Erasmus University Rotterdam

Erasmus School of Economics

Master's Thesis

Assessing the impact of Quantitative Easing on Inequality in the US

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September 23, 2018

A thesis submitted in fulfillment of the requirements for the degree of Master of Science in Policy Economics.

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Abstract

The Great Recession has had a great impact on inequality in the US, it further increased the already high income and wealth inequality levels. The crisis has also affected the US policy framework: in order to relaunch the economy, extraordinary policies were enforced. Some of them, such as the Quantitative Easing program, are claimed to further increase inequality. This paper investigates the relationship between the unconventional monetary policies implemented by the Federal Reserve, in particular the Quantitative Easing program, and inequality. In order to offer a broad analysis, the paper considers four different dimensions of inequality: income, salary, non-durable consumption and total expenditures. It uses micro level data from the Consumer Expenditures Survey to calculate quarterly Gini coefficients from 2004 to 2016. The vector autoregression models designed to study the effects of unconventional monetary policy present two main results. Quantitative Easing has had a positive impact on income inequality, leading to a temporary higher Gini coefficient, but it has had a non statistically significant impact on consumption.

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Acknowledgements

I would like to thank my supervisor, Dr. Gerritsen, for his help and for the time he dedicated to me. His feedback and his meetings were very useful to improve the quality of my thesis and to steer my work in the right direction.

I would also like to thank Ms. Ana-Maria Taradaciuc, Mr. Alexandros Achilleos, Mr. Alexander van Oeveren and Mr. Pedro Romão for their precious advice, diligent readings and greatly appreciated discussions that allowed me to reach the current final version of my thesis.

Finally, I would like to thank my family for their unconditional encouragement and support throughout this year in Rotterdam.

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Contents

1 Introduction

Inequality has continuously increased since the '80s, reaching an historical maximum in 2008, when the economic crisis began. During the first years of the Great Recession, inequality grew at a faster pace, in three years it rose as much as in the previous twelve years (OECD, 2013). The Great Recession did not only cause more income inequality, it also forced several Central Banks to implement unconventional and rarely used policies in order to stimulate the economy. The Federal Reserve (FED), the Bank of England (BOE), the Bank of Japan (BOJ) and the European Central Bank (ECB) all adopted a close-to-zero interest rate, BOJ and ECB even pushing it in the negative territory, and the Quantitative Easing program, an asset-purchase program aimed at reducing long-term interest rates and increase inflation (Viñals, Blanchard, and Bayoumi, 2013).

However, these policies implemented to relaunch the economies after the Great Recession could have further worsen the effects of the crisis by increasing inequality. In fact, the unconventional monetary policies (UMPs) cause a share appreciation and a lower return on savings (Haitsma, Unalmis, and Haan, 2016). Typically, financial assets are held by wealthy households, who see their revenues from dividends and capital gain increased, while the average household will have lower returns on its savings (Saiki and Frost, 2014). In addition, the mandate of the Central Banks is price stability, and in some cases also financial stability, but it is never income or wealth distribution. Therefore, inequality is not necessarily taken into account when monetary policies are discussed and implemented. Nonetheless, since inequality has recently become a hot topic, there have been debates on the consequences of UMPs on inequality. Krugman (2014) claimed that "the belief that Quantitative Easing systematically favors the kinds of assets the wealthy own is wrong or at least overstated". On the other hand, Cohan (2014) stated that FED's Quantitative Easing widened the gulf between the rich and the poor in the US. Even if nowadays this topic is more debated and the literature on the relation between monetary policy and inequality is growing, most of the papers only analyze the income distribution, ignoring other kind of inequalities, such as the consumption or wealth ones.

Studying inequality as a multi-dimension issue is important because income, wealth and consumption together determine people's well-being and therefore choosing to analyze only one dimension could understate the relevance of the issues implied by inequality. In addition, by taking these three measures together, it is possible to highlight the relations and synergies between these variables which are already used and studied jointly in some economic models, such as the inter-temporal budget constraint (Fisher et al., 2018).

Therefore, this paper aims to give a broad overview on the impact of QE on inequality in the United States. In fact, this relationship has been analyzed while the

unconventional monetary policies were still implemented[1], but it has not been assessed again once they were over. Availability of more data and the fact that Quantitative Easing programmes ended in 2014, should allow to obtain a more accurate and updated understanding of how it affected inequality. In addition, this paper also aims at yielding results which are comparable with studies on other countries, to assess how the impact varies based on the framework where QE is implemented.

In order to do so, I used a vector autoregression model based on the existing literature, to assess how income, salary and consumption inequality react to a change in the monetary base driven by the implementation of the quantitative easing. The measures of inequality level are calculated from the Consumer Expenditure Survey, a survey which collects data on individuals' income and expenditures. This approach is often used in the literature because it allows to obtain high-frequency data and to consider different inequality aspects.

The results show that the reaction of inequality to monetary policy is not unique and it varies depending on the analyzed dimension. QE increased income inequality but it did not significantly affect consumption inequality. The discrepancy in the results highlights the importance of analyzing all types of inequality and not focusing on only one. In fact, with a broader knowledge of inequality responses, it is possible to design expansionary monetary policies differently to avoid or at least limit their downsides or to implement correctional measures to counteract their undesired effects.

