The Effects of Monetary Policy on Income Inequality: Evidence from Germany

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Abstract

This paper studies the effects of conventional and unconventional monetary policy on income inequality in post-reunification Germany. Using the policy rate set by the Bundesbank from 1991 to 1998 and the ECB's main refinancing operations rate from 1999 to 2018 as the measure of conventional monetary policy, while quantitative easing is proxied by the 10-year German government bond yield, an autoregressive distributed lag (ADL) model is estimated with OLS to assess the impact of these variables on the Gini coefficient. The findings indicate that expansionary conventional monetary policy, that is, a reduction of the policy rate set by the central bank, is inequality-decreasing. On the other hand, unconventional monetary policy measures have a positive effect on the Gini coefficient in Germany from 1991 to 2018.

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List of Abbreviations

APP	Asset Purchase Programme
ADL	Autoregressive Distributed Lag
BoJ	Bank of Japan
CEX	Consumer Expenditure Survey
CMP	Conventional Monetary Policy
CPI	Consumer Price Index
DSGE	Dynamic Stochastic General Equilibrium
ECB	European Central Bank
Fed	Federal Reserve System
GDP	Gross Domestic Product
IP	Industrial Production
IRF	Impulse Response Function
MRO	Main Refinancing Operations
OLS	Ordinary Least Squares
OVB	Omitted Variable Bias
QE	Quantitative Easing
RBC	Real Business Cycle
SOEP	German Socio-Economic Panel
UMP	Unconventional Monetary Policy
VAR	Vector Autoregression
WSI	Institute of Economic and Social Research

1 Introduction

The mandate of central banks around the world has historically largely disregarded inequality effects when deciding upon policy courses. The European Central Bank's (ECB) primary mandate is to maintain price stability, since, according to the ECB's website, that is the best contribution monetary policy can make to enhance economic growth and create jobs. The Federal Reserve System's (Fed) objectives go a bit further with its dual mandate of fostering economic conditions to achieve both stable prices and maximum sustainable employment. Nevertheless, inequality is a worldwide issue extensively discussed among economists and politicians alike, and an accelerating globalization plus bestsellers such as "*Capital in the 21st Century*" by Thomas Piketty (2014) have led to increased devotion to this topic. Similarly, it plays an important role in the economic sciences, as the relationship between inequality and (financial) development is fundamental in the study of economics [Roine et al. (2009)].
Against this background, in recent years, the public, policy-makers and the board members of the ECB, among others, have started to consider the potentially inequality-enhancing effects of monetary policy following the prolonged period of Quantitative Easing (QE) [Guerello (2018)]. Notably, since the financial and sovereign crises, Guerello (2018) explains, central bankers across Europe have increased their interest in the distributional impact of monetary policy because of the possibility that the unconventional methods undertaken by the ECB might have merely led to an increase in asset prices from which rather wealthy people may have benefitted the most, leading to an increase in inequality. In turn, this resulting inequality could negatively impact consumption and long-term growth. Also for these reasons, in 2012, the British government recommended the Bank of England to begin to consider the distributional effects of its unconventional monetary policies [Mumtaz and Theophilopoulou (2017)].
It thus seem interesting to study the question: what are the effects of conventional and unconventional monetary policies on the levels of income inequality? The existent academic literature generally finds that expansionary conventional monetary policy (CMP) has equalizing effects. Examples include the studies by Coibion et al. (2017) for the U.S., Mumtaz and Theophilopoulou (2017) for the U.K. and Guerello (2018) for the euro area. On the other hand, an expansionary unconventional monetary policy (UMP) shock, typically in the form of QE, appears to have an inequality-increasing impact throughout the literature as for instance in the analysis by Saiki and Frost (2014) on the distributional impact of UMPs in Japan.
This analysis attempts to answer this research question by studying the case of Germany. To this end, an autoregressive distributed lag (ADL) model is estimated in which the Bundesbank's Diskontsatz, which functioned as the main policy rate in Germany before

the ECB was established enters as the measure of CMP from 1991 to 1998. For the period from 1999 to 2018, the main refinancing operations (MRO) rate set by the ECB replaces the Diskontsatz as the CMP measure. UMP is captured by the yield of the 10-year German government bond, as one of the main goals of QE is to flatten the yield curve through its massive long-term bond purchases [Priftis and Vogel (2017)]. For the inequality measure, the Gini coefficient constructed by Spannagel and Molitor (2019) based on the German Socio-Economic Panel (SOEP), which is an *income* inequality Gini[1], is employed. Since the Gini coefficient is the only variable in the model that is not available at quarterly frequency, a linear interpolation is applied in which quarterly Gini data are generated to allow for a substantially larger sample period, specifically, from 1991Q1 to 2018Q1. The results from estimating the ADL model with ordinary least squares (OLS) are consistent with the rather young academic literature. A one percentage point hike in the policy rate set by the central bank, that is, a contractionary CMP shock, leads c.p. to an increase in income inequality of 0.002% after one year, as measured by the Gini coefficient. Regarding the impact of UMP, a one percentage point increase in the yield of the 10-year German government bond is associated with a fall of the Gini coefficient of 0.004% after four quarters. This can analogously be interpreted in the opposite direction: A reduction in the 10-year German government bond yield resulting from QE has an inequality-increasing effect on income inequality levels.

To my knowledge, there are no other studies that analyze the impact of both conventional and unconventional monetary policies for the specific case of Germany estimating an ADL model over the period direct after German reunification up to the latest available data on income inequality, that is, from 1991 to 2018. The most closely related work is perhaps the study by Guerello (2018) who assesses the impact of CMP and UMP for euro area countries using a vector autoregression (VAR), yet over a shorter sample period, from 1999 to 2015.

The remaining of this paper is structured as follows. Section 2 provides an extensive literature review on monetary theory and on the empirical evidence of the effects of both conventional and unconventional monetary policies. In addition, section 2 introduces the relationship between monetary policy and income inequality by explaining the transmission channels through which monetary policy may affect inequality and presents some of the empirical evidence on this specific topic. Section 3 depicts the empirical analysis, including the data and the methodology and presents the findings. Moreover, in section 3 some robustness checks are conducted and the limitations of the ADL model are discussed. Section 4 concludes and points out potential policy implications.

[1]Throughout this paper, unless specified otherwise, the term inequality refers specifically to income (and not wealth) inequality.

2 Literature Review

Before getting into the empirical analysis, this literature review provides a brief historical overview of monetary theory, followed by a review of the academic work on the macroeconomic effects of both conventional and unconventional monetary policy. Subsequently, the theoretical channels through which central bank policy impacts inequality and the rather young empirical literature on the effects of monetary policy on inequality are addressed.

2.1 A Brief History of Monetary Theory

Historically, many researchers in the macroeconomic field have attempted to bring more understanding into the complex relationship between monetary policy and other macroeconomic variables such as inflation, employment, aggregate demand or output. This has led to the emergence of numerous theories and schools of thought regarding the real effects of money i.e. monetary policy on the economy since Keynes' infamous *General Theory* was published in 1936. In this work he sets some fundamentals in macroeconomics related, among others, to money mechanisms in general equilibrium. One prominent theory introduced by Keynes (1936) is the Liquidity Preference Theory, which explains how demand for money is determined by a preference of economic agents for liquidity. The main idea behind this theory is that individuals have a high inclination to remain liquid, such that the interest rate can be interpreted as the opportunity cost of holding money i.e. as the "price" for money. In other words, economic agents require a higher interest rate to incentivize them to invest liquid money in less liquid bonds[2][Keynes (1936)]. Furthermore, the Liquidity Preference Theory conjectures that money supply is exogenously set by the central bank, where an increase in the money stock causes the interest rate to fall which in turn leads to an increase in the demand for money, such that equilibrium in the money market is preserved [Twinoburyo and Odhiambo (2018)]. This means that the interest rate is determined by the money market equilibrium. Therefore, assuming constant prices, a policy that increases the money stock decreases the interest rate generating a positive feedback effect on investment, ergo leading to an expansion of output [Sims (1992)]. This mechanism is formalized by Hicks (1937) in a paper where he introduces the IS-LM framework one year after Keynes' book is published. Figure 1 depicts how an expansionary monetary policy affects the interest rate and output in the IS-LM model.

In this essentially static model, under the assumption of fixed prices, the IS (investment-saving) curve which is downward sloping represents every combination of the level of the interest rate and output in which the goods market is in equilibrium, while the upward-sloping LM (liquidity preference-money supply) curve represents equilibrium in the money

[2] The term *bonds* refers broadly to securities, such that it may include government bonds or stocks.

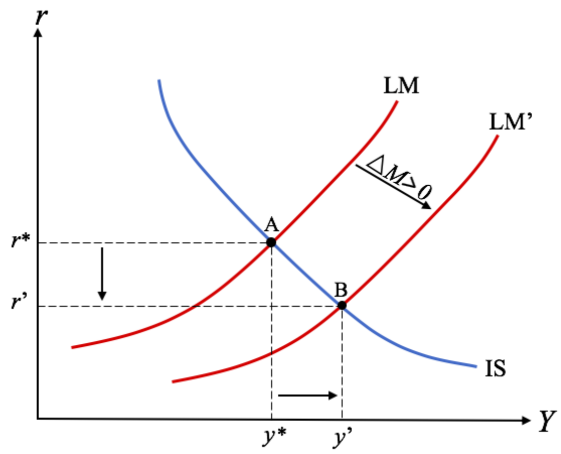

Figure 1: Expansionary Monetary Policy in the IS-LM Model

market for given levels of the interest rate and output [Hicks (1937)]. This implies that an increase in the money supply shifts the LM curve outward leading to a fall in the interest rate (from r^* to r') and an increase in output (from y^* to y'), assuming the IS stays fixed under this expansionary policy [Sims (1992)]. The simultaneous equilibrium in the goods and money markets then shifts from point A to point B.

Even though this simple general equilibrium framework for economic policy analysis still survives today in many macroeconomics textbooks, there is still not a consensus among economists regarding the accuracy of the IS-LM model, the real effects of money, or the power of monetary policy. Also Keynes' view on the role and effectiveness of monetary policy varied over the years. Moggridge and Howson (1974) document how, despite the common belief that Keynesian economics is characterized by the idea that monetary policy is at most a rather weak instrument for economic stabilization while, on the other hand, fiscal policy is the evident tool to steer the economy during recessions, Keynes himself did not refute the importance of monetary policy, only the extent of its effectiveness. In *The General Theory*, he expresses this potential impotence of monetary policy in times of economic downturns by arguing that when the interest rate falls below a certain level liquidity preference is nearly absolute, meaning that individuals prefer to hold cash instead of bonds which offer very low yields. At this point, policy by central bankers cannot influence the interest rate anymore [Keynes (1936)]. This aspect is also formalized in the IS-LM model as the "liquidity trap" in the form of a virtually flat left part of the LM curve. Thus, if the IS curve intersects the LM curve on its left flat part, any changes in the money supply that shift the LM curve affect neither the interest rate nor real output [Krugman (2000)].

A few decades after Keynes' and Hicks' groundbreaking work, monetarism emerged in the 1960s under the influence of economists like Milton Friedman, Anna Schwartz and Alan Greenspan. Monetarism is based on the Quantity Theory of Money as formulated by Irving Fisher in the pre-Keynesian era and differs in some important aspects to Keynesian economics [Goodfriend and King (1997)]. The main difference lies in the belief of monetarists that the efficient tool of stabilization during crises is monetary and not fiscal policy, while monetary policy should be conducted by controlling the quantity of money circulating in the economy through open market operations rather than by targeting the nominal interest rate directly [Cagan (1989)]. Friedman (1968) argues that the common belief that the Fed made strong efforts to curb the Great Depression is misleading and that it actually followed contractionary policies, allowing the monetary base to fall sharply, such that it failed to provide liquidity to the banking system as was its main task according to the Federal Reserve Act of 1913.

