion     46.91527
Schwarz criterion   63.58945    Hannan-Quinn         53.60043
rho                -0.015393    Durbin-Watson        2.018775

Excluding the constant, p-value was highest for variable 4 (GDP_growth)

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 31.172
  with p-value = P(Chi-square(27) > 31.172) = 0.264134

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 4.5556
  with p-value = 0.10251

LM test for autocorrelation up to order 4 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 1.26983
  with p-value = P(F(4, 69) > 1.26983) = 0.290267

RESET test for specification -
  Null hypothesis: specification is adequate
  Test statistic: F(2, 71) = 0.364033
  with p-value = P(F(2, 71) > 0.364033) = 0.696157


Variance Inflation Factors
Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

Oil_price_change    1.701
      DAX_change    1.236
   Gross_savings    1.044
     d_MS_growth    1.185
      GDP_growth    2.161
  Imports_growth    2.524

VIF(j) = 1/(1 - R(j)^2), where R(j) is the multiple correlation coefficient
between variable j and the other independent variables
```

Source: Author's calculations using a Gretl software.

Appendix 17. Regression with lagged variables and wage share.

```
Model 5: OLS, using observations 2001:1-2019:4 (T = 76)
Dependent variable: d_CPI

                      coefficient   std. error  t-ratio  p-value
  ------------------------------------------------------------------
  const                 1.10788     0.943603    1.174   0.2445
  Oil_price_change      1.86510     0.314920    5.922   1.21e-07 ***
  DAX_change           -0.366455    0.451769   -0.8112  0.4201
  Gross_savings        -8.80476     7.33652    -1.200   0.2343
  d_MS_growth_4         0.0112046   0.0561557   0.1995  0.8425
  GDP_growth_4         12.2598      9.05597     1.354   0.1804
  Imports_growth_4     -4.93362     1.32910    -3.712   0.0004   ***
  d_Wage_share       -128.838      41.5348     -3.102   0.0028   ***
  wage_share_x_MS_~   -12.9913     31.0317     -0.4186  0.6768

Mean dependent var  -0.019942   S.D. dependent var   0.447428
Sum squared resid    6.985431   S.E. of regression   0.322893
R-squared            0.534751   Adjusted R-squared   0.479199
F(8, 67)             9.626106   P-value(F)           9.06e-09
Log-likelihood      -17.13687   Akaike criterion     52.27375
Schwarz criterion    73.25035   Hannan-Quinn         60.65701
rho                  0.093287   Durbin-Watson        1.804736

Excluding the constant, p-value was highest for variable 15 (d_MS_growth_4)

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 55.8125
  with p-value = P(Chi-square(44) > 55.8125) = 0.10914

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 1.21809
  with p-value = 0.543869

LM test for autocorrelation up to order 4 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 1.07477
  with p-value = P(F(4, 63) > 1.07477) = 0.376554

RESET test for specification -
  Null hypothesis: specification is adequate
  Test statistic: F(2, 65) = 1.24423
  with p-value = P(F(2, 65) > 1.24423) = 0.294934

 Variance Inflation Factors
 Minimum possible value = 1.0
 Values > 10.0 may indicate a collinearity problem

       Oil_price_change    1.178
             DAX_change    1.241
          Gross_savings    1.310
          d_MS_growth_4    1.527
           GDP_growth_4    2.174
       Imports_growth_4    1.961
           d_Wage_share    2.330
 wage_share_x_MS_growth    2.584

 VIF(j) = 1/(1 - R(j)^2), where R(j) is the multiple correlation coefficient
 between variable j and the other independent variables
```

Source: Author's calculations using a Gretl software.

Appendix 18. Regression without lagged variables and with wage share.

```
Model 6: OLS, using observations 2000:1-2019:4 (T = 80)
Dependent variable: d_CPI

                      coefficient   std. error   t-ratio   p-value
  ---------------------------------------------------------------------
  const                 0.647869     0.841009     0.7703   0.4436
  Oil_price_change      1.08190      0.354559     3.051    0.0032  ***
  DAX_change           -0.554579     0.423257    -1.310    0.1943
  Gross_savings        -5.71939      6.58166     -0.8690   0.3878
  d_Wage_share        -77.8783      42.2765      -1.842    0.0696  *
  wage_share_x_MS_~   -10.9953      27.1919      -0.4044   0.6872
  GDP_growth           -3.03456      9.51852     -0.3188   0.7508
  Imports_growth        5.95647      1.44969      4.109    0.0001  ***
  d_MS_growth          -0.0139901    0.0541336   -0.2584   0.7968

Mean dependent var  -0.007191   S.D. dependent var   0.441243
Sum squared resid    6.722635   S.E. of regression   0.307709
R-squared            0.562924   Adjusted R-squared   0.513676
F(8, 71)            11.43037    P-value(F)           2.90e-10
Log-likelihood     -14.45323    Akaike criterion     46.90645
Schwarz criterion   68.34469    Hannan-Quinn         55.50165
rho                 0.014673    Durbin-Watson        1.954575

Excluding the constant, p-value was highest for variable 10 (d_MS_growth)

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 41.0315
  with p-value = P(Chi-square(43) > 41.0315) = 0.556995

LM test for autocorrelation up to order 4 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 0.896427
  with p-value = P(F(4, 67) > 0.896427) = 0.471133

RESET test for specification -
  Null hypothesis: specification is adequate
  Test statistic: F(2, 69) = 0.88592
  with p-value = P(F(2, 69) > 0.88592) = 0.416972

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 9.02183
  with p-value = 0.0109884

 Variance Inflation Factors
 Minimum possible value = 1.0
 Values > 10.0 may indicate a collinearity problem

       Oil_price_change    1.707
             DAX_change    1.282
          Gross_savings    1.165
           d_Wage_share    2.683
 wage_share_x_MS_growth    2.205
             GDP_growth    2.655
         Imports_growth    2.602
            d_MS_growth    1.596

 VIF(j) = 1/(1 - R(j)^2), where R(j) is the multiple correlation coefficient
 between variable j and the other independent variables
```

Source: Author's calculations using a Gretl software.

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