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**The Macroeconomic Effects of Monetary Policy through the Examples of the
Federal Reserve and the European Central Bank.**

Theses of doctoral dissertation

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1. INTRODUCTION

The thesis abstract summarizes the theoretical background of the doctoral dissertation, the hypotheses, the results of the applied methodology, and the derived theses, conclusions, and economic policy implications. In terms of structural coherence, the abstract initially addresses the relevance of the topic, the purpose of the dissertation, and then provides a summary of the applied methodology. Following this, it presents the theoretical background and the examined hypotheses. Finally, it consolidates the main results, theses, and economic policy relevance of the dissertation.

2. THE RELEVANCE OF THE RESEARCH TOPIC

The relationship between monetary policy variables and the real economy has been a constant topic throughout the evolution of monetary theory, gaining particular significance in contemporary times due to the heightened global integration of financial and capital markets, as well as the 2008-2009 financial crisis. Most monetary theories acknowledge that, in the long run, monetary policy decisions predominantly influence nominal variables with limited impact on real variables. **However, there is consensus that monetary policy shocks have substantial short-term effects on output.** The effectiveness of monetary policy is periodically scrutinized in both monetary theory literature and practice. Practical experiences, empirical studies, and mainstream monetary thought emphasize the pivotal short-term role of central bank decisions in the real economy. Different economic paradigms exhibit commonalities in their conceptualization of monetary policy, yet they also reveal numerous divergences. Additionally, notable crises and institutional transformations have observable effects that challenge established mainstream narratives. Hence, one of the objectives of this doctoral dissertation is to explore the perspectives on monetary policy within various economic paradigms, their mutual influence, and the examination of paradigm-shifting events.

During the 2008-2009 financial crisis and its aftermath the consensus on monetary policy thinking remained unchanged; however, its toolkit underwent significant changes. The policy interest rates reached their zero lower bound, reintroducing the concept of the Keynesian liquidity trap, emphasizing the real economic impact of monetary policy and its role in stimulating the economy. Concurrently, concerns arose

regarding the operation and effects of unconventional tools. Rather than focusing on the financial market, the research within this doctoral dissertation examined the effects of asset purchases on macro variables and their transmission. Based on empirical studies using models similar to the methodology I applied, the quantitative easing programs of the examined central banks significantly influenced output and inflation in most cases. However, there is no consensus regarding the magnitude and persistence of these effects.

3. THE MAIN OBJECTIVES OF THE RESEARCH

The **main objective of the research** is to observe the impact of monetary policy on output and its transmission channels by integrating monetary theory and econometric analysis. The research, on one hand, examines the real economic effects of traditional interest rate policy, investigates potential divergences in these effects among the studied central banks (Federal Reserve and European Central Bank), and identifies the dominant elements of the interest rate channel during the period between 1990 and the 2008 crisis. The selection of this timeframe considers the Federal Reserve's using of short-term interest rates for influencing target variables since the early 1990s. The starting point for studying the ECB corresponds to the commencement of the Eurozone's common monetary policy in the first quarter of 1999. On the other hand, the research places a prominent focus on the analysis of the macroeconomic effects, particularly on output and price levels, resulting from the widely applied novel tool of asset purchases introduced in response to the 2008 crisis. Simultaneously, it explores the real economic channels specific to each central bank associated with asset purchases. Consequently, the research spans the period from the first quarter of 1990 to the last quarter of 2019, distinguishing between two distinct periods due to the regime shift in 2008.

The motivation of the research lies in the comprehensive examination of interest rate policy and asset purchases across an extended period, encompassing multiple monetary regimes. Therefore, in selecting **the research subjects and period**, considerations prioritized the relative stability and sufficient length of the time series, extensive accessibility of data, and the prominence of a stable central bank reaction function. The research focuses on two globally influential central banks: the **Federal Reserve (Fed)** of the United States (USA) and the **European Central Bank (ECB)** within the eurozone. Decisions made by these two globally influential central banks significantly impact global

financial markets and the operations of other central banks. Consequently, a heightened focus on studying the behavior of these central banks is imperative. Additionally, substantial divergences are observed between the target and instrument frameworks of the two examined central banks, as well as in the structures of the two studied economies, further reinforcing the research objectives.

4. THE HYPOTHESES OF THE RESEARCH

The thinking about the real economic effects of monetary policy evolves over time.

According to the current mainstream view, there is consensus that monetary policy shocks can have a significant short-term impact on output, while in the long run, their effect is primarily on the price level. The dissertation examined the macroeconomic effects, particularly on output, of traditional interest rate policy in the period before the 2008 crisis using recursive VAR and sign restriction VAR models within the framework of the New Neoclassical Synthesis. In connection with this, the following hypothesis can be formulated:

- **1/A. Hypothesis:** *The impact of traditional interest rate policy on output can be observed through vector autoregressive models for the Federal Reserve and the ECB.*

Significant differences are observed regarding the reaction functions of the two examined central banks. The monetary policy strategy of the Fed is fundamentally determined by its dual mandate, wherein the ultimate objective encompasses both real economic considerations and a commitment to price stability. Conversely, reflecting genuine concerns about (hyper)inflation in continental Europe and adherence to the classical dichotomy, the ECB's ultimate objective is the assurance of price stability. Taking into account the divergent monetary strategies, the following hypothesis can be formulated:

- **1/B. Hypothesis:** *Differences are observable among the reaction functions of the Federal Reserve and the ECB, as well as in the responses of macroeconomic variables to monetary policy shocks.*