Post-monetarism was firstly dominated by Real Business Cycle (RBC) theory which emerged as a result of the introduction of rational expectations into macroeconomic models in the early 1970s and Lucas' Critique in 1976 regarding the lack of microfoundations in macroeconometric modeling [Goodfriend and King (1997)]. In contrast to the traditional IS-LM, RBC models are fully dynamic and incorporate optimizing economic agents (consumers, firms, governments) with rational expectations [Sims (1992)]. Another fundamental difference to the IS-LM framework and one of the disadvantages of RBC models concerns the effects of money on macroeconomic fluctuations. Since RBC models are characterized by completely flexible prices, monetary shocks (e.g. a change in the money supply) do not affect real quantities or relative prices but only have an impact on nominal prices [Romer (2012)]. Thus, an approach to critically test the performance of RBC models is studying whether monetary shocks have real effects on the economy.

As an alternative to the flexible-prices models of RBC theory, a New-Keynesian approach to macroeconomic modeling emerged, in which monetary disturbances have substantial real effects and are viewed as an important source of output variation, since they are characterized by incomplete adjustment of nominal prices and/or wages (nominal rigidities) [Romer (2012)]. Since modern conventional monetary policy does not focus on the money supply but rather targets the short-term nominal interest rate, the LM curve is replaced by the MP (monetary policy) curve which, contrary to the IS-LM model, includes optimizing agents with rational expectations i.e. a monetary policy rule, such as the Taylor Rule [Romer (2012)]. John Taylor (1993) formulates this rule where the nominal interest rate is set by central banks as an increasing function of the output gap and the inflation rate in order to fulfill their mandate of maintaining price stability and pursuing economic growth[3]. Equation 1 describes this relationship as follows:

$$i_t = \pi_t + r_t^* + \alpha_\pi(\pi_t - \pi_t^*) + \alpha_y(y_t - \overline{y}_t) \tag{1}$$

[3]This rule is based on the Fed's mandate. The exact mandate of central banks can vary across countries.

Where i_t is the nominal interest rate (i.e. federal funds rate), π_t is inflation, r_t^* is the real interest rate, π_t^* is the target inflation by the central bank, y is real GDP in logs and $\overline{y}_t$ is the log of potential output. This rule suggests that if output is lower (higher) than potential output, or inflation is lower (higher) than the target, the central bank should decrease (increase) the interest rate.

More recently, complex dynamic stochastic general equilibrium (DSGE) models have been developed which include nominal rigidities, optimizing agents and monetary policy. One example is the DSGE model by Clarida et al. (1999) that incorporates temporal nominal price rigidities and money. Within their framework, the monetary policy instrument is a short-term interest rate which affects the real economy in the short run, much as in the IS-LM model. The crucial difference is that the aggregated equations are derived from behavioral optimization by households and firms. Another key feature of the DSGE model by Clarida et al. (1999) is that the current behavior of economic agents depends not only on current policy but also on the expectations of the future course of monetary policy.

Moreover, models of unconventional monetary policy have been constructed, such as the one by Priftis and Vogel (2017). They develop a DSGE model for the euro area that incorporates QE in its initial form as well as in its subsequent modifications by introducing the ECB's balance-sheet operations in the model. The decision by the central bank to purchase long-term bonds is modeled as an endogenous response to the economic environment, e.g. the output gap or the slope of the yield curve. The results of their simulations are summarized in section 2.2.2.

2.2 Evidence on the Effects of Monetary Policy

After reviewing the evolution of monetary theory throughout the 20th century up to the most recent models, the next section provides a summary of the empirical literature on the effects of CMP, i.e. targeting the short-term nominal interest rate or the money supply. Section 2.2.2 is concerned with the economic impact of unconventional measures, specifically, large-scale asset purchase programs by central banks.

2.2.1 Conventional Monetary Policy

Three commonly used methods that aim at identifying the impact of monetary policy are the St. Louis equation (simple regression of money on output), natural experiments and more sophisticated statistical procedures such as vector autoregressions (VARs). These approaches also provide a critical test of pure RBC models since in these, as mentioned above, monetary shocks do not have real effects.

The St. Louis equation was introduced by Andersen and Jordan (1968) from the Federal Reserve Bank of St. Louis. An applied example of this equation is presented in Romer (2012), where the dependent variable is real GDP, while the monetary explanatory variables consist of the current value and four lags of M2 money growth. To control for trends in output and money growth a time trend is included. The regressions are run for the sample period 1962Q2 - 2008Q4 and the findings, which are statistically significant, indicate that if the Fed increases the money stock by one percent, output will be 0.25% higher after one year. Nevertheless, there are some major concerns regarding the ability of the St. Louis equation to identify *causation* from money to output, such that these results might be misleading. As Romer (2012) explains, firms may increase their demand for money because they plan on increasing production, and households may increase their demand for money because they intend to raise their consumption levels. This would create a case of reverse causality where the observed movements in the money stock in advance of output movements are actually caused by the anticipated higher demand of firms and households, such that the changes in output are the ones to cause the movements in money and not vice versa. Furthermore, as Kareken and Solow (1963) point out, there might be an omitted variable bias (OVB) in the estimates of the St. Louis equation. If, for instance, changes in policy by the central bank aimed at neutralizing other factors that have a negative impact on output are successful, monetary policy will have had a real impact on the economy even if output did not fluctuate.

The use of natural experiments or, as Romer and Romer (1989) call it, the "narrative approach", was pioneered by Friedman and Schwartz (1963) in their work titled "*A Monetary History of the United States, 1867-1960*" and is based on evidence from historical records. Its key feature is the identification of monetary shocks through non-statistical methods in which the determinants behind monetary policies are independent from developments in the economy [Romer and Romer (1989)]. Friedman and Schwartz (1963) investigate such episodes in the U.S. since the end of the Civil War until 1960 and find that many of these shifts in the money supply were followed by output movements in the same direction. Thus, the authors argue that this is evidence that there is a causal effect from money to output.

Turning to modern statistical procedures to measure the effects of monetary policy, a popular technique nowadays is the use of VARs, which were introduced in a more sophisticated form by Sims (1980). Simply put, a VAR is a system of equations (vectors) in which every variable is regressed on its own lagged values and on the lagged values of the other variables in the model [Romer (2012)]. Modern VARs have switched from using the money stock to using the central bank policy rate as the measure of CMP, because money supply often varies in response to shifts in money demand and not due to central bank policy [Romer (2012)].

Sims (1992) estimates VARs with monthly data for Germany, France, Japan, the U.S. and the U.K. using the following variables: short-term interest rate, an index for the value of domestic currency, a commodity price index, a monetary aggregate, a consumer price index (CPI), and an index for industrial production (IP). The variables enter the VAR system each with 14 lags for the sample period 1957-1990. The impulse response functions (IRFs) are depicted over a span of 48 months and feature a persistent and negative effect on money supply and output from an increase in the interest rate, consistent across the five countries. These results are in line with the IS-LM framework of monetary policy by Hicks (1937) described in section 2.1.

Another contribution to the applied-VAR literature is made by Cochrane (1998). He runs two VARs: one aimed at measuring the impact of a shock to M2 money and another aimed at assessing the effects of a change in the federal funds rate, both over the period 1959-1992 with quarterly data. A novel feature of this analysis is including the assumption that *anticipated* monetary policies also can have an effect on output and not only unanticipated shocks, as other economists believe[4]. Cochrane (1998) finds that a one-standard deviation unexpected increase in M2 leads output to rise by about 0.5% at its peak, which occurs two years after the shock and returns to its original path after five years. Regarding the interest rate, his results indicate that an unanticipated rise in the funds rate by one percentage point depresses output by 0.6% after 1.5 years, the effect also dying out after about five years. Changing the underlying assumption, letting anticipated changes in monetary policy impact the economy, leads to substantially shorter and weaker movements in output and consumption after shocks to M2 and to the interest rate [Cochrane (1998)].

2.2.2 Unconventional Monetary Policy

During the Financial Crisis of 2008, the Fed felt the need to go beyond the so-called conventional monetary policy measures, such as accommodating the interest rate or making changes in the money supply through open market operations. Having already lowered the federal funds rate to a level close to zero, the Fed implemented an *unconventional* method, namely a large-scale asset purchase program today known as Quantitative Easing (QE)[5]. QE is a monetary policy strategy that substantially increases the balance sheet of a central bank through asset purchases, thus providing additional liquidity to the economy [Priftis and Vogel (2017)]. In the case of the euro area, the ECB struggled not only with the aftermath of the Great Recession but also with the sovereign debt crisis that peaked between 2010 and 2012. In order to address weak inflation dynamics, the

[4]See, for example, Lucas (1972).

[5]Large-scale asset purchase programs had already been implemented by the Bank of Japan (BoJ) in 2001.

ECB, which was also operating close to the zero bound, announced its Asset Purchase Programme (APP) on September 2014, which consisted on buying €60 billion worth in bonds of Eurozone countries on a monthly basis starting on March 2015 until at least September 2016 [Elbourne et al. (2018)].
There are several theoretical and empirical studies that attempt to estimate the macroeconomic effects of these UMPs. On the theoretical side, a recent example is the model by Priftis and Vogel (2017) mentioned in section 2.1. The impact of QE in the Eurozone resulting from their simulations are summarized in Table 1.

Table 1: Effects of the ECB's QE Programs

	Initial APP	Extended programs
Increase in real GDP	0.2 %	0.4 %
Increase in price levels	0.3 %	0.6 %
Effective euro depreciation	0.4 %	1.1 %

Source: Priftis and Vogel (2017)

The authors conjecture that the positive GDP effect is driven by higher private consumption and investment associated with lower savings and the portfolio rebalancing towards riskier assets that results from the very low yields of long-term bonds caused by the ECB's massive purchases.
The empirical literature on the effects of QE also focuses on the use of VARs as the main statistical tool. One such example is the study by Gambacorta et al. (2014). They estimate a panel structural VAR (SVAR) using monthly data over a sample period from January 2008 to June 2011 for eight advanced economies[6]. The resulting IRFs suggest that an expansionary UMP shock, i.e. a positive shock to the central banks' balance sheet leads to a significant but only temporary rise in output and inflation. The exogenous shock increases output by 0.1% after six months and the effect gradually dies out after about 18 months. The impact on the price level is less persistent and weaker, featuring a rise of 0.04% about six months after the shock but already returning to the baseline after 12 months. Interestingly, Gambacorta et al. (2014) find no significant cross-country differences in the macroeconomic effects of these UMP shocks.
This is not the case in the analysis by Burriel and Galesi (2018), who estimate a global VAR that uses panel variation amongst all euro area economies and find substantially

[6]The economies included in the panel are Canada, the euro area, Japan, Norway, Sweden, Switzerland, the U.K. and the U.S.

heterogeneous QE effects from January 2001 to December 2015 across countries. A novelty of their global VAR is that they explicitly take cross-country interdependencies into account, allowing for spillover effects of UMPs to be measured. Burriel and Galesi (2018) find that a one-standard deviation UMP shock which translates into an increase of the ECB's balance sheet by 1.25% has a significant positive effect on output and inflation in most euro area countries.
However, as Hansen and Sargent (1991) argue, using the balance sheet as the measure for UMPs might lead to biased estimates due to the information structure at hand, in which the actions of the central banks such as the ECB's APP are announced in advance. Therefore, Wu and Xia (2016) instead develop a model that incorporates a negative shadow rate with its maximum being zero. This shadow rate is derived from bond rates and avoids the information structure bias of QE announcements since, assuming that markets are efficient, all public information about the future volume of a central bank's balance sheet is reflected in bond rates [Elbourne et al. (2018)]. It is used by Wu and Xia (2016) in a VAR with monthly U.S. data from July 2009 to December 2013 and they find that the UMPs by the Fed succeeded in reducing the unemployment rate by one percentage point compared to the level it would have had in the absence of these expansionary policies, while the IP index would have been 101.0 instead of 101.8. Interestingly, the QE effects on inflation exhibit a price puzzle since instead of increasing, as in the studies discussed above, the CPI decreased by one unit.
Lastly, Elbourne et al. (2018) apply the shadow rate by Wu and Xia (2016) in a SVAR with monthly data for the euro area from January 2009 to November 2016. They find rather weak evidence suggesting that a one-standard deviation unconventional monetary shock leads to a peak increase of GDP of 0.05% after 20 months while the impact on inflation is not significant.