The rest of the paper is organized as follows. Section 2 analyzes the existing literature on the topic. In particular, the review first assesses inequality, its rising trend and the causes. The focus is then on monetary policies, explaining why, in certain times, central banks have to implement unconventional measures. Lastly, the review investigates the relation between these two topics to evaluate how monetary policies could affect inequality. From Section 3 onwards, the paper focuses more on the model used to conduct the analysis. More specifically, Section 3 describes the data used in the model, also explaining the limitations and constraints of the data source, the Consumer Expenditure Survey. The methodology of the analysis, how the VAR model was implemented and the tests conducted in the process are explained in Section 4. Section 5 presents the results of the models, using different measures for inequality. In addition, it also describes the channels through which the QE affected inequality. Lastly, Section 6 concludes the paper highlighting the main results and the policy implications deriving from them.

[1] see Coibion et al. (2012)

2 Literature Review

2.1 Inequality

Inequality is a hot topic in economics since the beginning of the financial crisis in 2008. Socio-political movements such as the "Occupy" movement and bestseller books such as "Capital in the 21st century" by Piketty (2014) highlighted the topic and helped generating a public and political debate about inequality. Economic inequality is not uni-dimensional, but it is a multifaceted concept. In fact, income, wealth and consumption inequality refer to different definitions of inequality and emphasize different issues related to the unequal distribution of returns from capital and labor, of personal wealth and of consumption (Fisher et al., 2018).

Even if these three types of inequalities have different paths and levels, they are related and a shock to one of them could also affect the other two. An increase in income inequality causes more wealth inequality, which in turn increases income inequality again (Piketty, 2014). In fact, higher income allows people to save more and thus buy more assets; if assets have a larger return than the economic growth, financial revenues will be higher than wages leading to a more unequal income distribution. Aguiar and Bils (2015) found that consumption inequality mirrors income inequality: an increase in the former leads to an increase in the latter. The reason for this is the shift of high-income households from essential goods to luxury products. The authors tried to capture this shift by analysing the ratio between expenditures for luxury goods, proxied by the expenditures in entertainment, and for essential goods, proxied by the expenditures in food. This ratio increased from 0.21 in 1980 to 0.27 in 2008 for high-income households, while the same ratio decreased from 0.09 to 0.06 for low-income ones (Aguiar and Bils, 2015). In addition, they estimated that from 1980 to 2010 there has been a 30% increase in consumption inequality, measured as the ratio beetwen the expenditures of those in the 80th to 95th percentiles and those in the 5th to 20th percentile. In the same period, income inequality rose by circa 30%. These findings contradict Krueger and Perri (2006), who claimed that the increase in consumption inequality does not correspond with a proportional increase in income inequality. The authors used a different approach and they took in account the total amount of expenditures, instead of the ratio between luxury and essential goods. With this approach, they found that the Gini coefficient for income inequality increased by circa 23% from 1980 to 2004 and the one for income inequality increased only by 13%.

In addition, Bostic, Gabriel, and Painter (2009) found that consumption inequality also depends on wealth distribution. Hence, consumption inequality could decrease, but income inequality could stay constant or increase, as it happened during the Great Reces-

sion. In fact, a decrease in asset prices, housing and financial assets, leads to a decrease in consumption inequality, but does not affect the income distribution (Meyer and Sullivan, 2017).

2.1.1 Rising Inequality

The rising trend in inequality has been vastly studied and many factors have been found to be the main drivers of this growth. Jacobson and Occhino (2012) claimed that one of the main causes is the decrease in labor share. This is the part of GDP which is payed out to the workers as wages and salaries; it shows how national income is divided between labor and capital (Schneider, 2011). A decrease in the labor share leads to higher inequality because, usually, labor income is more evenly distributed than capital income. It also implies that the capital share, which is less evenly distributed among the population, has a larger share. Therefore, if the share which is more concentrated at the top, capital income, has a larger role in the composition of total income, total income will also become more concentrated at the top of the distribution (Jacobson and Occhino, 2012).

The decrease in the labor share is caused by different factors. Elsby, Hobijn, and Şahin (2013) identified some of the most important ones to be the weakening of the union power and globalization. Unions' bargaining power allows unionized workers to have a union wage premium, hence, when the union power is stronger, the labor share is larger. However, since the '90s, the number of workers who are members of unions or employee associations decreased and consequently also the union wage premium fell. The authors claimed that this decrease can explain part of the labor share reduction. With regards to the second factor, globalization led companies in developed countries to move part of the production in developing countries, where the labor cost was lower. In addition, the amount of goods traded from developing countries to developed countries increased. Such off-shoring and the larger import exposure caused a decrease in labor shares since many jobs disappeared in the developed countries.

Young and Tackett (2018) had similar results: they analyzed more than 100 countries between 1970 and 2009 to assess how globalization affects labor share. They found that the economic influences of globalization, such as trade and investment flows, have a negative impact on labor share. The capital bargaining power became larger than the labor one due to goods and capital mobility. However, the authors also found that the social dimension of globalization, the informational flows and cultural influences from abroad, has a positive impact on labor share. In fact, better information and greater worker mobility increases labor bargaining power. The positive effects of the social dimension offset the negative ones of the economic factors, leaving a neutral impact of globalization on

labor share.

Another reason behind the decline in labor share is proposed by Autor et al. (2017). They implemented a "superstar firm" model characterized by the fact that sales are concentrated amongst few firms with better products or productivity. This scenario is consistent with the reality: in the US, the concentration in sales and employment increased from 1982 to 2012. In this framework, the superstar firms will have a smaller share of labor since they are more profitable. Then, as these firms increase their weight in the economy, the aggregate labor share will fall.