The dissertation examined the decomposition of the interest rate channel of conventional monetary policy using a Structural Vector Autoregressive (SVAR) model. The question arises as to which part of the interest rate channel central bank decisions affect the real economy through. Specifically, whether changes in the policy rate exert their influence more on investments or consumption, thereby impacting changes in aggregate demand. Taking into account the divergent financial and economic structures, historical conditions of the USA and the eurozone, and the monetary transmission theory, the dissertation formulated the following hypotheses:

- **2/A. Hypothesis:** *Central bank interest rate decisions in the United States predominantly influence output through consumption expenditures, meaning that in the case of the Fed, consumption expenditures dominate the interest rate channel.*
- **2/B. Hypothesis:** *Central bank interest rate decisions in the Eurozone primarily impact output through changes in investment expenditures, meaning that in the case of the ECB, investment expenditures dominate the interest rate channel.*

The second major section of the thesis describes the post-2008 crisis period and examines the macroeconomic effects of asset purchases within the SVAR model framework. As a research question, it is posed whether asset purchases can be effective tools for central banks in mitigating economic downturns and steering towards inflation postulates. Given the absence of consensus in the examined empirical studies on this matter, it is worthwhile to investigate the effects and transmission of asset purchases on output. Furthermore, the transmission of traditional interest rate policy and asset purchases into relevant variables significantly differs, and divergencies are also observed among the examined central banks.

- **3. Hypothesis:** *In the cases of the Federal Reserve and the European Central Bank, large-scale asset purchases had a significant impact on the trajectory of output in the years following the 2008 crisis.*

Based on the results of the research and practical experiences, I analyze perceived and actual inflation concerns that emerged mainly along the lines of the Federal Reserve's quantitative easing programs using a recursive VAR model. As a control model and to enhance the robustness of the results, a model for the European Central

Bank is also presented. The asset purchases led to a drastic expansion of the monetary base and M2, and according to theories related to the quantity of money, such extensive expansion of the money supply should be accompanied by high inflationary pressure. However, the data indicates that the expansions of the money aggregates caused by asset purchases did not result in high inflationary pressure in the examined economies. Therefore, it is worthwhile to examine the changes in money aggregates caused by quantitative easing, the framework of central bank policy implementation in the presence of ample reserves, and their effects on the price level:

- **4. Hypothesis:** *The asset purchase-induced expansion of money aggregates did not result in high inflationary pressure for the Federal Reserve and the European Central Bank in the years following the crisis.*

The structural units, objectives, temporal dimensions, and associated methodology of the research are summarized in Table 1:

1. Table: The dimensions of the research

Period	Subjects	Objective	Methodology	Subsection	Hypothesis
1990 - 2008 (ECB 1999-2008)	Fed, ECB	<ul style="list-style-type: none"> • The real economic impact of interest rate policy 	recursive VAR, sign-restricted VAR	4.1.	1/A.
		<ul style="list-style-type: none"> • Analysis of differences between central banks 			1/B.
		<ul style="list-style-type: none"> • Decomposition of the interest rate channel 	recursive VAR	4.2.	2/A, 2/B.
2008 - 2020	Fed, ECB	<ul style="list-style-type: none"> • Macroeconomic effects of asset purchases 	structural VAR	4.3.	3.
2008 - 2020	Fed, ECB	<ul style="list-style-type: none"> • Inflationary effects of asset purchases 	recursive VAR	4.4.	4.

Source: own editing.

5. THE RESEARCH METHODOLOGY AND ITS RELATIONSHIP WITH THE HYPOTHESES

The measurement of the effects of monetary policy is methodologically challenging (Felcser et al. (2017); Trung – Kiss (2021)). Firstly, there is a question of which variable is suitable for measuring monetary policy decisions. Secondly, monetary policy actions are largely reactions to real economic and financial processes, making it difficult to isolate the impact of monetary policy on these variables. While the impact of monetary policy actions also depends on the expectations of economic agents regarding future steps, the effects of the same action may change over time, thus requiring consideration of the Lucas critique in the examination of monetary policy. (Felcser et al. (2017); Trung – Kiss (2021)).

Various Vector Autoregressive (VAR) models have been an efficient and consistent tool for academic and central bank analyses of monetary policy for several decades. The Vector Autoregressive (VAR) model is a linear model containing n equations and n variables, where the variables are explained by their own past (lagged) values, as well as the past (and, in the case of structural VAR, current) values of other variables, along with an error term. Since Sims' study in 1980, the VAR model framework has been an efficient and consistent tool for analyzing monetary policy (e.g., Bernanke – Blinder 1992; Christiano et al. 1996; Bernanke – Mihov 1998).

A VAR models are the most widely accepted econometric methodology in the literature for examining the effects of monetary policy. There are numerous theoretical and practical reasons for this. **The endogeneity of monetary policy** complicates the measurement of its effects. Solving the problem of endogeneity is most effectively done with econometric methods. In resolving the problem, unexpected monetary effects due to shocks are separated from systematic actions reacting to economic processes. Regarding monetary policy, this means excluding all interest rate movements that respond to shocks affecting the target variable, beyond the interest rate movement. The isolation of monetary policy shocks is achieved through the identification and imposition of restrictions in VAR models.

In **recursive VAR** models, the error terms in individual equations are not correlated with the error terms of other equations because the equations use the simultaneous values of

variables as explanatory variables. One possible solution to the simultaneity problem is the Cholesky decomposition of the variance-covariance matrix of VAR errors. In recursive VAR models, the ordering of variables plays a crucial role. According to the literature, the order of variables in the recursive model should be based on response times. Macroeconomic variables come at the beginning of the order, while monetary variables come at the end because, on the one hand, monetary policymakers react to the evolution of macro variables, and, on the other hand, there is a kind of delay in this reaction and its effects.