2.3 Monetary Policy and Inequality

Having reviewed the academic literature on monetary theory and the evidence of the overall macroeconomic impact of monetary policies in sections 2.1 and 2.2, respectively, this section describes theoretical channels through which central bank policies can affect wealth and income inequality and provides some empirical evidence of this relationship.

2.3.1 Theoretical Transmission Channels

Prior to presenting the empirical analysis, it is essential to explain the theoretical mechanisms that link monetary policy to the levels of inequality in an economy. The literature on this specific topic broadly summarizes the distributional transmission mechanism of monetary policy into five channels[7].

The fact that there is heterogeneity across households regarding their primary sources of income leads to the *income composition channel.* While most households depend primarily on labor earnings, others receive larger shares of their income from business, capital or transfer income. To the extent that monetary policy affects these different forms of income heterogeneously, different types of households will experience different responses to their income. For example, wealthier households generally receive relatively more capital income and since this type of income tends to increase relative to wages after expansionary monetary shocks through an increase in asset prices, this mechanism will tend to contribute to a rise in income inequality.

Another channel that tends to work in the same direction is the *financial segmentation channel.* If some households actively participate in financial markets such that they are affected by changes in monetary policy in advance of other households, an expansionary monetary policy shock will generally benefit agents most connected to financial markets more compared to unconnected individuals.

A third channel is the *portfolio composition channel.* Assuming that low-income households hold relatively more cash than high-income households which hold a larger share of there wealth in other types of financial assets, the increased inflation resulting from expansionary central bank policies could generate a transfer from low-income households to high-income households, leading to a rise in inequality.

Nevertheless, there are also channels through which an expansionary policy can positively affect income inequality. One such transmission mechanism is the *savings redistribution channel.* An unexpected increase in inflation due to an expansionary shock can benefit borrowers and hurt savers as in Doepke and Schneider (2006). To the extent that, typically, wealthier households are savers while low-income households are borrowers, this channel decreases inequality as inflation decreases the value of debt payments.

The second channel working in this direction is the *earnings heterogeneity channel.* Labor earnings of low-income and high-income households may be affected to a differing extent by expansionary central bank policies. For instance, as Heathcote et al. (2010) show, labor income and employment react the strongest to business cycle fluctuations at the bottom of the distribution, such that a policy rate cut that lowers unemployment in the short run tends to disproportionally benefit low-income households, thus, reducing income inequality.

2.3.2 Empirical Evidence

One of the earlier works to empirically study this topic is that by Romer and Romer (1998), who analyze the long-run relationship between CMP and poverty and inequality

[7]Examples include Bundesbank (2016), Coibion et al. (2017), Guerello (2018) and Bunn et al. (2018).

for a sample of 76 countries from 1980 to 1990. However, the authors do not use the tools available to central banks as the measures of monetary policies but instead macroeconomic indicators that, according to Romer and Romer (1998), monetary policy affects most in the long run, namely average inflation and aggregate demand variability. Their results indicate that a one percentage point rise in average inflation is associated with an increase in the Gini coefficient of 0.2 percentage points, while a positive one-standard deviation in demand variability is associated with a 2.9 percentage point increase in Gini. Nevertheless, the interpretation of this findings requires caution since they are about correlations rather than causal effects. Therefore, the possibility of an OVB is present in this case, since average inflation and aggregate demand volatility are not solely determined by monetary policy actions.

More recently, an influential paper by Coibion et al. (2017) attempts to quantify the inequality effects of CMP shocks. They construct a Gini coefficient from U.S. quarterly household-level data based on the Consumer Expenditure Survey (CEX) from 1980Q1 to 2008Q4. Estimating the IRF of Gini to a one percentage point contractionary shock to the federal funds rate, Coibion et al. (2017) observe a rise in the inequality coefficient of 1.5 percentage points occurring about 18 months after the shock.

While these results refer to shocks to the federal funds rate, Saiki and Frost (2014) investigate the effects of UMPs on income distribution in Japan, a country with considerable experience with unconventional methods. Employing a VAR with Japanese household survey data from 2008Q3 to 2013Q3, a period when the BoJ reinstated its massive asset-purchase program, the authors find that an expansionary monetary shock, measured as a positive one-standard deviation in assets held by the BoJ relative to GDP, increases the top to bottom quintile ratio by 0.1 percentage points. This result opposes the findings by Coibion et al. (2017), yet they are not necessarily inconsistent. Saiki and Frost (2014) point out that the distributional impact of UMP may be essentially different from the impact of CMP since it disproportionally increases asset prices. When the overall economy is stagnant, as during the Great Recession, this increase benefits the households with larger financial asset holdings, which are generally high-income households. On the other hand, low-income households which hold less financial assets, do not experience an impact on wages and may even be negatively affected by lower interest rate earnings on saving accounts, and this disparity can lead to higher inequality.

Another example comes from Mumtaz and Theophilopoulou (2017), who estimate a SVAR for the U.K. over the period 1969 to 2012 and examine the impact of both CMP and UMP on wage and income inequality. Across their estimates, at the one year horizon, a contractionary shock that raises the short-term rate by 100 basis points is associated with an increase in the income and wage Ginis by 3–10%, which is in line with the findings by Coibion et al. (2017). To give the reader a sense of perspective, the increase in the

Gini coefficient observed between 1980Q1 and 1990Q1 amounted to 20%. Regarding the effects of QE, they conduct a counterfactual experiment and find only weak evidence that in the absence of QE income inequality would have been slightly lower between 2009 and 2012.

Guerello (2018) uses the qualitative Consumer Survey conducted monthly by the European Commission that enables to construct Theil coefficients at an aggregate euro-area level. By employing a VAR the author analyzes the distributional impact of both conventional and unconventional measures in the euro area from 1999 to 2015 arriving at conclusions that support both Coibion et al. (2017) and Saiki and Frost (2014). Expansionary CMP has equalizing effects while an unconventional expansionary shock to the ECB's balance sheet slightly increases income inequality.

Finally, a recent paper by Furceri et al. (2018) assesses how CMP influences income inequality for a panel of 32 countries including not only advanced but also emerging market economies over the period of 1990–2013. The results show that a monetary contraction leads to a lasting rise in income inequality. An unanticipated short-term policy rate increase of 100 basis points increases the Gini coefficient by about 1.25% in the short term (one year after the shock) and by 2.25% in the medium term (five years after the shock). On average, the effect eventually settles after about seven years at 2.5%.

3 Empirical Analysis

Having reviewed the existent literature on the links between redistribution and monetary policy, the following section empirically investigates how conventional and unconventional monetary policies have affected inequality in Germany from 1991 to 2018. The structure of the analysis is the following: section 3.1 describes the data and presents an outline of inequality in Germany since its reunification, section 3.2 explains the methodology, while section 3.3 presents the findings. Sections 3.4 and 3.5 are concerned with robustness checks and the limitations of the analysis, respectively.

3.1 Data and Inequality in Germany

3.1.1 Income Inequality in post-reunification Germany

With respect to the specific case of Germany, income inequality increased substantially in the years succeeding the reunification in 1990 and after the turn of the millennium [Schmid and Stein (2013)]. According to OECD data, the former Federal Republic of Germany (West Germany) was one of the wealthiest and most equal countries in terms of income. In the 1980s the Gini coefficient of West German net household income was below 0.25 and remained constant between 1960 and 1990 [Bundesbank (2016)]. Immediately after reunification, there was initially little sign of changes in the distribution of income. While income inequality tended to increase due to the unification of the west German population with their poorer eastern German counterpart (German Democratic Republic), incomes in eastern Germany were distributed more evenly, thus keeping inequality relatively constant in absolute terms. However, the former factor appears to have become more dominant over the years as the unequal distribution of gross income subsequently increased.

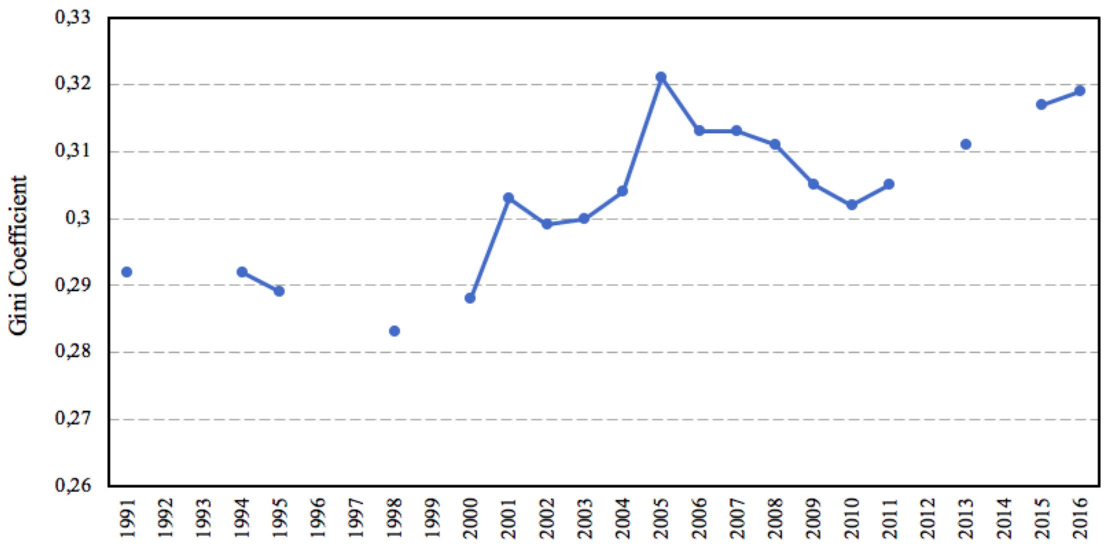

Figure 2: Income Inequality in Germany: 1991-2016

Notes: World Bank data. Values for the years 1992, 1993, 1996, 1997, 1999, 2012 and 2014 not available.

An empirical study by Biewen and Juhasz (2012) finds that the strong increase in inequality over the period 1999 to 2006 can be mostly attributed to increasing dispersion in wages due to skill-biased technical progress, loss of power of unions, and supply-side effects. Other considerable effects come from shifts in the employment structure, such as an increase in unemployment and in part-time employment that particularly affected individuals in the middle and lower income groups. High-income households, on the other hand, seemed to be unaffected by such shifts. Lastly, the authors argue that tax-system reforms in Germany further enhanced inequality dispersion because high-income individuals disproportionally benefitted from lower tax rates.

Schmid and Stein (2013) also analyze the determinants of rising income inequality in Germany from 1990 to 2010 and arrive to similar results as Biewen and Juhasz (2012) up to 2005. Shifts in the employment structure and a decreasing redistributive effectiveness of the tax system and public transfers strongly contributed to the rise in income inequality. Additionally, rising capital income shares further strengthened this trend. However, between 2006 and 2010 inequality stagnated due to two counteracting effects: a strong

rise in employment plus a constancy in the share of part-time employed individuals, and a further increase in redistributional and transfer-system ineffectiveness.
Since 2010, regardless of the favorable economic and labor market conditions, there has been again an upward trend in income inequality which, according to Spannagel and Molitor (2019), is caused by developments in the top and bottom quintiles of the income distribution. While the top quintile has experienced rising incomes, the bottom quintile has been affected by low minimum wages.