The shrink in labor share is not the only cause of the increase in inequality: another reason often discussed in the literature is the skill-biased technological change. The skill biased technological change is a shift in the labor demand from low-skilled workers towards high-skilled workers caused by technological innovation. Innovation leads to a larger demand for high-skilled workers able to manage the new technologies and to a smaller demand for low-skilled workers who will be replaced by the more advanced technologies. If education does not keep up with innovation, the demand for high-skilled workers, mostly graduate students, will be larger than the supply and the skills premium, the differential between graduate and non-graduate worker wage, will be higher (Goldin and Katz, 2007). If technological innovation wins the race against education and the demand for high-skilled workers increases more rapidly than the supply, inequality will tend to increase. In fact, graduate households will have a higher income due to the scarce supply and non-graduate households will struggle to find a job, since the technological progress will replace low-skilled jobs with automation. Therefore, in this scenario, income will be more unevenly distributed among the population: a small share composed of the high-skilled workers will earn most of the total income.

Feenstra and Hanson (2001) claimed that trade in inputs has the same importance as the skill biased technological change and it works in a similar way. It shifts labor demand from low-skilled to high-skilled workers, increasing the skill premium. In fact, in developed countries, the labor cost for low and unskilled workers is higher than in developing countries, hence firms prefer to outsource the production of goods which require a large amount of low-skilled labor force. Doing so, there is a reduction in the demand for this type of workers similar to the decrease caused by technological innovation and the consequence is the same: higher inequality.

Another factor responsible for the increase in inequality is represented by political preferences. Politicians could prefer to design their political programs in order to win elections, giving a larger weight to the median voters and their needs, rather than proposing re-distributional policies which may not be supported by a large number of citizens. Zoutman, Jacobs, and Jongen (2016) exploited the fact that Dutch political parties pro-

vide their proposals for tax-benefit system to the national Bureau for Economic Policy Analysis (CPB) to measure the parties' redistributive preferences. The authors found that parties generally give more weight to poor households than to rich ones. However, they noticed that the social welfare weight increases until the mode of the earning distribution: they value giving a euro to individual in the middle class more than giving it to a poorer individual. In addition, they also found that in order to facilitate a coalition government, the tax-benefit system proposals do not deviate much from the status quo. This could prevent a reduction in inequality since a change in the status quo, in which inequality tends to increase, is crucial. Bierbrauer and Boyer (2015) analyzed the political preferences regarding inequality with a theoretical approach. The authors found that in a framework where politicians are vote-share maximizers and voters have private information on their own preferences, the political equilibrium allocations are surplus-maximizing and Pareto efficient. In addition, in this environment, there is a surplus-maximizing policy which defeats any welfare-maximizing policy. Therefore, in a majority vote, a proposal which benefits many rich and some poor is preferred to a policy which redistributes from richer to poorer households (Bierbrauer and Boyer, 2015).

2.1.2 Inequality measures

Blau (1977) was one of the first sociologists to contribute to the debate concerning inequality measures. He proposed to conceptualize inequality in two ways that are actually equivalent. The first one is "the average difference in status between any two pairs relative to average status". This means that the more the average difference exceeds the average status, the greater is the inequality. The second one is "the extent to which a status resource is concentrated". Allison (1978) introduced some rules that inequality measures have to respect to be considered valid measures. The first could be considered rather basic: the measure should be 0 when individuals have the same amount of the analyzed variable and it should be positive when at least two individuals differ. The second rule is that the inequality measures should pass the scale invariance criterion: if everyone's income is multiplied by a constant, then inequality should remain the same. In fact, a change in the unit in which inequality is measured is not a real change that actually affects the distribution. The third rule claims that a transfer from an individual at the top of the distribution to one at the bottom represents a decrease in inequality and a transfer in the opposite direction represents an increase.

The few inequality measures which respect these rules, particularly the scale invariance criterion, are the most commonly used ones. The most diffused one is the Gini coefficient (G): it is often described in relation to the Lorenz curve, a cumulative frequency curve that compares the distribution, of a variable with the uniform distribution

which represents equality. However, it could also be defined as a measure of statistical dispersion as follows:

$$G = \frac{\sum_{i,j}^{n} |x_i - x_j|}{2n^2 \bar{x}}, \tag{1}$$

where x could be income, consumption, salary etc held by households *i,j..n*; $\bar{x}$ is the mean of the variable considered and n is the size of the sample. This measure is the ratio between the mean absolute difference between the pairs of households and the mean $\bar{x}$. It could be interpeted as the percentage difference between consumption, salary or income of two indivuduas. Then the coefficient ranges from 0, in case of perfect equality since there is no difference, to 1, when there is perfect inequality. In this paper, the Gini coefficient is used to measure inequality; this allows to compare the results with the ones obtained from similar empirical researches in other countries.

Other inequality measures which respect the aforementioned rules are the Theil Index (T) and the Atkinson measure. The first is an entropy measure to calculate how far the population is from the ideal egalitarian state, where everyone has the same amount of income, wealth, etc. It is defined as:

$$T = \frac{1}{n} \sum_{i=1}^{n} \log \left(\frac{\bar{x}}{x_i} \right), \tag{2}$$

where x_i is the amount of money earned or consumed by the i-th household, $\bar{x}$ is the mean of the variable considered and n the size of the sample. This measure compares the relative income, salary and consumption of every individuals. When everyone has the same share there is the ideal egalitarian state and the Theil Index has value 1. Since its sensitivity to transfer decreases as scores increase, it is often used for social variables with decreasing marginal utility (Allison, 1978).