In **Structural VAR (SVAR)** models, simultaneous relationships between variables can be more widely identified. This method allows incorporating internal delays of monetary policy (the time needed to recognize shocks) into the models. It can be assumed that the central bank cannot immediately recognize and respond to the effects of demand and supply shocks. Moreover, other quickly responding variables (e.g., asset prices) can also be included in the model.

If, under a given identification strategy (application of constraints), the reaction of the variables under investigation does not align with economic (piori) theory, the obtained results are questioned. When examining the effects of monetary policy, many empirical studies have encountered the phenomenon known as the "price puzzle" (e.g., Sims (1992); Eichenbaum 1992; Uhlig 2005). The essence of the price puzzle is that, following a restrictive monetary policy shock, the price level temporarily rises. A widely applied solution to the identification problem is the use of **sign restrictions** (e.g., Uhlig (2005); Vonnák (2005)). In this case, we impose priori constraints on the direction of the reactions of variables based on economic theory. We can determine, for instance, that a monetary tightening (positive monetary shock) should lead to a decrease in inflation and an increase in the policy rate, as justified by monetary theory. Sign-restricted VAR models are typically less restrictive than other SVAR models (Uhlig 2005). In the model, the sign restrictions on variable reactions can be maintained throughout the entire forecast horizon, but typically these restrictions have effects for only a few quarters.

In testing the first group of hypotheses and the fourth hypothesis, a recursive VAR and a sign-restricted VAR model were applied. In both cases, we assume that monetary shocks do not immediately affect real economic variables (in contrast to demand, supply,

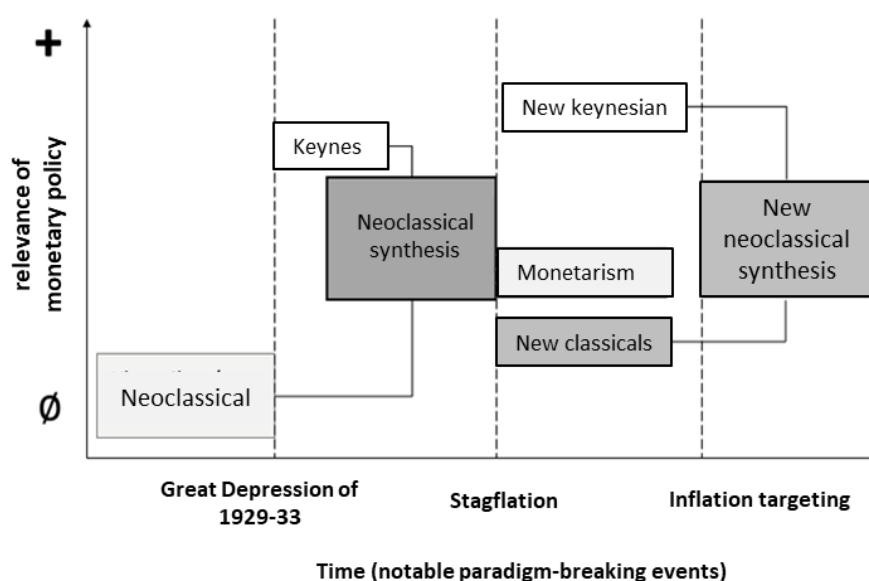
or inflation shocks), but only after one (or more) time periods. This reflects the impact of delays inherent in the operation of monetary policy. Moreover, in the sign-restricted model, we impose a priori constraints on the direction of variable reactions based on economic theory. We can set, for example, that a monetary tightening should lead to a decrease in inflation and an increase in the policy rate, as justified by monetary theory. **The second group of hypotheses and the third hypothesis are tested using structural VAR (SVAR) models.** Restrictions can be applied to any element outside the main diagonal of the SVAR, allowing for broader identification of simultaneous relationships between variables.

6. THE THEORETICAL BACKGROUND AND ITS RELATIONSHIP WITH THE HYPOTHESES

The basis for the hypotheses examined in the dissertation is provided by the mainstream thinking on monetary policy, particularly the New Neoclassical Synthesis. The consensus assumes that in the short term, monetary policy has real economic effects due to market frictions, but it acknowledges the rational expectations of agents, while asserting the neutrality of monetary policy in the long term. Interest rate decisions impact various channels leading to target variables, with the interest rate channel typically playing a prominent role. Changes in the central bank's policy rate affect corporate investment decisions through the traditional Keynesian interest rate channel, influencing output. Additionally, changes in the nominal interest rate can influence households' consumption and savings decisions, as reflected in the Patinkin real balance effect and in New Keynesian models. **Based on this, the formulation of the first and second hypothesis groups, which examine the real economic effects of traditional interest rate policy and the decomposition of the interest rate channel, was developed.** The 2008 global financial crisis fundamentally shaped the practice of monetary policy. Central banks' traditional toolkit has expanded with numerous unconventional instruments, and this study focuses on asset purchases among them. **The third and fourth hypotheses analyze the macroeconomic effects of asset purchases and the transmission channels of these tools into target variables.** The research horizontally examines differences between the selected two globally influential central banks across the entire time horizon.

The economic paradigms presented in the theoretical chapter of the dissertation share numerous commonalities in their thinking about monetary policy, but they also exhibit many differences. Moreover, the notable effects of crises and institutional transformations breaking the mainstream are well observed. The thinking about monetary policy in the examined economic trends and the significant events breaking the paradigms are summarized in Figure 1.