3.1.2 Inequality Measure

The collection of data poses some challenges when it comes to conducting research regarding the relationship between monetary policy and inequality, mainly due to the low frequency and unavailability of inequality measures.
Several surveys are conducted in Europe to collect microdata on income and wealth. Examples include the EU Statistics on Income and Living Conditions (EU-SILC) by Eurostat, the ECB's Household Finance and Consumption Survey (HFCS) or the Consumer Survey of the European Commission.
The annual EU-SILC provides cross-sectional and longitudinal multidimensional microdata on income, poverty, social exclusion, and living conditions from which a Gini coefficient of equivalized disposable income is constructed. Nevertheless, it was first conducted in 1995 for Germany and there are some years where the survey did not take place, such that there are missing observations for an empirical analysis. The HFCS has only been conducted and published in three survey waves so far, in 2013, 2016 and recently, in March 2020. Thus, with only three observations, a time series analysis is not feasible. The Consumer Survey of the EU Commission offers high frequency data since it is conducted on a monthly basis, yet this survey is of qualitative nature where respondents are asked to categorize the change in their personal income in the last 3 months on a five-option ordinal scale. The EU Commission survey is used by Guerello (2018) to construct measures of income dispersion which, according to the author, are highly correlated with the Gini coefficient of the EU-SILC. Nevertheless, Samarina and Nguyen (2019) point out that this type of qualitative survey may be subject to bias due to a personal perception of income variation over a short period by the respondents.
Similar difficulties arise regarding the use of German household survey data. The primary microcensus conducted by the German Federal Statistical Office (Destatis) is conducted only annually and its access requires special permits. A second source of survey data comes from the Socio-Economic Panel (SOEP), a longitudinal panel dataset of Germany's population. The surveys are conducted annually by the German Institute for Economic Research (DIW Berlin).
A popular source of published Gini coefficients is the one provided by the World Bank

with annual frequency, which is based on primary household survey data from government statistical agencies and World Bank country departments. However, as shown in Figure 2, the Gini coefficients for Germany are only available until 2016 and there are missing data points.

Lastly, the Standardized World Income Inequality Database (SWIID) assembled from different sources around the world by Solt (2019) provides the most comprehensive inequality database, enabling multi-country comparison as it standardizes income [De Haan and Sturm (2017)]. The issue with this database in the case of Germany is that the Gini coefficients reported lack consistency with respect the equivalence scale applied.

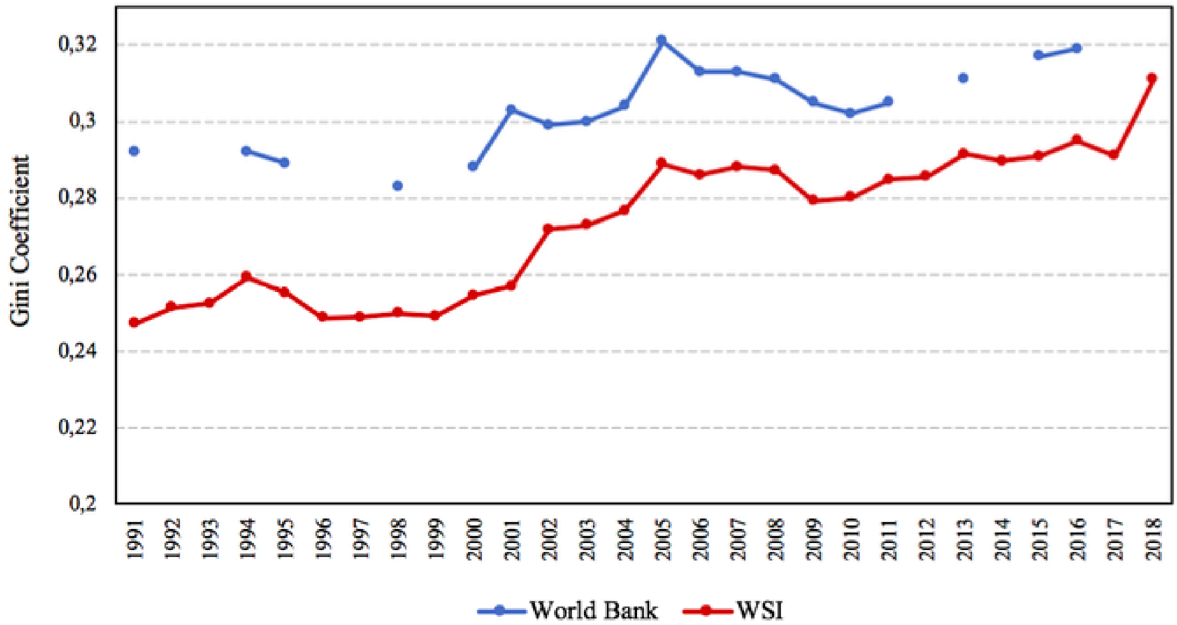

Figure 3: Income Inequality in Germany: World Bank vs. WSI

Therefore, in order to overcome the issues of the sources mentioned above, mainly the low frequency and the short sample periods available, this paper makes use of the equivalized disposable household income Gini coefficient constructed by Spannagel and Molitor (2019) of the Institute of Economic and Social Research (WSI) of the Hans Boeckler Foundation for the WSI Distribution Report 2019. This Gini coefficient is constructed based on the SOEP and provides a consistent measurement and a sample period from 1991 to 2018. Since European and German surveys are, as described above, generally conducted annually unlike the American Consumer Expenditure Survey (CEX) which takes place on a quarterly basis, the strategy in this study consists in applying a linear interpolation to generate quarterly Gini data based on the annual values. This higher frequency and the resulting larger number of observations permit a more suitable time series regression analysis.

Figure 3 exhibits a comparison of the German Gini coefficient published by the World Bank and the Gini constructed by Spannagel and Molitor (2019) from the WSI based on the survey data from the SOEP. The most striking difference between both lines in Figure 3 lies in their levels, as the Gini coeffcients from the WSI run below the World Bank Ginis. From 1991 to 2016, the sample period for which the World Bank Gini is available (with some years missing), the values range from 0,283 to 0,321. Across the same period, the Gini from the WSI ranges from 0,247 to 0,295. However, as is visible from Figure 3, the shapes of the lines are almost identical, supporting the strategy of using the WSI Gini coefficients as the inequality measure for this study, because its path over time resembles the path of the Gini of a reliable data source as is the World Bank and has the additional advantage of providing two more years of data. This two additional years of data enable the generation of five more observation points in the regressions after the linear interpolation of Gini, specifically, the five quarters from 2017Q1 to 2018Q1.

3.1.3 Monetary Policy and Control Variables

Besides the Gini coefficient, which is used as the income inequality measure, several monetary policy instruments and additional controls enter the regressions as explanatory variables.
In the studies presented in section 2.3.2, the authors use the central banks' policy rate, a short-term bond yield or, as Guerello (2018) in her analysis on the Eurozone, the Eonia rate, as a proxy for CMP. As explained in Romer (2012), modern central banks focus on adjusting the nominal short-term interest rate i.e. the policy rate to the inflation rate or the output gap, that is, central banks follow some form of Taylor Rule when conducting CMP. Therefore, the measure used in this paper as the CMP variable is the policy rate set by the central bank. More precisely, from 1991Q1 to 1998Q4, the Diskontsatz set by the Bundesbank is used, which functioned as the main policy rate before the ECB's main refinancing operations rate (MRO) was introduced in January 1999 in the Eurozone. From 1999Q1 to 2018Q1, the MRO rate set by the ECB replaces the Diskontsatz as the CMP measure.
Figure 4 depicts the course of the policy rate set by the German and European Central Bank during the sample period of the analysis. The graph shows a contractionary policy conducted by the Bundesbank after reunification, that is, a hike in the policy rate from 6.5% in 1991Q2 to 8.25% in 1993Q3. This level remained for one quarter until 1992Q4 after which the Bundesbank steadily reduced the Diskontsatz until it reached a level of 2.5% in 1996Q2. This level persisted until the ECB was created and for the first time set the main refinancing operations rate in January 1999 at 3%. It was not until the third quarter of 1999 that the ECB substantially changed the course of the MRO rate, compared to the level that had endured in Germany in the years before the introduction

of the ECB, when it conducted contractionary monetary policy and the MRO rate increased to 4.25%, a level that prevailed until the Great Recession. During the Financial Crisis of 2008 the ECB lowered the MRO rate from 4.25% to 1% in less than a year. In the years after the crisis, the ECB was not able to normalize its monetary policy due to the arrival of the European sovereign debt crisis. As a consequence, it kept conducting expansionary policies, further lowering the policy rate after 2012Q2 as shown in Figure 4. It was also during the debt crisis that the ECB announced it would start conducting UMP according to its APP (see section 2.2.2). In March 2016, the MRO rate reached 0% and has remained constant at that level until the present day (April 2020).

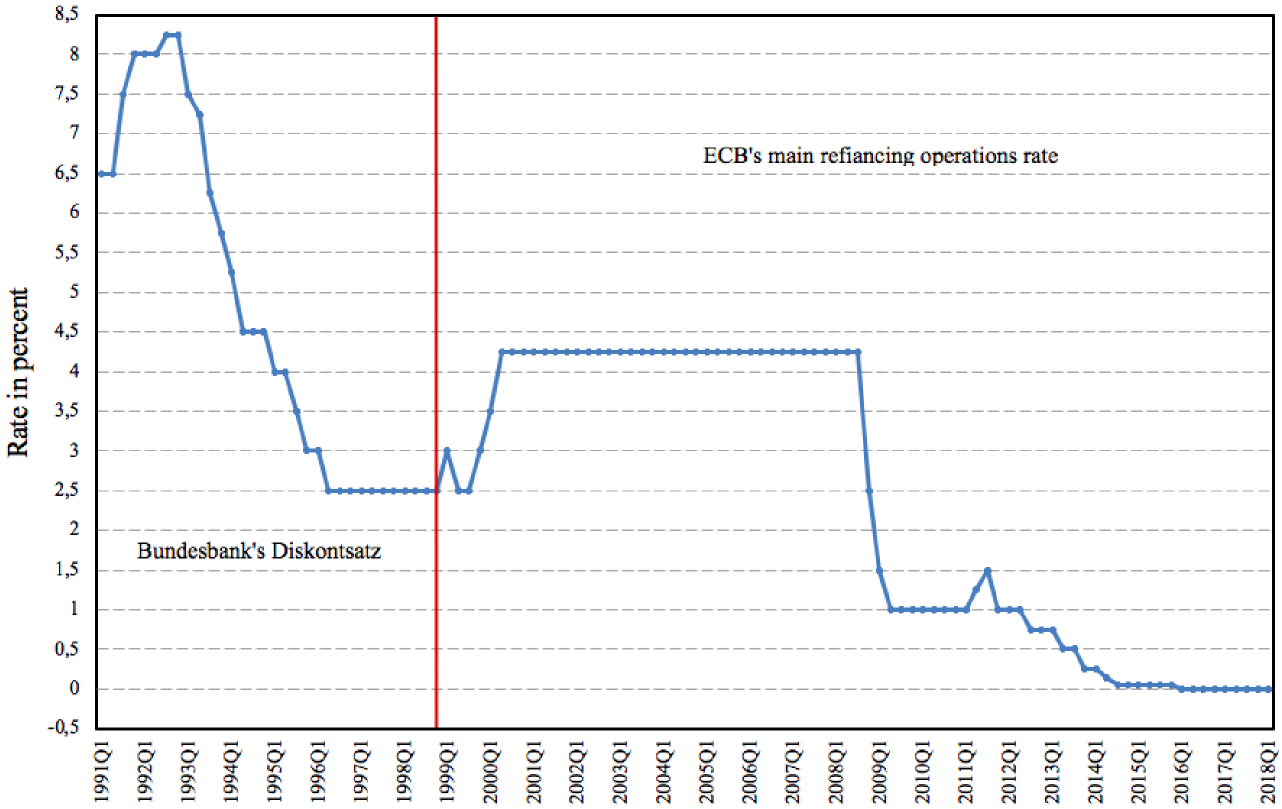

Figure 4: Policy Rate by the Bundesbank and the ECB: 1991-2018

As with CMPs, QE is proxied with several measures across the academic literature in order to capture the effects of UMPs. Some authors use the central banks' balance sheet, such as in the theoretical model by Priftis and Vogel (2017), while others employ the monetary base (e.g. Saiki and Frost (2014)), the long-term government bond yield (e.g. Mumtaz and Theophilopoulou (2017)) or the shadow rate by Wu and Xia (2016) in their regressions[8]. Since, as Priftis and Vogel (2017) point out, one of the main objectives of QE is to flatten the yield curve i.e. reduce the spread between short and long maturities

[8]Refer to sections 2.2.2 and 2.3.2 for more details.

through the massive purchase of long-term bonds, and due to the higher availability of data, this study employs the 10-year German government bond yield as the main measure of UMP.