The Atkinson measure (A) differs conceptually from the Gini and Theil coefficients. These two coefficients measure inequality as a distance from the perfect egalitarian state, where everyone has the same score in a certain variable. However, they ignore the social welfare function and the households' preferences on redistribution. This more theoretical approach is used by the Atkinson measure which is the most popular welfare-based measure of inequality (Bellù and Liberati, 2006). This index depends on the degree of aversion to inequality and it measures the percentage of income that a society has to forgo to obtain a more equal distribution. It is given by the sum over all individuals of the relative incomes, but high and low income have different weights based on the inequality aversion parameter. The Atkinson Index is defined as:

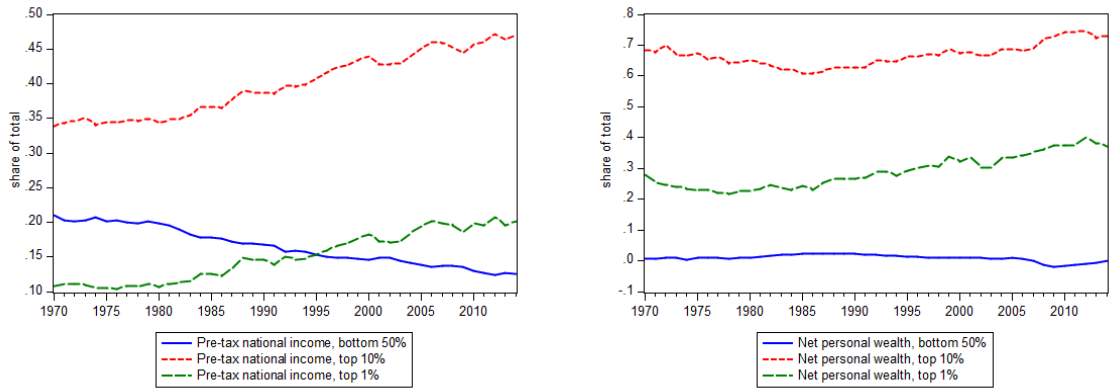
$$A_\epsilon = 1 - \left[\frac{1}{n} \sum_{i=1}^{n} \left[\frac{x_i}{\bar{x}} \right]^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \tag{3}$$

where ϵ is the inequality aversion parameter: if it is low, the society is more concerned about changes at the top of the distribution and if it high, the society is more concerned of low income households. x_i is the income, salary or consumption held by the i-th households; $\bar{x}$ is the mean of the variable considered and n is the sample size.

2.1.3 Inequality in US

Inequality in the United States is often studied and due to the greater availability of data there is a vast literature researching the evolution and the main drivers of inequality. Analyzing the data from the World Inequality Database, it is clear that, since the last decade of the 20th century, the top 1% and top 10% have had an ever-increasing share of the total income and total wealth, as shown by Figure 1. On the other hand, the

Figure 1: Income and wealth inequality in US



(a) Income distribution

(b) Wealth distribution

Source: World Inequality Database

shares of the bottom 50% of the distributions kept decreasing. After the eruption of the Great Recession, the wealth share was negative for seven years, from 2008 to 2014; this means that the poorest half of the US population has a negative financial position, more debt than assets. Moreover, since 1995, the pre-tax income of the top 1% is higher than the pre-tax income of the bottom 50%. Also, the income Gini coefficient confirms the increasing trend in inequality: it increased almost every year since 1970 and the OECD declared a Gini coefficient for the US higher than the OECD countries average.

Even if income and wealth inequality are at a high level and keep increasing, consumption inequality is lower and steadier (Meyer and Sullivan, 2017). The different trends could be justified by the fact that high-income households tend to save more by buying financial assets: a recent study found that the richest 10% have 84% of all the stocks

(Wolff, 2017). Hence, since income could be used either to consume or save, a large amount of savings implies that a smaller share of income is used for consumption and, for this reason, consumption inequality is lower than income and wealth inequality.

As seen before, Piketty (2014) claimed that the large amount of financial assets held by the people at the top of the income and wealth distribution, is one of the drivers of the rising inequality. However, Mankiw (2015) found a return of capital higher than the economic growth is normal and a symptom that the economy has not accumulated an excessive amount of capital. Moreover, he claimed that, to have the "endless inegalitarian spiral" predicted by Piketty, capital return should be seven percentage points higher than economic growth every year which is an unlikely scenario.

Nevertheless, even if the capital return does not reach the level needed for the "endless inegalitarian spiral", a policy which affects asset value, especially when the economy growth is very small or even negative, could lead to a higher inequality because of the financial assets' very uneven distribution in the US.

2.2 Unconventional Monetary Policy

Central Banks can operate in two different ways: by setting the interest rate or by deciding the amount of money injected in the economy. The former method is usually referred to as conventional monetary policy and it has been mainly used before the Great Recession. In fact, central banks used to influence the economy through the nominal interest rate.

However, the conventional monetary policy tools have some shortcomings and could become insufficient during economic crises. If the nominal interest rate is brought to zero and the desired effects, higher GDP and inflation, are not present, this *modus operandi* does not offer other tools to give a monetary stimulus. For this reason, when the interest rate is at the zero lower bound (ZLB), central banks usually resort to balance sheet policies to further stimulate the economy. These measures consist of increasing the monetary base to further lower the cost of credit and improving the condition of the financial sector (Smaghi, 2009). Since this type of measures have been used only in abnormal times, they are known as unconventional monetary policies.