1. Figure: The various paradigms' perspectives on monetary policy and the notable events breaking them



Source: own editing

The **neoclassical paradigm** separated monetary processes entirely from real economic processes based on the neutrality of money. In this framework, the role of monetary policy was limited to ensuring a stable money supply. However, the tangible effects of the **Great Depression of 1929-33** revealed that the market system is not a stable, self-regulating equilibrium system. Neoclassical theories receded into the background, and a new economic and monetary perspective emerged, led by Keynes.

According to **Keynes**, the market system is not self-regulating, and supply does not always create adequate demand due to the rigid adjustment of prices and wages. Keynes, emphasizing the intermediating role of interest rates, broke with the orthodox economics by rejecting the separation of the real and monetary spheres. In his monetary theory, policy decisions influence investment demand through changes in the money supply,

affecting output (income) in the end. However, the existence of the liquidity trap limits the applicability of monetary policy. According to Keynes, the ultimate task of monetary policy is to ensure a stable interest rate, stabilizing the demand for money and smoothing out fluctuations in the real economy.

In response to Keynesian criticisms, neoclassical economics did not entirely fade away but, through the **neoclassical synthesis**, found common ground in macroeconomic analysis by distinguishing between short and long-term perspectives. According to the synthesis, in the short term, due to nominal rigidities (such as wage rigidities observed by Keynes), price adjustments are inflexible. Therefore, activist economic policies can influence aggregate supply by changing aggregate demand. However, in the long term, price adjustments are flexible, and the dichotomy applied by neoclassicals prevails. The neoclassical synthesis provided a framework for macroeconomic analysis that did not succumb entirely to the inconsistencies of economic theory but was disrupted by the **stagflation of the 1970s**. Monetarists did not seek to reform the theoretical framework of stabilization policy interventions but returned to the self-regulating, equilibrium markets, and market-clearing prices.

Monetarists argue that monetary policy surprises create temporary money illusion, leading economic agents to confuse relative price increases with a general rise in the price level. Based on this misconception, they make savings, consumption, and investment decisions. The growth in production and employment does not result from a change in economic fundamentals but rather from faster monetary growth resulting in a higher inflation rate. Consequently, **the role of monetary policy** is not interest rate regulation but a constant increase in the money supply parallel to real economic needs, fixing inflation expectations.

The **new classicals** supported the monetarist view of the neutrality of monetary policy and went further by believing in microeconomic-based macroeconomics, rational expectations, and the neutrality of monetary policy. The new classical theory contributed to the development of real business cycle (RBC) models, which gained prominence in the 1980s. According to the model, in an environment characterized by perfect competition and frictionless markets, most economic fluctuations observed in industrialized countries can be interpreted as an equilibrium outcome resulting from the economy's response to

exogenous shocks (primarily technological shocks). RBC models, typically explaining economic fluctuations without monetary variables and often excluding the entire monetary sector, imply a limited role for the central bank in managing economic fluctuations.

The observations of new classical economists, **institutional changes of central banks**, and **practical experiences regarding the real economic relevance of monetary policy** led to a convergence between new classical theories and new Keynesian statements in the 1980s and 1990s. The synthesis of the two theoretical schools resulted in the **new neoclassical synthesis**, which can be considered the theoretical foundation of inflation targeting regimes. In this consensus, short-term economic effects of monetary policy are assumed due to market frictions (price and wage rigidities). However, rational expectations are accepted, and the long-term neutrality of monetary policy prevails. The goal of monetary policy is to minimize welfare losses arising from market imperfections by directing the economy toward more efficient resource allocation. The short-term real economic impact of monetary policy is a natural consequence of the existence of nominal rigidities. If prices do not adjust to changes in monetary factors (thus changing real balances), or if expected inflation does not move one-to-one with changes in nominal interest rates (thus changing real interest rates), the central bank will be able to alter the level of aggregate demand, and consequently, the level of output, in the short term. However, in the long term, similar to the new classicals, under rational expectations, regardless of any shocks, be they technological or monetary, inflation and inflation expectations converge. Therefore, in the long term, shocks will have no effect on the real economy.

7. THE THESES OF THE RESEARCH AND ITS POLICY RELEVANCE

The basis of the dissertation lies in the observation that the effectiveness of monetary policy is periodically questioned in the monetary theory literature. However, practical experiences, empirical studies, and mainstream monetary thinking emphasize the short-term prominent role of central bank decisions in the real economy. Previous empirical studies using vector autoregressive models similar to or consistent with the research methodology employed in the dissertation demonstrate the real economic relevance of monetary policy (e.g., Sims (1980 and 1992), Bernanke – Blinder (1992),

Christiano et al. (1996); Stock – Watson (2001); Uhlig (2005); Panizza U. – Wyplosz C. (2016); Gross J. – Zahner J. (2021).

The aim of the first part of the dissertation, in line with the theoretical chapter, was to generally examine the impact of conventional interest rate policy on output and inflation using VAR models. In contrast to previous empirical results, this research examines, within a unified modeling framework, the reactions of two influential central banks (the Federal Reserve and the ECB) to various macroeconomic shocks and the effects of central bank interest rate decisions on macroeconomic variables. As a result, differences in central bank behaviors could be identified. The following hypotheses were formulated:

1/A. Hypothesis: *The impact of traditional interest rate policy on output can be observed through vector autoregressive models for the Federal Reserve and the ECB.*

1/B. Hypothesis: *Differences are observable among the reaction functions of the Federal Reserve and the ECB, as well as in the responses of macroeconomic variables to monetary policy shocks.*

In the recursive VAR model, the reactions of the variables to monetary tightening were not consistent with economic theory. In response to an interest rate increase shock, the output gap rises, whereas, for the Fed, this phenomenon is observed for inflation as well. On the one hand, the reaction of the output gap contradicts expectations from the monetary theory literature, and on the other hand, the empirical studies reveal the presence of the price puzzle phenomenon frequently observed in the case of the U.S. central bank. According to Sims (1992), simple recursive VAR models are unable to handle this phenomenon. Based on this, and following Uhlig's (2005) methodology, various sign restrictions were used regarding the reactions of the variables to address this issue.