Table 2: Model Variables

Variable	**Description**	**Source**
Gini coefficient	Gini coefficient, scaled to 0-100	WSI
Policy rate	Central bank's main refinancing operations rate	1991-1999: Bundesbank 2000-2017: ECB
Long-term government bond yield	10-year German government bond yield	Destatis
M3 money	Size of M3 money	Destatis
ECB balance sheet	Size of the ECB's balance sheet	ECB
Real GDP per capita	Real gross domestic product per capita, chained 2010 euros	Eurostat
Inflation rate	YoY rate of inflation	Destatis
Unemployment rate	Registered unemployment rate	Destatis
Stock price index	German stock index (DAX)	Destatis
Government spending	Central government final consumption expenditure as a share of GDP	OECD
Household saving	Gross domestic saving as a share of GDP	World Bank
Household debt	Total stock of loans and debt securities issued by households as a share of GDP	IMF
Trade	Sum of exports and imports of goods and services as a share of GDP	World Bank
Crisis dummy	Dummy that takes the value of 1 for the quarters 2007Q3 to 2009Q2 and 0 otherwise	
Population	Number of inhabitants in Germany	Destatis

Nevertheless, in section 3.4, the amount of M3 money in Germany and the size of the ECB's balance sheet replace the long-term bond yield in the regressions as robustness checks. The latter variable having the disadvantage of reducing the sample size to 1999Q1-2018Q1 since the ECB was not established before June 1998 and its first balance sheet

statement was published in January 1999.
Since income inequality is arguably not solely determined by monetary policy but by several socioeconomic, demographic, political and cultural factors, a set of seasonally-adjusted control variables are brought into the equations in the attempt of reducing the risk of OVB. These additional variables are GDP per capita, the inflation rate, the unemployment rate, a stock price index (DAX), government expenditures as a share of GDP, household saving as a share of GDP, household debt as a share of GDP, the value of trade as a share of GDP as a proxy for globalization and the size of the population. Furthermore, a crisis dummy enters the regression models to control for the Financial Crisis of 2008.
All model variables are listed and described in Table 2, where the respective sources are presented. Besides the Gini coefficient, which is only available on an annual basis and is thus interpolated, all variables are available with quarterly frequency. As mentioned above, the Gini coefficient comes from the WSI's study by Spannagel and Molitor (2019). The size of the ECB's balance sheet is drawn from the weekly reports published on the ECB's website and the remaining variables are extracted from Thomson Reuter's Datastream.

3.2 Methodology

Throughout the literature review in section 2 it is discernible that most academic work concerning monetary policy analysis chooses VARs as the statistical tool for research. One of the advantages of VARs is that it is a technically straightforward procedure. Every variable in the system is regressed on its own lagged values and on the lagged values of all other variables. This has the benefit of reducing the risk of simultaneity bias [Romer (2012)]. VARs also allow the identification of "innovations" by estimating the impact of an exogenous shock through the analysis of their IRFs. Furthermore, as Carnot et al. (2011) point out, VARs do not require assumptions regarding the exogenous variables since all variables in the system are endogenous.
Nevertheless, the simplicity in VAR-modeling can be deceptive and there also some disadvantages when using this method for applied macroeconomic analysis. One major concern regarding this approach is that it lacks a comprehensive theoretical foundation. As argued by Lütkepohl et al. (2004), VARs have the status of "reduced-form" models and are thus merely instruments to compile the dynamic properties of the data.
The choice of variables in a VAR is not completely devoid of theory but it is subject to the technical constraint that the number of variables can only be very limited, usually from two to five, in order to avoid the estimates becoming too imprecise. Therefore, it is often the case that the structure and the modeling of the VAR is justified with speculative considerations [Carnot et al. (2011)].

Also from a strictly methodological standpoint some weaknesses arise from VAR systems. According to Romer (2012), it is not clear that VARs have actually solved the obstacles originating from simpler money-output regressions, such as reverse causation. For instance, in the case of monetary policy analysis, VARs still do not control for the possibility that the central bank may be adjusting policy in response to information it has with respect to the future development of the economy.
Choosing the right number of lags poses a further challenge when estimating a VAR model. The number of lags and variables should not be that large, because the higher they are, the more observations are required to keep a certain degree of precision. Given that high-frequency time series are often not available for very prolonged periods, the number of parameters can be of the same dimension as the number of observations. This can cause overparametrization and, in turn, multicollinearity and loss of degrees of freedom. Thus, VARs estimated with a large number of variables and lags or on short samples are not very precise [Carnot et al. (2011)].
Hence, this study opts for an alternative econometric method with the purpose of capturing additional theoretical factors that may have an impact on income inequality which cannot all be included in a VAR system. Specifically, the strategy is to run an autoregressive distributed lag (ADL) model. An ADL is a time series model in which the regressors may include lagged values of the dependent variable and current and lagged values of one or more explanatory variables [Enders (2008)]. In this case, the dependent variable is the current value of the Gini coefficient and lagged Gini values enter as explanatory variables in the right-hand side of the equation. The Gini values are transformed to a scale of 0-100 instead of the traditional 0-1 scale to keep all variables on a comparable dimension. The remaining independent variables, that is, the monetary policy variables and the additional controls enter the regressions with their current value and all lags up to lag p. The ADL model has the following simplified form:

$$
\begin{aligned}
log(y_t) = \beta_0 + \beta_1 log(y_{t-1}) + \beta_2 log(y_{t-2}) + \beta_3 log(y_{t-3}) \\
+\beta MRO_{t-p} + \beta 10y_{t-p} + \beta \pi_{t-p} \\
+\beta log\mathbf{X}_{i,t-p} + GFC + \gamma_t + u_t
\end{aligned}
\tag{1}
$$

Where y is the Gini coefficient, *MRO* is the CMP measure, specifically, the Bundesbank's Diskontsatz from 1991Q1 to 1998Q4 and the ECB's main refinancing operations rate from 1999Q1 to 2018Q1, while *10y* is the yield of the 10-year German government bond as a proxy for UMP. π is the inflation rate and $\mathbf{X}$ is a vector of additional control variables consisting of GDP per capita, the unemployment rate, a stock price index (DAX), government expenditures as a share of GDP, household saving as a share of GDP, household debt as a share of GDP, the value of trade as a share of GDP as a proxy for globalization and the size of the population. The dummy *GFC* takes the value of 1 in the quarters from 2007Q3 to 2009Q2 and 0 otherwise to control for the global Financial Crisis of 2008, and u is white noise. Furthermore, a deterministic time trend γ is included to account for trending variables and unobserved factors that might influence the upward trend in income inequality observed in Figure 3. All variables are included in the ADL model in logarithms with the exception of *MRO*, *10y* and π which are included in levels because these three variables have non-positive observations which impede a logarithmic transformation.

Sims (1980) argues that the logarithmic transformation of the variables makes the model produce consistent estimates even in the presence of non-stationary variables. However, a second ADL model with first-differenced variables is estimated in order to ensure stationarity throughout all variables. The detrended model is expressed as follows:

$$\begin{aligned}\Delta log(y_t) = \beta_0 + \beta_1 \Delta log(y_{t-1}) + \beta_2 \Delta log(y_{t-2}) + \beta_3 \Delta log(y_{t-3}) \\ + \beta \Delta MRO_{t-p} + \beta \Delta 10y_{t-p} + \beta \Delta \pi_{t-p} \\ + \beta \Delta log \mathbf{X}_{i,t-p} + GFC + u_t\end{aligned} \tag{2}$$

Analogously to Model 1, all variables in Model 2 enter in log-differences except for *MRO*, *10y* and π which are included in first differences but without logs.

Both models are estimated over the sample period 1991Q1-2018Q1 with ordinary least squares (OLS) using Newey-West standard errors to correct for serial correlation and heteroskedasticity [Enders (2008)]. The lag length is selected according to the Akaike information criterion (AIC) based on which a maximum lag length of 4 lags is recommended for both the log-levels and the first-differences models. The exact lag structure of both models is presented in Table 3. Besides the Gini coefficient, which naturally only enters with lagged values as independent variables since its current value is the dependent variable, all other variables enter with their current value and the number of lags specified in Table 3.

The selection of the control variables is based on three broad criteria. First, following authors such as Coibion et al. (2017), Saiki and Frost (2014) and Mumtaz and Theophilopoulou (2017), the most common macroeconomic magnitudes used in their VAR systems are included. These are the inflation rate, the unemployment rate, the stock price index and GDP per capita. Second, the strategy is to add factors which are not included in the models by these authors due to the low number of variables tolerated in a VAR but that may have an impact on income inequality. Following Roine et al. (2009), these factors are trade openness, government spending and population size. Third, in the attempt to

capture the monetary transmission channels described in section 2.3.1 more accurately, household debt and saving are also included in the regressions.
In addition, three lagged values of the Gini are included as regressors. As argued by Wooldridge (2012), this might provide a solution to control for historical factors that impact the current value of the dependent variable that are difficult to account for. The following section presents the findings from running models 1 and 2 with OLS.

Table 3: Lag Structure of Explanatory Variables

Variable	**Lags Model 1**	**Lags Model 2**
Gini	3	3
MRO	4	2
10y	4	4
Real GDP per capita	2	1
Inflation rate	3	2
Unemployment rate	3	2
DAX	4	1
Government expenditures	2	3
Household debt	4	3
Household saving	3	3
Trade	3	2
Population	4	4

3.3 Results

Table 4 summarizes the estimated results from the OLS regression of Model 1, that is, the model specified in log-levels.
Starting with the lagged values of the Gini coefficient, the estimated coefficients strongly suggest that the past levels of income inequality have a positive effect on the present income inequality levels in post-reunification Germany[9] Even though only the coefficient of the first lag is positive while the second and third lags seem to have a statistically negative

[9]Positive effect refers to the statistical positive correlation of the variables. Not to be mistaken with the effect being "good" with respect to inequality. Thus, a positive effect on income inequality i.e. on the Gini coefficient means an increase in inequality.

impact on the current value, the sum of the coefficients equals 0.704. This indicates that an increase in the Gini coefficient of 1% leads, other things equal, to an increase in Gini of 0.704% after three quarters. That past inequality levels play a role in explaining current levels seems plausible from a theoretical standpoint, since inequality generally does not change drastically over short periods of time but rather is a consequence of several socio-political, institutional, cultural and economic factors that build up over prolonged periods.

Turning to the main variables of interest, namely the monetary policy variables, an increase in the policy rate set by the central bank appears to have an overall significant positive effect on income inequality. Specifically, all MRO coefficients except the third-lag coefficient are statistically significant. While the current value and the fourth lag positively affect inequality, the third and the second lag coefficients have a negative sign. The significant coefficients sum up to 0.002, indicating that a one percentage point hike in the MRO rate, that is, a contractionary CMP shock, leads c.p. to an increase in income inequality of 0.002% after one year. To put this number into perspective, the average annual change of the Gini coefficient was 0.837% from 1991 to 2018. Despite the effect of the MRO rate being relatively small, its direction is in line with the results by Coibion et al. (2017) and Mumtaz and Theophilopoulou (2017) who find that contractionary monetary policy is inequality-increasing. This evidence supports the *savings redistribution channel*, through which an expansionary CMP in the form of a policy rate cut induces inflation which, in turn, reduces the value of debt payments of borrowers (low-income households) and the value of cash deposits of savers (high-income households).