In this section I discuss why, when the interest rate is close to zero, *conventional monetary policy* does not work, but the *unconventional* one could. Then, I analyze Quantitative Easing, one of the most used unconventional measures and, in particular, how it was implemented by the Federal Reserve in the US.

2.2.1 Conventional monetary policy

Conventional monetary policy is the *modus operandi* used by central banks to influence the economy through the nominal interest rate. By changing it, they will affect the real interest rate that, in turn, will modify asset prices and consequently the willingness of banks to lend, individuals to consume and firms to invest (Fawley and Neely, 2013).

This policy consists mainly of two tools: setting a target for the key interest rates and open market operations. The former is the main one: by deciding the nominal interest rates, the central banks are able to manage the liquidity condition in the system and pursue their mandate of price stability. The latter is used to adjust the quantity of money circulating in the economy (Smaghi, 2009).

The nominal interest rate decided and set by the central banks is the overnight interest rate in the interbank money market. This is the rate paid by banks which have a money shortage during the day to other banks in order to borrow money short-term. During the day, the banks' liquidity fluctuates according to the customers' operations, hence, in order to keep the banking system liquid, banks lend money to each other overnight, avoiding a shortage at the end of the day. The overnight interest rate affects the other interest rates because, when it increases, banks have to pay more to settle their account and, consequently, they will require a higher interest rate for loans, mortgages or other operations.

The monetary policy decisions regarding the interest rate in normal times are usually taken following the Taylor (1993) rule. This rule suggests how the nominal interest rate should be set in order to pursue price stability and economic growth. The Taylor rule could be written as follows:

$$i_t = \pi + r^* + a_\pi(\pi - \pi^*) + a_y(y - \bar{y}) \tag{4}$$

where i_t is the nominal interest rate, π_t is inflation, r_t^* is the real interest rate, π^* is the inflation target, y is the log of real output and y^* is the log of potential output. The coefficients a_π and a_y are the weights the central banks give to shocks in output and inflation gaps, respectively. The Taylor rule implies that, if the inflation is lower (higher) than the target, or the output is lower (higher) than the potential output, the central bank should decrease (increase) the interest rate.

2.2.2 Zero Lower Bound and Liquidity Trap

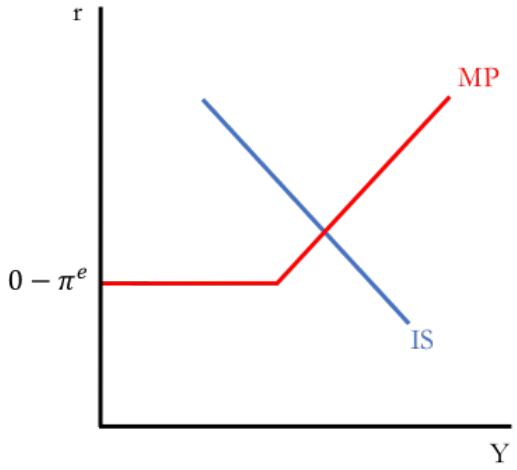
Conventional monetary policies allow to keep the economies stable, reducing inflation and the output gap through the control of the (nominal) interest rate. However, the central banks face a constrain when they set the interest rate: the zero lower bound. Typically, the interest rate should be positive. When the interest rate is zero, the cost of

holding money can be neglected and short-term bonds and money become perfect substitutes. If the interest rate is negative, it is more convenient to hold cash instead of lending it out (Hicks, 1937). The reason why the interest rate should not be lower than zero, hence the expression "zero lower bound", is that, in this case, monetary policy loses its grip and it is not able to affect the economy anymore. In fact, any further open-market operation by the central bank would not have an impact, since the private sector would be indifferent between holding bonds or money (Lukkezen, Jacobs, and Kool, 2015).

The situation where the interest rate is close to the ZLB and the monetary policy is ineffective is known as "liquidity trap". In the presence of a liquidity trap, some economic relations which are valid in normal periods now reflect the opposite. The IS-MP model is a useful tool to highlight the differences occurring when the interest rate is close to zero. In this model, the IS (investment-saving) curve represents the equilibrium points in the "real economy", between saving and investments. MP (monetary policy) represents the equilibrium points between the real interest rate and inflation. The point where the IS curve intersects the MP curve is the general equilibrium.

The MP curve is derived by the conduct of monetary policy: since, when output increases, the central banks increase the real interest rate, there is a positive relation between these two variables and the curve is upward sloping. However, since central banks cannot set a nominal interest rate lower than zero, in the presence of the ZLB, the real interest rate is $r = 0 - \pi^e$, where r is the real interest rate and π^e is expected inflation. Therefore the MP curve has a flat part. The IS is a downward sloping curve, since there is a negative relation between inflation and output as shown in Figure 2.