In the sign-restricted model, the reactions to monetary policy shocks follow theoretical literature and are consistent with previous empirical research: contractionary monetary policy leads to a decrease in output and inflation, while the nominal interest rate increases. In the model, both central banks exhibit significant real economic effects of monetary policy decisions. By raising the policy rate, the central

bank, due to price rigidities, deviates the real interest rate from its natural level. The increase in the real interest rate leads to a temporary decline in aggregate demand (through a decrease in consumption and/or investment spending) for at least two quarters, according to the model. The decrease in aggregate demand also determines a temporary downturn in aggregate supply, ultimately resulting in a decline in the price level. However, **the central bank effects are time limited**. In response to the negative output gap and falling inflation, the central bank reacts with an interest rate cut. Ultimately, after the transient effects, the variables return to their equilibrium levels.

The results obtained in the study demonstrate the real economic relevance of monetary policy, a timeless subject of investigation in monetary theory literature. **The findings reinforce mainstream monetary thinking and practical central banking experiences, emphasizing the short-term prominent role of central bank decisions in the real economy**. Based on this, monetary policy decisions may prove effective in dampening economic cycles, which is a foundation of practical monetary decision-making.

Based on the results, Hypothesis 1/A has been accepted with slight modifications, taking into account the observation that, although there is a real economic impact of monetary policy in the recursive VAR model, this impact is not consistent with theoretical literature due to model specification errors. At the same time, the results of the sign-restricted model, which applies a priori constraints derived from economic theory, align with the expectations of the monetary theory literature.

1/A. Thesis: *The impact of traditional interest rate policy on output can be observed through sign-restricted vector autoregressive models for the Federal Reserve and the ECB.*

The results formulated by Thesis 1/A confirm the observations of mainstream economics, the existing findings of the New Neoclassical Synthesis, and practical central banking experiences. While methodologically expanding the insights gained from sign-restricted VAR models, increasingly prominent in monetary research.

Both the recursive and sign-restricted VAR model results draw attention to differences among the examined central banks – based on their distinct policy objectives – in terms of their reactions to macroeconomic shocks and the effects of

central bank interest rate decisions on macroeconomic variables. Regarding the reaction functions to inflationary shocks, for the Fed, the negative response of the policy instrument suggests that, given its dual mandate, the central bank is more inclined towards regimes focusing on the output gap during this period. In contrast, the positive reaction of the ECB's policy instrument indicates a tendency to respond to inflation with interest rate hikes. **Based on the results, the Fed can be considered more as a regime focusing on the output gap, while the ECB can be seen as one focusing on inflation during this period.** Although the results are statistically uncertain and not significant within a 68% confidence interval, they are consistent with previous empirical and practical experiences. This is supported by the results of variance decompositions. The Fed's decisions regarding the policy rate are influenced to a greater extent by the evolution of the output gap than by changes in inflation. In contrast, the ECB exhibits a stronger reaction to changes in the price level. A kind of divergence between the two central banks can be observed in the reactions of macro variables to monetary policy shocks. For U.S. data, in response to a unitary surprise monetary tightening, the output gap reacts more forcefully than the price level, whereas, for the ECB, a stronger reaction of inflation is observed.

These observations may be of particular interest considering that, in response to the rising inflationary pressure in 2022, the Fed's communication and the timing of the initiation of the interest rate hiking cycle suggest a willingness to approach inflation even at the cost of accepting a decrease in the output. The Federal Reserve relatively early, already in March 2022, initiated its interest rate hiking cycle (with a 25 basis point increase), and in its communication, it emphasized more strongly the risk of persistently high inflation. In contrast, the ECB reacted somewhat later, starting its interest rate hiking cycle in the summer of 2022 (with a 50 basis point increase), while its communication long argued for the transience of inflationary pressures and highlighted the avoidance of potential recessionary effects. **The results of the dissertation and current experiences point to the time-varying nature of the central bank reaction function.**

Based on the results, Hypothesis 1/B has been accepted.

1/B. Thesis: *Differences are observable among the reaction functions of the Federal Reserve and the ECB, as well as in the responses of macroeconomic variables to monetary policy shocks.*

The results articulated by Thesis 1/B support that the transmission and macroeconomic impacts of monetary policy decisions are significantly influenced by economic and financial structural conditions. This can be observed through the examples of the USA and the Eurozone. The examination of structural factors influencing monetary transmission in the literature is not exhaustive, and investigating rapidly changing structural conditions is of paramount importance. The results obtained by the dissertation emphasize the significance of studying these conditions and contribute to the existing findings and observations on the subject.

The first phase of the research examined the macroeconomic effects and real economic relevance of traditional interest rate policy between 1990 (1999 for the ECB) and 2008. The results are summarized in Table 2.