The estimated coefficients of the UMP measure are also consistent with the empirical evidence on the effects of QE on income inequality. With only lags 1 and 4 having a significant negative effect, both to the 1% confidence level, a one-percentage point increase in the yield of the 10-year German government bond is associated with a fall of the Gini coefficient of 0.004% after four quarters. As mentioned above, one of the main goals of QE is to reduce the yield of long-term government bonds by large-scale purchases of these bonds by the central bank. Thus, an increase in *10y* which lowers the Gini coefficient can analogously be interpreted in the opposite direction: a fall in the 10-year German government bond resulting from QE has an increasing impact on income inequality levels, in line with the findings by Saiki and Frost (2014), Mumtaz and Theophilopoulou (2017) and Guerello (2018). This result suggests that, as argued by Saiki and Frost (2014), in the case of Germany, QE mainly benefitted high-income individuals more likely to be active in financial markets through its positive effect on capital income.

In section 2.3.1 two channels through which inflation affects inequality are discussed, the *portfolio composition channel* and the *savings redistribution channel*. As explained above, interpreting the impact of MRO on the Gini coefficient, the savings redistribution

Table 4: Model 1 Regression Output

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
c	-8.945554	1.984769	-4.507101	0.0000
$Gini_{t-1}$	1.182232***	0.098226	12.03584	0.0000
$Gini_{t-2}$	-0.342893**	0.138509	-2.475598	0.0166
$Gini_{t-3}$	-0.135464**	0.064728	-2.092827	0.0413
MRO	0.005998***	0.000618	4.850633	0.0000
MRO_{t-1}	-0.003059***	0.001011	-3.025747	0.0038
MRO_{t-2}	-0.002505***	0.000615	-4.073122	0.0002
MRO_{t-3}	0.001829	0.001761	1.038324	0.3039
MRO_{t-4}	0.001230**	0.000518	2.373427	0.0214
$10y$	-0.000750	0.000751	-0.997535	0.3231
$10y_{t-1}$	-0.001340***	0.000450	-2.978031	0.0044
$10y_{t-2}$	-0.001495	0.001027	-1.455820	0.1515
$10y_{t-3}$	0.000314	0.000432	0.727783	0.4700
$10y_{t-4}$	-0.002458***	0.000456	-5.388716	0.0000
Inflation Rate	0.003088***	0.000574	5.379889	0.0000
$Inflation\ Rate_{t-1}$	0.000529	0.000591	0.895912	0.3744
$Inflation\ Rate_{t-2}$	0.000128	0.001244	0.103140	0.9182
$Inflation\ Rate_{t-3}$	0.001004***	0.000327	3.071647	0.0034
GDP per capita	-0.062675*	0.035888	-1.746386	0.0866
$GDP\ per\ capita_{t-1}$	-0.109987**	0.047511	-2.314962	0.0246
$GDP\ per\ capita_{t-2}$	0.056770	0.080288	0.707084	0.4827
Unemployment Rate	0.023908**	0.009056	2.639906	0.0109
$Unemployment\ Rate_{t-1}$	-0.029316	0.028024	-1.046096	0.3004
$Unemployment\ Rate_{t-2}$	-0.020681**	0.008294	-2.493370	0.0159
$Unemployment\ Rate_{t-3}$	0.016225***	0.004076	3.980432	0.0002
DAX	-8.945554***	1.984769	-4.507101	0.0000
DAX_{t-1}	1.182232***	0.098226	12.03584	0.0000
DAX_{t-2}	-0.342893**	0.138509	-2.475598	0.0166
DAX_{t-3}	-0.135464**	0.064728	-2.092827	0.0413
DAX_{t-4}	0.002998***	0.000618	4.850633	0.0000
Government Spending	-0.011080	0.018006	-0.615335	0.5410
$Government\ Spending_{t-1}$	-0.088669***	0.027953	-3.172026	0.0025
$Government\ Spending_{t-2}$	-0.114671**	0.047996	-2.389191	0.0205
Household Debt	-0.038869	0.097736	-0.397691	0.6925
$Household\ Debt_{t-1}$	-0.154964	0.129600	-1.195708	0.2372
$Household\ Debt_{t-2}$	0.374918***	0.121021	3.097952	0.0031
$Household\ Debt_{t-3}$	-0.426276***	0.104159	-4.092552	0.0001
$Household\ Debt_{t-4}$	0.212226***	0.029711	7.143008	0.0000

Table 4: Model 1 Regression Output (continued)

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
Household Saving	0.013379	0.099070	0.135050	0.8931
$Household\ Saving_{t-1}$	-0.162414	0.101703	-1.596951	0.1163
$Household\ Saving_{t-2}$	0.218365***	0.055296	3.949033	0.0002
$Household\ Saving_{t-3}$	-0.112258**	0.066122	-1.697743	0.0955
Trade	0.099690***	0.032386	3.078160	0.0033
$Trade_{t-1}$	-0.069664	0.043563	-1.599181	0.1158
$Trade_{t-2}$	-0.096910**	0.043186	-2.243996	0.0291
$Trade_{t-3}$	0.073267**	0.033824	2.166136	0.0349
Population	-0.819568***	0.212517	-3.856491	0.0003
$Population_{t-1}$	1.542577***	0.364117	4.236491	0.0001
$Population_{t-2}$	-0.226028	0.267722	-0.844264	0.4024
$Population_{t-3}$	-0.385028***	0.127736	-3.014258	0.0040
$Population_{t-4}$	0.543056***	0.117447	4.623831	0.0000
Crisis	-0.006379***	0.001792	-3.559384	0.0008
Trend	0.000880*	0.000468	1.881499	0.0655
R-squared	0.999409	S.D. dependent variable		0.067405
Adjusted R-squared	0.998819	Akaike info criterion		-8.990729
S.E. of regression	0.000279	Schwarz criterion		-7.651111
Sum squared residuals	-0.385028	Durbin-Watson statistic		2.269177
F-statistic	1692.412	Wald F-statistic		290734.8
Prob(F-statistic)	0.000000	Prob(Wald F-statistic)		0.000000

Notes: ADL model is estimated with OLS using Newey-West std. errors over the sample period 1991Q1-2018Q1 for a total of 105 observations after adjustments. *, **, *** indicate significance levels of 10, 5, and 1 percent, respectively. All variables except *MRO*, *10y* and *Inflation Rate* are included in logarithms.

channel seems to prevail when it comes to CMP-induced inflation. However, this is not the case when the effects of inflation itself are observed. The estimated output in Table 4 suggests that, as specified in Model 1, portfolio composition is the predominant channel through which inflation affects inequality levels. That is, assuming that low-income households hold relatively more cash, inflation leads to a rise in inequality due to the value decrease of cash. Here, a rise in inflation by a one percentage point c.p. increases the Gini coefficient by 0.004% after three quarters, while only the current value and the third lag of inflation have a significant impact.

With respect to the remaining controls, GDP per capita is negatively correlated with income inequality but only up to the first lag, while the second lag no longer significantly affects Gini. Rather unsurprisingly, a higher unemployment rate positively correlates with the level of income inequality, with a 1% increase in the unemployment rate being associated with an increase in the Gini coefficient of 0.019% with a lag of three quarters. Interestingly, the estimated coefficients of the German stock price index (DAX) are all negative and significant with the exception of the fourth lag, which is positive and as well significant. The DAX coefficients sum up to a total of -0.011, indicating that 1% increase in the DAX correlates with a fall in Gini of 0.011% after four quarters. This result contradicts several studies[10] on the effects of QE that find that higher asset prices are inequality-increasing since typically low-income individuals are much less involved in capital markets than high-income individuals.

In addition, consistent with the theory and the empirical evidence[11], higher government expenditures as a share of GDP have an equalizing impact. This result could indicate that, in the specific case of Germany, a larger share of central government expenditures with respect to GDP historically indeed has had positive redistributive impact. Household debt and saving as well as the value of trade as a share of GDP all positively affect the Gini coefficient as shown in Table 4. From a theoretical perspective, the positive correlation of globalization and income inequality could be explained based on the model by Melitz (2003), in which openness to trade i.e. globalization leads the least productive firms to exit the market due to greater competition generating job loss for unskilled individuals, which typically are low-income individuals. Population size also has an inequality-increasing effect in Germany according to the estimated coefficients.

Furthermore, the crisis dummy displays a significant negative coefficient suggesting that, in Germany, the Great Recession affected high-income households more relative to low-income households. An explanation could be that workers might have been widely protected by the comprehensive German labor law system even in the case of job loss while wealthy individuals incurred large capital income losses.

The results from regressing the detrended Model 2 with OLS are reported in Appendix A. This model includes the same variables as Model 1 but in first differences and with a slightly differing lag structure which is presented in Table 3. The main results do not change drastically when first-differencing the model variables. With respect to the impact of CMP on income inequality, the estimated statistically significant coefficients of the current value and the second lag of MRO indicate that a rise in the central bank policy rate by a one percentage point is c.p. associated with an increase in Gini of 0.27% after two quarters. On the other hand, a one-percentage point increase in the yield of the 10-year German government bond leads, other things equal, to a decrease of the Gini coefficient of 0.303% after a year.

Overall, according to the Durbin-Watson statistic (2.270), the residuals are not serially

[10]Examples include Saiki and Frost (2014), Priftis and Vogel (2017), Mumtaz and Theophilopoulou (2017) and Samarina and Nguyen (2019).

[11]See, for example, Roine et al. (2009) and Piketty (2014).

correlated. However, when the explanatory variables are not strictly exogenous, such as when lagged dependent variables are present, the Durbin-Watson statistic loses validity [Wooldridge (2012)]. That is also the justification for using Newey-West standard errors that correct for autocorrelation and heteroskedasticity. Thus, since the models include lagged Gini values, it is more useful to look at a plot of the residuals and check if they are constant over the whole sample period. As explained in Enders (2008), residuals should ideally be randomly and equally distributed around the horizontal axis which appears to be the case for Model 1 as shown in Figure 5, confirming the absence of serial correlation. Moreover, the p-value of the Wald F-statistic, which is a joint test robust to serial correlation, is essentially zero, meaning that the null hypothesis that all non-intercept regression coefficients are zero is rejected to the 1% significance level.

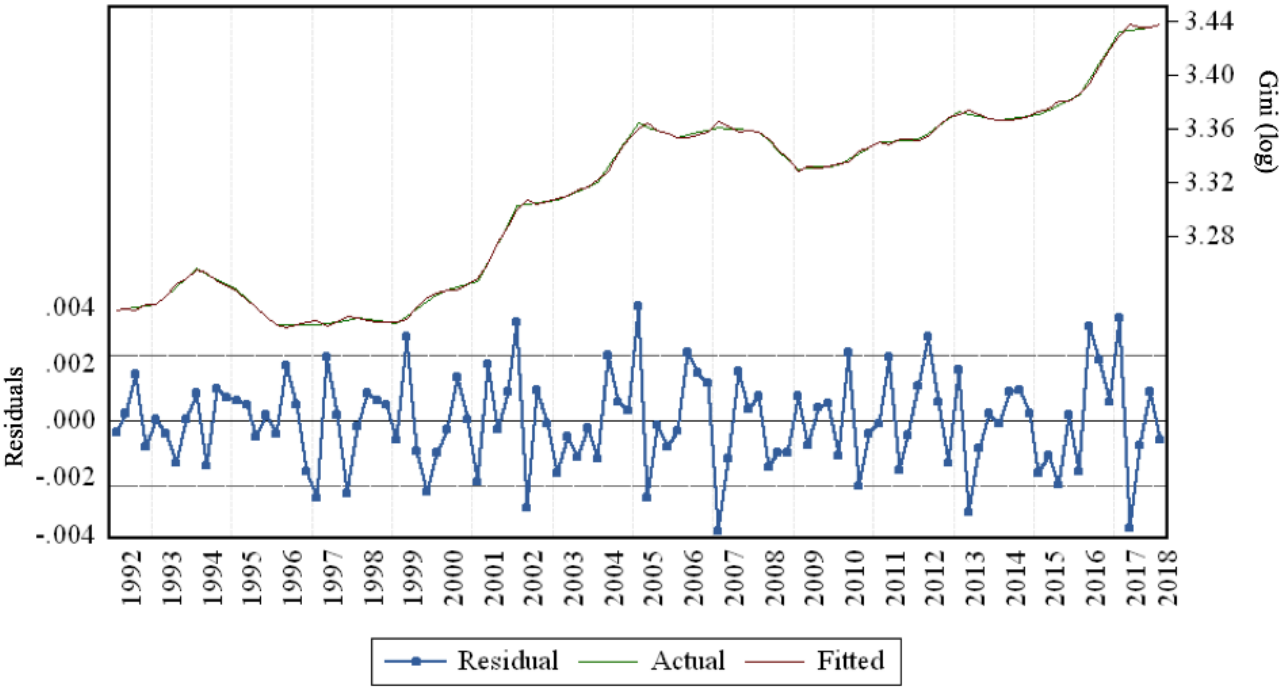

Figure 5: Residuals: Estimated vs. Actuals

3.4 Robustness

In order to examine the robustness of the results presented in the previous section, two additional models with alternative measures of UMP are evaluated. The reason that no robustness check with respect to CMP is conducted is that the policy rate set by the central bank is, as Romer (2012) argues, the predominant conventional method, while standard open market operations which used to be a further conventional measure in the past have largely been replaced by what is known today as QE. In addition, the empirical literature on the effects of CMP mainly uses the MRO rate in the case of euro area or