Figure 2: IS-MP model

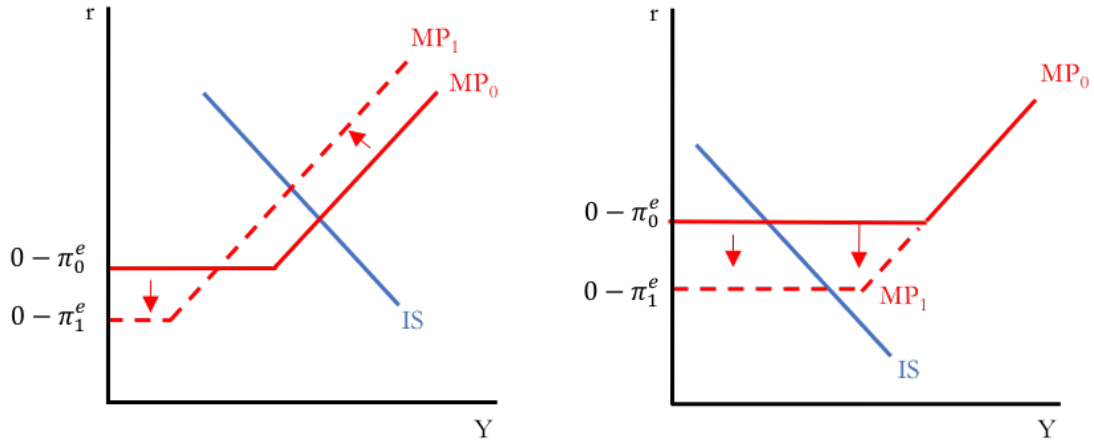


Source: Romer, 2013

The model reacts differently to the same shock in the case when the nominal interest

rate is at the zero lower bound. If the nominal interest rate is higher than zero, the IS curve intersects the MP curve in the sloping part, not in the flat one. Then the central bank, following the Taylor rule, will reply to an increase in inflation by increasing the nominal interest rate[2]. Since the real interest rate is approximately the nominal interest rate minus inflation, the central bank's reaction leads to a higher real interest rate which, in turn, causes a decrease in output. In the model, the tight monetary policy is represented by an upward shift of the sloping part of the MP curve. In fact, with higher inflation, the central banks want to set a real interest rate higher than before, at a given output level. The flat part is moving downward, since if π^e is larger, $0 - \pi^e$ is lower, as shown in Figure 3. If the nominal rate is at the ZLB and there is a liquidity trap, the IS curve intersects the MP curve in its flat part. In this case, an increase in expected inflation causes a lower real interest rate which in turn leads to more output (see Figure 3). Therefore, in a liquidity trap scenario, higher inflation leads to more output while in normal times inflation is negatively related to output.

Figure 3: IS-MP model: increase in inflation



(a) Normal times (b) Liquidity trap

Source: Romer, 2013

Krugman, Dominquez, and Rogoff (1998) claimed that people's expectations on the future generate the liquidity trap. If people are pessimistic about the future, they will save more and consume less in the current period in order to be able to also consume in the next periods, when the situation is expected to be worse. In this scenario, the utility given by consumption in the future is larger than the utility of current consumption, hence the market clearing interest rate is negative.

[2]The coefficient a is bigger than 0

Therefore, the key to dealing with the liquidity trap is managing the expectations (Eggertsson, 2003). Expected inflation is necessary to exit the liquidity trap. As seen above, higher inflation leads to a lower real interest rate and this in turn increases consumption and investment. This should also increase the aggregate demand and generate upward pressure on inflation. However, in a liquidity trap scenario, stimulating inflation is not easy and measures that would lead to a higher price level in normal times could not be enough.

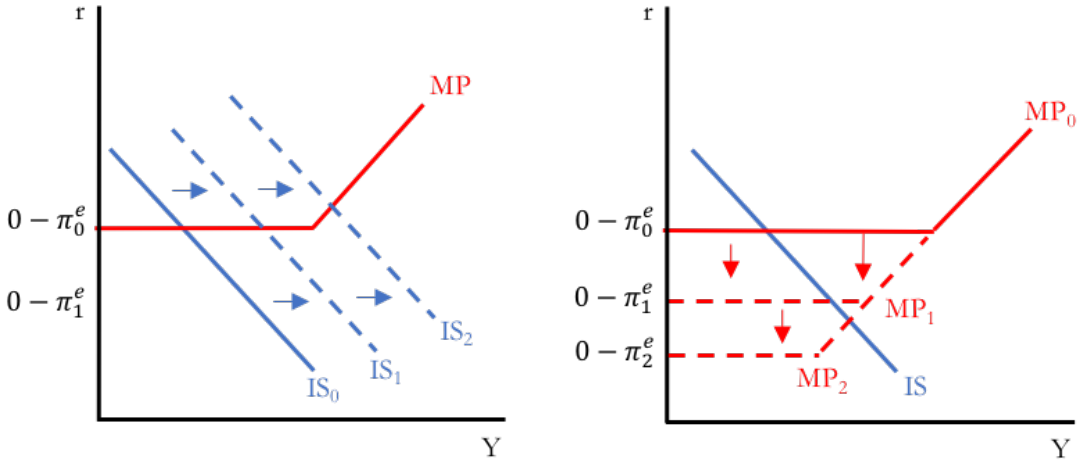
A temporary fiscal stimulus could work only if consumption is strongly affected by current income. However, if households prefer to smooth their consumption and perceive the fiscal stimulus only as a temporary measure, the pessimistic expectations about the future could prevent them from increasing their current consumption. If the temporary fiscal stimulus is not enough, the stimulus should be extended to a longer period in order to change households' expectations and exit the liquidity trap. However, this type of measure has a cost, since an extended fiscal expansion leads to larger public debt and could lead to other issues regarding its solvency.