2. Table: The hypotheses, results, and theses of the research I.

1/A.	Hypothesis	<i>The impact of traditional interest rate policy on output can be observed through vector autoregressive models for the Federal Reserve and the ECB.</i>
	Results (methodology: sign-restricted VAR)	<ul style="list-style-type: none"> - The results of the recursive VAR model are not in line with economic theory; hence, the application of the sign restriction VAR model is justified. - In the sign restriction VAR model, the reactions to monetary policy shocks align with theoretical literature: a monetary tightening leads to a decrease in output and inflation, with a rise in the nominal interest rate. - In this model, both central banks exhibit significant real economic effects of monetary policy decisions.
	Thesis	The impact of traditional interest rate policy on output can be observed through sign-restricted vector autoregressive models for the Federal Reserve and the ECB.
1/B.	Hypothesis	<i>Differences are observable among the reaction functions of the Federal Reserve and the ECB, as well as in the responses of macroeconomic variables to monetary policy shocks.</i>
	Results (methodology: sign-restricted VAR)	<ul style="list-style-type: none"> - In the case of the Fed, the negative reaction of the policy rate to a supply shock suggests that, based on its dual mandate, the central bank can be considered more focused on regimes that prioritize the output gap during this period. - In contrast, the ECB's positive reaction of the policy rate to a negative supply shock indicates a preference for responding to inflation through interest rate increases. - The Fed's decisions regarding the policy rate are more influenced by the evolution of the output gap than changes in inflation, whereas for the ECB, it is the opposite. - Based on the results, the Fed can be regarded as operating more within a regime focused on the output gap, while the ECB operates within a regime more oriented towards inflation during this period.
	Thesis	Differences are observable among the reaction functions of the Federal Reserve and the ECB, as well as in the responses of macroeconomic variables to monetary policy shocks.

Source: own editing

The first set of theses demonstrates the significant impact of monetary policy on output among the examined central banks during the specified period. **The theoretical literature** (presented in Chapter 2 of the thesis) **supports the necessity of decomposing the interest rate channel.**

However, it is worth considering that within a complex economic system, the effects within the interest rate channel can vary significantly across countries or country groups due to differences in financial and economic structures. While a wide range of literature

examines the effects of monetary policy, the decomposition of the interest rate channel into consumption and investment expenditures is less commonly addressed. Decomposing the interest rate channel can contribute to a deeper understanding of how interest rate decisions permeate the economy.

Based on previous empirical research, **monetary policy in the United States tends to affect output more through consumption expenditures, while in the Eurozone, the impact is more pronounced through investment expenditures** (Angeloni et al. (2003); Fujiwara (2004); Phan (2013)). Given the observed differences between the two central banks in practical experiences and empirical literature, investigating these distinctions becomes a prominent task, leading to the formulation of the hypotheses examined in this dissertation.

2/A. Hypothesis: *Central bank interest rate decisions in the United States predominantly influence output through consumption expenditures, meaning that in the case of the Fed, consumption expenditures dominate the interest rate channel.*

2/B. Hypothesis: *Central bank interest rate decisions in the Eurozone primarily impact output through changes in investment expenditures, meaning that in the case of the ECB, investment expenditures dominate the interest rate channel.*

Based on the structural VAR analysis, central bank interest rate decisions influence output through consumption and investment expenditures. The results support the robustness of Thesis 1/A. **However, significant differences are observed among the examined central banks when analyzing the decomposition of the interest rate channel.** In the United States, consumption expenditures play a prominent role within the interest rate channel, while in the Eurozone, the dominance of investment expenditures is evident. In the United States, the shocks to consumption expenditures significantly and in the long term affect the output positively, whereas the reaction to investment expenditure shocks is noticeably smaller and statistically uncertain. In the Eurozone, the reaction of output to investment shocks is more significant and remains so in the long term, contrasting with the shocks to consumption expenditures. Consumption expenditures in the United States are less smooth and more interest-sensitive, while in the Eurozone, characterized by a more uniform consumption structure, expenditures are less

sensitive to interest rates, and investment sensitivity appears higher and more quickly adaptable.

There is also a difference between central bank reactions. The Fed responds significantly and forcefully to consumption shocks, while reacting weakly to investment shocks. In contrast, the ECB reacts weakly to consumption shocks, while responding strongly and significantly to investment shocks. Divergence is also observed in the interest sensitivity of output components for both subjects. It is noted that consumption expenditures are less interest-sensitive than investments for both research subjects; however, in the Eurozone, the interest sensitivity of investment expenditures is significantly higher than in the United States.

The results highlight the structural differences in interest rate transmission. The structural conditions of the economy fundamentally influence the mechanisms of interest rate decisions, which must be considered when making central bank decisions. The decomposition of the interest rate channel can contribute to a deeper understanding of how the interest rate channel operates and how interest rate decisions permeate the economy.

Based on the results, hypotheses 2/A and 2/B are accepted, while reinforcing the robustness of thesis 1/B.

2/A. Thesis: *Central bank interest rate decisions in the United States predominantly influence output through consumption expenditures, meaning that in the case of the Fed, consumption expenditures dominate the interest rate channel.*

2/B. Thesis: *Central bank interest rate decisions in the Eurozone primarily impact output through changes in investment expenditures, meaning that in the case of the ECB, investment expenditures dominate the interest rate channel.*

The results of the decomposition of the interest rate channel for the period before the 2008 crisis are summarized in Table 3.