the federal funds rate in studies on the U.S. market. On the other hand, as shown in section 2.2.2, when estimating the impact of UMP several proxies are used including the monetary base, the central banks' balance sheet, the long-term government bond yield or the shadow rate.
The first alternative measure of UMP used is the value of M3 money in Germany as QE is a strategy that, besides flattening the yield curve, also increases the amount of money circulating in the economy through large-scale asset purchases. Model 3 is identical to Model 1 with the exception that the log of *M3* replaces the 10-year government bond yield as the measure of UMP:

$$\begin{aligned} log(y_t) = \beta_0 + \beta_1 log(y_{t-1}) + \beta_2 log(y_{t-2}) + \beta_3 log(y_{t-3}) \\ + \beta MRO_{t-p} + \beta log M3_{t-p} + \beta \pi_{t-p} \\ + \beta log \mathbf{X}_{i,t-p} + GFC + \gamma_t + u_t \end{aligned} \tag{3}$$

The regression output of Model 3 is reported in Table A2 of Appendix B. When using M3 money as the measure of QE, only the first lag displays a significant effect with a positive coefficient of 0.076. This suggests that a 1% increase in the amount of M3 money in Germany leads c.p. to a rise in the Gini coefficient of 0.076% with a lag of a quarter. This is consistent with the findings of Model 1 reported in the previous section.
The second alternative unconventional measure is perhaps the most direct way of quantifying QE, namely the balance sheet of the ECB. However, the reasons for not using the ECB's balance sheet as the main UMP variable are twofold. First, the sample period is reduced from 1991Q1-2018Q1 to 1999Q1-2018Q1 since the ECB was established in June 1998 and the first balance sheet report was published in January 1999. The second reason is that the mere size of the ECB's balance sheet does not reveal how QE has specifically impacted Germany, contrarily to the long-term German government bond. Analogously to Model 3, in Model 4 the only difference to Model 1 is that the balance sheet size of the ECB replaces *10y* as the UMP measure:

$$\begin{aligned} log(y_t) = \beta_0 + \beta_1 log(y_{t-1}) + \beta_2 log(y_{t-2}) + \beta_3 log(y_{t-3}) \\ + \beta MRO_{t-p} + \beta log ECBbs_{t-p} + \beta \pi_{t-p} \\ + \beta log \mathbf{X}_{i,t-p} + GFC + \gamma_t + u_t \end{aligned} \tag{4}$$

As shown in Table A3, non of the lag values of the ECB's balance sheet has a significant effect on the Gini coefficient, suggesting that the mere balance sheet size does not impact income inequality in Germany from 1999 to 2018. One possible explanation for this result could be that, as mentioned above, the balance sheet of the ECB reflects asset purchases from all euro area countries and thus does not have explanatory power over German inequality levels, as do the other two UMP measures, *10y* and *M3*.

3.5 Limitations

In section 3.2 some of the weaknesses of using a VAR and the justification for instead employing an ADL model in this study are presented. Nevertheless, an ADL model for monetary policy analysis is not completely absent of drawbacks.

One limitation of the models estimated in this paper pertains generally to the use of OLS with time series data, namely the possible violation of the strict exogeneity assumption that ensures that OLS estimates are unbiased and consistent. As argued by Keele and Kelly (2006), this strict exogeneity of the explanatory variables is almost always violated in time series data and definitely so when the he right-hand side of the equation contains lagged dependent variables. The strict exogeneity assumption is thus violated in this analysis due to the inclusion of lagged Gini values as regressors. There are, however, methods to circumvent this infringement such as using robust standard errors. The use of Newey-West standard errors appears to successfully correct for this issue based on the residual plot in Figure 5.

Another issue is external validity as this paper specifically analyzes the case of Germany and the effects of an euro-area wide type of policy. Countries in the Eurozone vary to a large extent with respect to their fiscal policy and institutional setting and thus, there is the possibility that the effects of monetary policy on income inequality uncovered for Germany as specified in Model 1 are not applicable to other euro area countries. An extension of this analysis could be done with a panel time series regression including several countries in the Eurozone to examine the external validity of the findings presented here.

Moreover, the possibility that two or more variables in the model are cointegrated poses a limitation in the use of these ADL models, since in the presence of cointegrating equations a vector autoregressive model (VECM) could be a more suitable approach. Lastly, from a technical perspective, the low frequency of household surveys conducted in Germany and in Europe complicate a proper time series analysis on income inequality. A linear interpolation to generate quarterly Gini data is thus a broad approximation of the actual inequality levels which are not available. The availability of *real* quarterly Gini coefficients through the introduction of quarterly micro-level surveys, such as the CEX in the U.S., could help improve the accuracy of these types of analyses.

4 Conclusion and Policy Implications

Since the Financial Crisis of 2008, the ECB has experienced a transition from conducting conventional monetary policy in the form of adjusting the MRO rate to the current economic state to conducting solely unconventional policies, mainly in the form of QE, but also in the form of forward guidance and, more recently, by introducing negative interest rates on bank deposits. This, together with the rising issue of increasing income inequality among developed countries and its repercussions for long-term growth have led central bankers to start considering the possible implications that monetary policy may have on inequality levels.

Therefore, this paper aims to assess how conventional and unconventional monetary policies have had an impact on income inequality in post-reunification Germany. In order to do so, an autoregressive distributed lag (ADL) model is estimated via OLS where the policy rate set by the Bundesbank and the MRO set by the ECB after its establishment in 1998 enter the regressions as the measure of CMP, while UMP is proxied with the yield of the 10-year German government bond. Income inequality is captured with an annual Gini coefficient constructed by Spannagel and Molitor (2019) based on the German SOEP. After linearly interpolating the Gini coefficient to generate quarterly values, the regressions are run over the sample period from 1991Q1 to 2018Q1.

The analysis finds that contractionary conventional monetary policy is inequality-increasing. Other things equal, a one-percentage point increase in the policy rate set by the central bank leads to a rise in the Gini coeffiient of 0.002% after one year. This suggests that CMP affects inequality through the savings redistribution channel. That is, a policy rate cut induces inflation which in turn reduces inequality due to the reduction of the value of debt payments of borrowers and cash deposits of savers. On the other hand, a one-percentage point increase in the yield of the 10-year German government bond (contractionary UMP shock) is associated with a decrease in the Gini coefficient of 0.004% after four quarters. This indicates that a fall in the 10-year German government bond resulting from QE has an inequality-increasing impact, suggesting that in the case of Germany, QE mainly benefitted high-income individuals more likely to be active in financial markets through its positive effect on capital income and increased asset prices.

A crucial challenge that the ECB faces in the process of monetary policy making is that it cannot conduct it in accordance to the fiscal policy of the 19 euro area states, since there is such large heterogeneity in the fiscal systems and institutional settings of these countries. This is a disadvantage that other central banks, such as the Fed, the Bank of England or the Bank of Japan are not confronted with. This has led to the problem that the ECB has not been able to normalize its monetary policy since the Great Recession due to the arrival of the sovereign debt crisis, when the initial QE program was introduced and, more recently, the arrival of the crisis induced by the Coronavirus that forced the ECB to announce a Pandemic Emergency Purchase Programme (PEPP) in March 2020 in which it intends to purchase bonds and assets of euro area countries worth €750 billion until the end of 2020.

The findings presented in this paper, which are in line with the results found in the academic literature, suggest that it is imperative that the ECB attempts to normalize its monetary policy despite the obstacles mentioned above, such that the MRO rate once again becomes a powerful tool to support the economy as it did during the global financial crisis. These types of expansionary policies could aid in the reduction of income inequality which in turn could support long-term economic growth. On the other hand, the current UMPs at the zero lower bound seem to have limited stabilizing effects on the economy, as they have failed to bring euro area inflation to the target of almost 2% and have led to increased asset prices that appear to contribute to the further rise in income inequality.

Future research could extent the models presented in this study in a panel data set-up that includes several or ideally all euro area countries to examine if the findings presented for the case of Germany are valid for the other members of the Eurozone.

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A First-Differences Model

Table A1: Model 2 Regression Output

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
c	0.002577	0.000789	3.264333	0.0018
$Gini_{t-1}$	0.634119***	0.092468	6.857724	0.0000
$Gini_{t-2}$	0.131408*	0.067375	1.950383	0.0557
$Gini_{t-3}$	-0.223459***	0.058734	-3.804601	0.0003
MRO	0.002782*	0.001535	1.812990	0.0748
MRO_{t-1}	-2.05E-05	0.001430	-0.014307	0.9886
MRO_{t-2}	-0.002509*	0.001272	-1.972374	0.0531
$10y$	0.000703	0.000979	0.718138	0.4754
$10y_{t-1}$	-0.001186*	0.000707	-1.676678	0.0987
$10y_{t-2}$	-0.001422	0.000958	-1.484309	0.1429
$10y_{t-3}$	-6.12E-06*	0.000903	-0.006781	0.9946
$10y_{t-4}$	-0.001839**	0.000911	-2.019172	0.0479
Inflation Rate	0.002151**	0.000870	2.472436	0.0162
Inflation Rate$_{t-1}$	0.002385**	0.001069	2.231154	0.0294
Inflation Rate$_{t-2}$	0.000512	0.000917	0.558382	0.5786
GDP per capita	-0.119043*	0.060262	-1.975404	0.0528
GDP per capita$_{t-1}$	-0.156167*	0.080842	-1.931751	0.0580
Unemployment Rate	0.000280	0.015105	0.018552	0.9853
Unemployment Rate$_{t-1}$	0.001351	0.021129	0.063956	0.9492
Unemployment Rate$_{t-2}$	-0.024946	0.019042	-1.310091	0.1951
DAX	-3.72E-05	0.002134	-0.017421	0.9862
DAX_{t-1}	-0.000213	0.002495	-0.085333	0.9323
Government Spending	-0.014765	0.042561	-0.346922	0.7298
Government Spending$_{t-1}$	-0.080027*	0.043562	-1.837064	0.0711
Government Spending$_{t-2}$	-0.138037**	0.057094	-2.417724	0.0186
Government Spending$_{t-3}$	-0.075286**	0.037305	-2.018120	0.0480
Household Debt	0.059151	0.292856	0.201981	0.8406
Household Debt$_{t-1}$	-0.077257	0.289462	-0.266900	0.7904
Household Debt$_{t-2}$	0.146805	0.140551	1.044495	0.3004
Household Debt$_{t-3}$	-0.205790**	0.101801	-2.021487	0.0476
Household Saving	0.089024	0.174287	0.510788	0.6113
Household Saving$_{t-1}$	-0.165131	0.146187	-1.129591	0.2631
Household Saving$_{t-2}$	0.014914	0.054478	0.273758	0.7852
Household Saving$_{t-3}$	-0.048224	0.049562	-0.973008	0.3344

Table A1: Model 2 Regression Output (continued)

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
$Trade$	0.073128	0.063806	1.146093	0.2562
$Trade_{t-1}$	-0.020073	0.061096	-0.328551	0.7436
$Trade_{t-2}$	-0.102920**	0.036970	-2.783865	0.0071
$Population$	-1.097662*	0.607883	-1.805712	0.0759
$Population_{t-1}$	0.755341	0.829389	0.910720	0.3660
$Population_{t-2}$	0.337156	00.471086	0.715698	0.4769
$Population_{t-3}$	-0.186318	0.376566	-0.494783	0.6225
$Population_{t-4}$	0.514894	0.320469	1.606689	0.1133
$Crisis$	-0.004392**	0.001743	-2.520301	0.0144
R-squared	0.817439	S.D. dependent variable		0.004937
Adjusted R-squared	0.691742	Akaike info criterion		-8.667477
S.E. of regression	0.002741	Schwarz criterion		-7.574123
Sum squared residuals	0.000458	Durbin-Watson statistic		2.074217
F-statistic	1692.412	Wald F-statistic		35.46410
Prob(F-statistic)	0.000000	Prob(Wald F-statistic)		0.000000

Notes: ADL model is estimated with OLS using Newey-West std. errors over the sample period 1991Q1-2018Q1 for a total of 104 observations after adjustments. *, **, *** indicate significance levels of 10, 5, and 1 percent, respectively. For the variables MRO, *10y* and *Inflation Rate*, first differences of their levels are taken. The remaining variables are included in log-differences.