In the IS-MP model, a fiscal expansion causes the IS curve to move outward; the IS curve is not affected by the liquidity trap, so it moves as in normal time. If after the positive shock the IS curve still intersects the MP curve in its flat part, the fiscal stimulus was not enough and the economy is still in a liquidity trap. Instead, if the new IS curve meets the MP curve in its upward sloping part, the stimulus was efficient to lead to exiting the liquidity trap. In Figure 4, the first fiscal stimulus which moves the IS curve from IS_0 to IS_1 is not sufficient to push the economy outside the liquidity trap: the intersection point is still in the flat part. The second impulse is large enough: IS_2 intersects the MP curve in its sloping part.

Another tool that could be used in this scenario is the monetary policy. Even if, as aforementioned, in a liquidity trap, monetary policy loses its grip on the economy, a monetary expansion could work under certain circumstances. If the expansion is perceived as permanent, it will lead to higher prices and a higher expected future price level will increase current consumption. However, in order to generate a credible permanent expansion, central banks have to commit to being irresponsible and not respecting their mandate. If central banks are still committed to a low and predictable inflation, the stimulus would be perceived as temporary. In fact, households will expect the monetary authorities to revert their decisions and tighten monetary policy to stabilize prices (Krugman, Dominquez, and Rogoff, 1998).

In the IS-MP model, a monetary expansion affects the MP; in particular, if the expansion is perceived as permanent and succeeds in increasing future inflation expectations, the MP curve moves downward. If the downward movement is large enough, the IS

Figure 4: IS-MP model: policy in a liquidity trap



(a) Fiscal policy expansion (b) Monetary policy expansion

Source: Romer, 2013

intersects the MP in the sloping part and there is no liquidity trap anymore. In Figure 4, the monetary expansion causes higher inflation and the flat part of the MP moves downward; however the first stimulus is not large enough, since the IS curve intersects MP_1 in its flat part. The second expansion further pushes the MP curve downward and, in this case, the liquidity trap disappears. The intersection point between the IS curve and MP_2 is where both curves are tilted.

2.2.3 Quantitative Easing

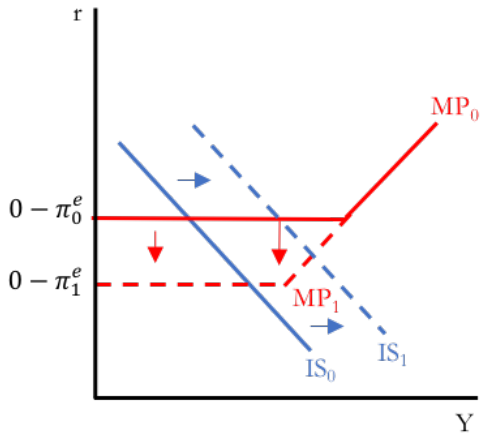
The most famous expansionary measure used by central banks to exit the liquidity trap during the Great Recession is commonly known as Quantitative Easing (QE).

Quantitative Easing is a term conied by Richard Werner to describe the policies implemented in Japan at the end of the last millennium in order to boost credit creation. QE then became famous when former FED chairman, Ben Bernanke, implemented it to push the US economy out of the Great Recession. The definition of QE is broad and economists described it focusing on different features which characterized this policy (Borio and Disyatat, 2010). Taylor (2009), Krugman (2009) and Auerbach and Gale (2009) described it stressing the increase in the central bank reserve balances, which are the deposits held by banks at the central bank. In fact, QE consists of purchasing assets and one way to do it is by printing new money. However, in order to expand the monetary base, central banks have to create new bank deposits, thus increasing reserve balances. Spiegel (2006) focused more on its aims and defined QE as a measure to reduce the long-

term interest rate and increase the money base. The final purpose of these two goals is to give a stimulus large enough to escape the liquidity trap. Ugai (2007) defined QE as a measure used by the central bank to commit to keeping the interest rate close to zero for a long period. This commitment is needed to generate expectations of economic recovery and higher expected inflation, with the final purpose of increasing aggregate demand and the price level. Benford et al. (2009) termed QE as the purchase of public and/or private bonds using the central bank's money with the purpose of stimulating spending and reaching the inflation target.

Romer (2013) claimed that QE has similar effects to a fiscal expansion. This measure leads to a general reduction in the interest rates: they are lower than they should have been. The lower interest rates encourage more investments and in turn increase output. In an IS-MP framework this effect is represented by IS shifting to the right, the same as with a fiscal expansion. Therefore, as mentioned before, if the stimulus is large enough and the new IS intersects the MP in the sloping part, there is no liquidity trap anymore. Moreover, Krishnamurthy and Vissing-Jorgensen (2011) claim that QE also leads to an increase in expected inflation. Figure 5 shows how now the flat part of the MP curve moves downward and a smaller fiscal stimulus is required to exit the liquidity trap.

Figure 5: IS-MP model: the effects of QE



Source: Author elaboration based on Romer, 2013 and Krishnamurthy and Vissing-Jorgensen, 2011

Despite the fact that there are different definitions of Quantitative Easing, there is a common agreement on how this policy works and affects the economy. There are two main transmission channels of the QE: *policy signaling* and *portfolio balancing*. The former consists of changing market agents' expectations about the future through a credible commitment to keep interest rate low (Krishnamurthy and Vissing-Jorgensen, 2011). A massive asset purchase is seen as a credible commitment because the interest rate increase

would cause a financial loss on these assets bought by the central bank (Clouse et al., 2003). The lower interest rates and the simultaneous purchase of assets induce the latter channel, *portfolio balancing*: investors will buy new assets to replace those sold to the central banks or those whose returns have declined.