3. Table: The hypotheses, results, and theses of the research II.

2/A.	Hypothesis	<i>Central bank interest rate decisions in the United States predominantly influence output through consumption expenditures, meaning that in the case of the Fed, consumption expenditures dominate the interest rate channel.</i>
	Results (methodology: SVAR)	<ul style="list-style-type: none"> - In the United States, the shocks to consumption expenditures significantly and in the long term positively influence the evolution of the output gap, while the reaction to shocks in investment expenditures is noticeably smaller and not significant. - Consumption expenditures are more interest-sensitive than investment expenditures, which can be explained by the less smoothed consumption structure and higher levels of indebtedness.
	Thesis	Central bank interest rate decisions in the United States predominantly influence output through consumption expenditures, meaning that in the case of the Fed, consumption expenditures dominate the interest rate channel.
2/B.	Hypothesis	<i>Central bank interest rate decisions in the Eurozone primarily impact output through changes in investment expenditures, meaning that in the case of the ECB, investment expenditures dominate the interest rate channel.</i>
	Results (methodology: SVAR)	<ul style="list-style-type: none"> - In the Eurozone, the dominance of investment expenditures is evident. The reaction of the output gap to investment shocks is more substantial and significant in the long term, in contrast to the shocks to consumption expenditures. - Investment expenditures are more interest-sensitive than consumption expenditures, which can be attributed to the stability of available income.
	Thesis	Central bank interest rate decisions in the Eurozone primarily impact output through changes in investment expenditures, meaning that in the case of the ECB, investment expenditures dominate the interest rate channel.

Source: own editing

The second phase of the research examined the macroeconomic effects of unconventional large-scale asset purchase programs between 2008 and 2020. The first part of the study focused on the real economic impacts, while the second part concentrated on the link between asset purchases, money supply, and inflation.

The global economic crisis that originated from the U.S. money and capital markets in 2008-2009 severely impacted both the U.S. and the Eurozone economies. The central banks, following the outbreak of the crisis, deviated from traditional central banking practices and initiated substantial, large-scale asset purchases in varying timing and amounts. According to existing empirical studies, the quantitative easing programs of the Federal Reserve (Fed) and the European Central Bank (ECB) significantly influenced the output and inflation in most cases. However, there is no consensus regarding the magnitude and persistence of these effects (e.g., Chung et al. (2012); Bernoth et al.

(2016); Weale – Wieladek (2016); Hesse et al. (2018) Kim et al. (2020); Stefanski (2021); Lhuissier – Nguyen (2021)).

In this dissertation, a recursive vector autoregressive (VAR) model incorporating 7 variables was employed to examine quantitative easing processes. However, it utilized different variables and a longer time horizon compared to previous empirical studies. While prior quantitative research has typically focused on monetary and real economic aspects, this study also extensively examined the transmission channels of asset purchases.

3. Hypothesis: *In the cases of the Federal Reserve and the European Central Bank, large-scale asset purchases had a significant impact on the trajectory of output in the years following the 2008 crisis.*

In the case of the United States, the fundamental objective of asset purchases introduced from the early stages of the crisis was initially to navigate through the acute phase of the crisis, followed by maintaining inflation around the target and closing the output gap. According to the model results, for the **Fed** during this period, the impact of traditional monetary policy on output was lacking, while the **shock of asset purchases directly and significantly influenced the output gap in the long term. The inflationary effects of quantitative easing, based on the model results, appear to be long-term,** while short-term effects are not significant. Commitment to asset purchases, banking system liquidity, rising asset prices, and declining yield levels may influence the price level in the long run.

Among the real economic channels of asset purchases, the dominant ones in the U.S. are the banking liquidity channel, the portfolio balance channel, and the monetary policy signaling channel. The increase in banking liquidity, supported by a decrease in the general interest rate, may incentivize banks for credit expansion under appropriate credit demand conditions, thus expanding aggregate demand. Asset purchases significantly affected the prices of assets outside the purchasing circle through portfolio rebalancing, indicating a substantial impact of quantitative easing on asset prices. With lower corporate financing costs and higher stock prices, corporate investment activities increase, while the rise in securities prices also appreciates the financial wealth of the households, contributing to an increase in consumption.

The ECB introduced its large-scale quantitative easing program, the Asset Purchase Program (APP), later than the Fed, following the effects of the European debt crisis, during the deflationary pressure period in 2015. However, **in the Eurozone, the impulse response functions suggest a direct, yet smaller impact of asset purchases on output compared to the Fed.** Additionally, **asset purchases positively and significantly affect inflation in the Eurozone**, indicating that the APP introduced during the deflationary pressure period directly impacted inflation.

Examining the transmission channels of quantitative easing, the **dominance of the banking financing channel and the direct impact of government bond purchases on the yield curve are observed**, while the portfolio rebalancing effect is not significant in the case of the ECB. Given that the movement of long-term yields plays a significant role in shaping aggregate demand in the eurozone, and asset purchases had a significant impact on 10-year government bond yields, it can be concluded that indirectly, through the reduction of long-term yields and the provision of banking system liquidity, asset purchases could substantially influence aggregate demand.

The results suggest that monetary policy can have a decisive impact on the real economic conditions through asset purchases. Examining the transmission channels of asset purchases reveals differences between the two central banks, emphasizing that asset purchase programs need to be tailored to the structural conditions of the respective economy.

Based on the results, the following thesis can be formulated:

3. Thesis: *In the cases of the Federal Reserve and the European Central Bank, large-scale asset purchases had a significant impact on the trajectory of output in the years following the 2008 crisis.*

The research, diverging from the money market focus of previous empirical studies, investigated the macroeconomic effects of asset purchases and their transmission using a methodology similar to the one I applied. According to empirical studies employing models similar to the methodology I used, the quantitative easing programs of the examined central banks significantly influenced output and inflation in most cases, yet there is no consensus on the magnitude and persistence of these effects. **The results of**

this study expand on previous empirical observations, while the examination of the real economic transmission channels of asset purchases appears as a novel outcome.