B Robustness Checks

Table A2: Model 3 Regression Output

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
c	-3.093249	3.929994	-0.787088	0.4348
$Gini_{t-1}$	1.286385***	0.126487	10.17009	0.0000
$Gini_{t-2}$	-0.386502**	0.181486	-2.129655	0.0380
$Gini_{t-3}$	-0.103006	0.073400	-1.403345	0.1665
MRO	0.002167	0.001360	1.594000	0.1170
MRO_{t-1}	-0.001319	0.002234	-0.590332	0.5575
MRO_{t-2}	-0.000135	0.001715	-0.078633	0.9376
MRO_{t-3}	0.001009	0.001541	0.654558	0.5156
MRO_{t-4}	0.000784	0.001074	0.729763	0.4688
$M3$	-0.040600	0.046814	-0.867264	0.3898
$M3_{t-1}$	0.076255**	0.029377	2.595719	0.0122
$M3_{t-2}$	0.020316	0.029833	0.680988	0.4989
$M3_{t-3}$	-0.039232	0.031850	-1.231787	0.2236
$M3_{t-4}$	0.003099	0.033368	0.092888	0.9263
Inflation Rate	0.002676**	0.001263	2.118378	0.0389
$Inflation\ Rate_{t-1}$	-0.000286	0.000849	-0.337189	0.7373
$Inflation\ Rate_{t-2}$	-0.000979	0.001169	-0.837056	0.4064
$Inflation\ Rate_{t-3}$	-0.000363	0.000780	-0.465947	0.6432
GDP per capita	-0.030784	0.065170	-0.472363	0.6386
$GDP\ per\ capita_{t-1}$	-0.064777	0.064905	-0.998025	0.3229
$GDP\ per\ capita_{t-2}$	0.079399	0.116073	0.684042	0.4970
Unemployment Rate	0.023908**	0.009056	2.639906	0.0109
$Unemployment\ Rate_{t-1}$	-0.029316	0.028024	-1.046096	0.3004
$Unemployment\ Rate_{t-2}$	-0.020681**	0.008294	-2.493370	0.0159
$Unemployment\ Rate_{t-3}$	0.016225***	0.004076	3.980432	0.0002
DAX	-0.003008	0.002488	-1.209252	0.2320
DAX_{t-1}	0.002456	0.002428	1.011572	0.3164
DAX_{t-2}	0.000420	0.002609	0.160823	0.8729
DAX_{t-3}	-0.004039	0.002572	-1.570579	0.1223
DAX_{t-4}	0.001297	0.002074	0.625341	0.5345
Government Spending	0.024321	0.037316	0.651762	0.5174
$Government\ Spending_{t-1}$	-0.078876	0.073003	-1.080450	0.2849
$Government\ Spending_{t-2}$	-0.094316	0.059201	-1.593157	0.1172
Household Debt	0.305578	0.188624	1.620040	0.1113
$Household\ Debt_{t-1}$	-0.410435	0.306952	-1.337132	0.1870
$Household\ Debt_{t-2}$	0.164148	0.269380	0.609352	0.5449

Table A2: Model 3 Regression Output (continued)

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
$Household\ Debt_{t-3}$	-0.231722	0.217756	-1.064137	0.2922
$Household\ Debt_{t-4}$	0.148328*	0.078973	1.878207	0.0660
$Household\ Saving$	0.152566	0.093014	1.640241	0.1070
$Household\ Saving_{t-1}$	-0.302519*	0.154497	-1.958088	0.0556
$Household\ Saving_{t-2}$	0.161147	0.105505	1.527389	0.1327
$Household\ Saving_{t-3}$	-0.053637	0.060586	-0.885312	0.3801
$Trade$	0.101955*	0.060459	1.686342	0.0977
$Trade_{t-1}$	-0.089695	0.077760	-1.153479	0.2540
$Trade_{t-2}$	-0.067982	0.050391	-1.349085	0.1832
$Trade_{t-3}$	0.038051	0.026790	1.420384	0.1615
$Population$	-1.020658**	0.402977	-2.532796	0.0144
$Population_{t-1}$	1.473545**	0.576237	2.557185	0.0135
$Population_{t-2}$	-0.246932	0.420659	-0.587014	0.5597
$Population_{t-3}$	0.096880	0.318645	0.304037	0.7623
$Population_{t-4}$	-0.057092	0.246832	-0.231300	0.8180
$Crisis$	-0.008630**	0.003948	-2.186164	0.0333
$Trend$	0.000782	0.000677	1.155043	0.2534
R-squared	0.999305	S.D. dependent variable		0.067405
Adjusted R-squared	0.998611	Akaike info criterion		-8.828466
S.E. of regression	0.002512	Schwarz criterion		-7.488848
Sum squared residuals	0.000328	Durbin-Watson statistic		2.131463
F-statistic	1438.769	Wald F-statistic		62879.40
Prob(F-statistic)	0.000000	Prob(Wald F-statistic)		0.000000

Notes: ADL model is estimated with OLS using Newey-West std. errors over the sample period 1991Q1-2018Q1 for a total of 105 observations after adjustments. *, **, *** indicate significance levels of 10, 5, and 1 percent, respectively. All variables except MRO and *Inflation Rate* are included in logarithms.

Table A3: Model 4 Regression Output

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
c	-12.41178	15.68856	-0.791136	0.4381
$Gini_{t-1}$	0.803989***	0.171966	4.675276	0.0001
$Gini_{t-2}$	-0.277897*	0.139616	-1.990441	0.0604
$Gini_{t-3}$	-0.279471**	0.098876	-2.826475	0.0104
MRO	0.005124	0.003836	1.335594	0.1967
MRO_{t-1}	0.000573	0.005864	0.097687	0.9232
MRO_{t-2}	-0.003500	0.004586	-0.763118	0.4543
MRO_{t-3}	0.003054	0.003846	0.794150	0.4364
MRO_{t-4}	0.000172	0.003707	0.046507	0.9634
ECB balance sheet$_t$	0.013019	0.023780	0.547479	0.5901
ECB balance sheet$_{t-1}$	0.015380	0.012822	1.199529	0.2443
ECB balance sheet$_{t-2}$	-0.005684	0.015449	-0.367886	0.7168
ECB balance sheet$_{t-3}$	0.004654	0.015721	0.296006	0.7703
ECB balance sheet$_{t-4}$	0.008915	0.008606	1.035959	0.3126
Inflation Rate	0.003146*	0.001613	1.950630	0.0653
Inflation Rate$_{t-1}$	0.001951	0.001438	1.357005	0.1899
Inflation Rate$_{t-2}$	-0.000556	0.002999	-0.185369	0.8548
Inflation Rate$_{t-3}$	0.003195*	0.001536	2.080355	0.0506
GDP per capita	0.024889	0.168778	0.147465	0.8842
GDP per capita$_{t-1}$	-0.201738	0.175184	-1.151580	0.2631
GDP per capita$_{t-2}$	0.088624	0.214580	0.413013	0.6840
Unemployment Rate	0.075551***	0.024895	3.034811	0.0065
Unemployment Rate$_{t-1}$	0.039974	0.029807	1.341084	0.1949
Unemployment Rate$_{t-2}$	-0.018136	0.038701	-0.468605	0.6444
Unemployment Rate$_{t-3}$	-0.000815	0.036053	-0.022612	0.9822
DAX	-0.004143	0.006560	-0.631502	0.5349
DAX_{t-1}	-0.010011**	0.003879	-2.580810	0.0179
DAX_{t-2}	0.001383	0.006264	0.220799	0.8275
DAX_{t-3}	-0.002457	0.003858	-0.636732	0.5315
DAX_{t-4}	-0.004110	0.004249	-0.967266	0.3450
Government Spending	-0.064217	0.224284	-0.286318	0.7776
Government Spending$_{t-1}$	-0.221645	0.140180	-1.581147	0.1295
Government Spending$_{t-2}$	-0.030099	0.130325	-0.230952	0.8197
Household Debt	0.027883	0.441406	0.063168	0.9503
Household Debt$_{t-1}$	-0.143273	0.602807	-0.237676	0.8146
Household Debt$_{t-2}$	1.081284	0.703096	1.537890	0.1397
Household Debt$_{t-3}$	-0.901169	0.833046	-1.081776	0.2922
Household Debt$_{t-4}$	-0.166526	0.340230	-0.489451	0.6298

Table A3: Model 4 Regression Output (continued)

Dependent: $Gini_t$	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
Household Saving	0.049489	0.293258	0.168757	0.8677
$Household\ Saving_{t-1}$	-0.034702	0.279884	-0.123986	0.9026
$Household\ Saving_{t-2}$	0.541816**	0.245760	2.204659	0.0394
$Household\ Saving_{t-3}$	-0.469468*	0.240224	-1.954293	0.0648
Trade	0.097330	0.131529	0.739988	0.4679
$Trade_{t-1}$	-0.015250	0.143369	-0.106368	0.9164
$Trade_{t-2}$	-0.269650*	0.135110	-1.995776	0.0598
$Trade_{t-3}$	0.132070	0.117324	1.125680	0.2736
Population	-0.617215	0.661266	-0.933384	0.3618
$Population_{t-1}$	1.136007	1.391782	0.816225	0.4240
$Population_{t-2}$	-0.519295	0.665179	-0.780685	0.4441
$Population_{t-3}$	-0.073308	1.157333	-0.063342	0.9501
$Population_{t-4}$	0.954231	0.884493	1.078846	0.2935
Crisis	-0.002739	0.002317	-1.182544	0.2509
Trend	0.002692	0.001989	1.352939	0.1912
R-squared	0.999412	S.D. dependent variable		0.045393
Adjusted R-squared	0.997884	Akaike info criterion		-9.347750
S.E. of regression	0.002088	Schwarz criterion		-7.684814
Sum squared residuals	8.72E-05	Durbin-Watson statistic		2.961458
F-statistic	653.9223	Wald F-statistic		9783.998
Prob(F-statistic)	0.000000	Prob(Wald F-statistic)		0.000000

Notes: ADL model is estimated with OLS using Newey-West std. errors over the sample period 1999Q1-2018Q1 for a total of 73 observations after adjustments. *, **, *** indicate significance levels of 10, 5, and 1 percent, respectively. All variables except *MRO* and *Inflation Rate* are included in logarithms.