In the model analyzing asset purchase programs following the 2008 crisis, a long-term inflationary effect of asset purchases was observed in the case of the Fed. The fundamental operation of monetary policy decisions expects them to have only short-term, transient effects on macroeconomic variables, while in the long run, variables converge towards their equilibrium levels according to market self-regulation. The results for the United States question this expectation. Therefore, the focus of the model, which is centered on money supply and inflation, aimed to examine these results in a model supplemented with multiple relevant variables. The empirical analysis primarily focused on the Fed, but as a control model and to enhance the robustness of the results, a model related to the European Central Bank (ECB) was also presented.

4. Hypothesis: *The asset purchase-induced expansion of money aggregates did not result in high inflationary pressure for the Federal Reserve and the European Central Bank in the years following the crisis.*

In the model expanded with money aggregates focusing on inflation processes concerning **the Federal Reserve (Fed), the asset purchase shock, within a 68% confidence interval, raises inflation in the medium term (5 quarters)** and returns to the equilibrium path in the long run. The model concentrating on inflation processes more accurately describes the inflationary effects of asset purchases while remaining consistent with theoretical literature. In the **Eurozone**, the inflation response to the asset purchase shock followed the pattern of the previous model. **The asset purchase shock temporarily increases the price level for 2-3 quarters and then reverts to its equilibrium state.** The results obtained reinforce the robustness of the previous 7-variable model.

Quantitative easing can influence inflation processes at various points, but the data indicate that the money abundance caused by quantitative easing materialized in bank deposits due to commercial banks over-reserving and private-sector portfolio decisions. **For the examined central banks, the shocks to money aggregates do not cause significant shifts in the price level.** The disruption of the relationship between money supply and inflation can likely be explained by the prevailing negative output gap during

the period. In contrast, for the Fed, short-term inflation expectations are influenced by asset purchases and the evolution of time deposits, and in the long run, they are influenced by the level of over-reserving. Observations suggest that asset purchases temporarily impact inflation dynamics; however, under restrained credit extension and proper sterilization, money aggregate shocks do not cause significant movements in the price level. Still, they influence inflation expectations, and the signaling channel of asset purchases becomes apparent. **In the case of the U.S. central bank, it is observable that money aggregate shocks are incorporated into inflation expectations**, indicating that the changes in money supply caused by quantitative easing facilitate the achievement of the medium-term inflation target for the examined central bank. **In the ECB's model, inflation expectations do not significantly respond to shocks in the variables.** The obtained results may be explained by the notion that inflation expectations in the Eurozone are considered more anchored during the period.

Based on the results, Hypothesis 4 has been accepted:

4. Thesis: *The asset purchase-induced expansion of money aggregates did not result in high inflationary pressure for the Federal Reserve and the European Central Bank in the years following the crisis.*

The impact of asset purchases on inflation remains a subject of ongoing economic debates. The novelty of this research lies in the fact that the applied model specifically captures the inflationary effects of money aggregate expansions through asset purchases. **The results contribute to a deeper understanding of the inflationary effects of asset purchases.**

The results of the second phase of the research are summarized in Table 4.

4. Table: The hypotheses, results, and theses of the research III.

3.	Hypothesis	<i>In the cases of the Federal Reserve and the European Central Bank, large-scale asset purchases had a significant impact on the trajectory of output in the years following the 2008 crisis.</i>
	Results (methodology: SVAR)	<ul style="list-style-type: none"> - For the Fed, the direct effect of asset purchases, boosting output, is evident, while the indirect effects are dominated by the bank liquidity channel, portfolio rebalancing effect, and signaling channel. - In the case of the ECB, the direct impact of asset purchases on output is smaller. Asset purchases have also had a substantial, indirect impact on aggregate demand through the decrease in long-term yields and the bank liquidity channel.
	Thesis	In the cases of the Federal Reserve and the European Central Bank, large-scale asset purchases had a significant impact on the trajectory of output in the years following the 2008 crisis.
4.	Hypothesis	<i>The asset purchase-induced expansion of money aggregates did not result in high inflationary pressure for the Federal Reserve and the European Central Bank in the years following the crisis.</i>
	Results (methodology: recursive VAR)	<ul style="list-style-type: none"> - Asset purchases exert upward pressure on inflation at most in the medium term. - The expansion of MB and M2 does not induce inflationary movements. - However, in the case of the Fed, their effect on inflation expectations is discernible, supporting the central bank's medium-term inflation target.
	Thesis	The asset purchase-induced expansion of money aggregates did not result in high inflationary pressure for the Federal Reserve and the European Central Bank in the years following the crisis.

Source: own editing

Summarizing the lessons of the thesis, the research examined the real economic effects of the monetary policies of globally influential central banks, namely the Fed and the ECB, using econometric methods for the period between 1990 and 2020. **Beyond the observation period of the thesis, it could provide further research directions by extending the period under consideration.** Firstly, exploring the effects of aggregate demand and supply shocks during the COVID-19 pandemic is crucial. The central banks under study responded to the pandemic's impact by expanding asset purchases, and investigating this response could be of significant importance for future research. Secondly, in parallel with the high inflationary pressures following the year 2021, traditional interest rate policies have regained prominence for the central banks under scrutiny, while the cessation of asset purchases and the withdrawal of securities from central bank balance sheets (quantitative tightening) have opened up new areas of

research. **Furthermore, in the future, it may be worthwhile to expand the scope of the research subjects.** Specifically, examining the monetary policy of Hungary, with particular attention to the time-varying nature of interest rate policy. Additionally, comparing the current results and future lessons from Hungary with the experiences of regional countries (Poland, Czech Republic, Romania) could be valuable.

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