The effects of the *portfolio balancing* are twofold: it increases asset prices and lowers the value of the currency. Investors will want to replace bonds whose yield is lower due to QE, with more remunerative assets. Therefore, they will buy riskier assets, such as corporate equity, and the increase in the demand will lead to a general increase of share prices. In addition, they can also replace national bonds, affected by QE, with foreign-currency assets, causing a currency depreciation (Priftis and Vogel, 2017). An increase in asset prices implies lower borrowing costs for firms and more consumption for households which hold assets, since their wealth increases (Joyce, Tong, and Woods, 2011). Moreover, a currency depreciation leads to more exports, therefore stimulating economic growth (Rodrik, 2008).

There are also other transmission mechanisms with smaller effects. One such mechanism is the *liquidity channel*, which decreases liquidity premia for illiquid assets and eases trading by expanding the monetary base. The injection of liquidity and the presence of a buyer who does not value how liquid an asset is (the central banks) reduces the spread between Treasury securities and less liquid assets such as agency securities. Moreover, it removes illiquid assets, such as old Treasury securities, from private portfolios, freeing capital and allowing new investments (Gagnon et al., 2011). Another mechanism is the *credit channel* which should also facilitate the issuance of new loans. This channel could be divided in two parts. The first is the *balance sheet channel*: changes in the interest rate affect the value of borrowers' portfolios and cash-flows, hence their creditworthiness, which in turn affects the credit cost. An expansionary policy increases borrowers' liquidity and portfolios' value, reducing the cost of borrowing money (Bernanke, 2007). The second component is the *bank-lending channel*: open market operations increase the amount of bank deposits and reserves, easing bank loans by increasing bank's access to loanable funds (Bernanke and Gertler, 1995).

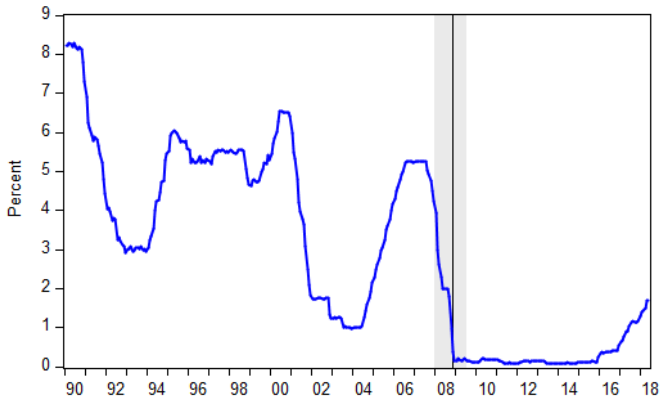
Lastly, the QE could also affect people's confidence: since the policy leads to a better economic outlook it boosts their confidence and consumption, leading to an increase in inflation (Joyce, Tong, and Woods, 2011). This is the *confidence channel*.

2.2.4 Unconventional Monetary Policy in US

The Federal Reserve and the US Government reacted with different measures to the beginning of the Great Recession. After Lehman Brothers filed for bankruptcy in September 2008, the FED implemented a large lending program to several financial insti-

tutions to try to solve liquidity problems and avoid further bankruptcies. In addition to the lending program, the FED used the interest rate, its conventional tool, to stimulate the economy. Figure 6 shows the Federal Funds Rate (FFR) which, already cut at the end of 2007, reached the zero lower bound in the last quarter of 2008.

Figure 6: Federal Fund Rate



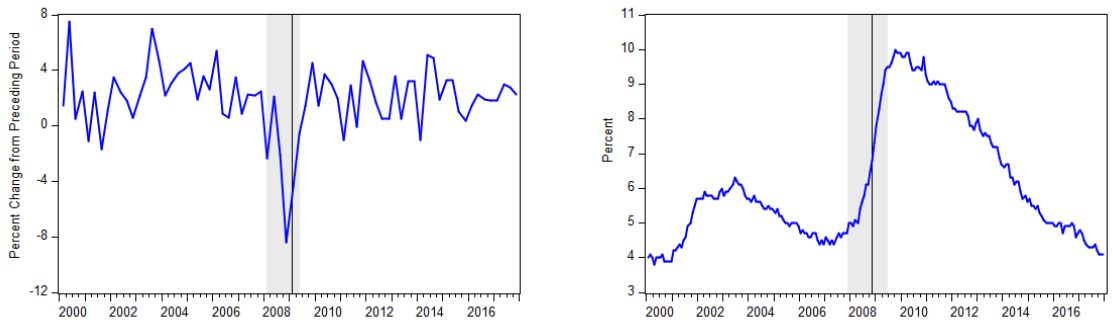
Note: The shaded area represents the Great Recession and the black line represents the beginning of the QE programmes.
Source: FED St. Louis

Despite the implementation of these two conventional measures, the recession was not over and the consequences on the US economy were very severe. In fact, as illustrated in Figure 7, GDP was decreasing and unemployment rate was increasing. Consequently, the FED decided to experiment with unconventional measures: forward guidance and quantitative easing (Williamson, 2017). First of all the central bank started to be more open communicating periodically its targets and its future actions to reach them in order to influence the markets and the consumers. In particular, the FED announced and promised a federal fund rate of 0 to 0.25% for an extended period[3]. This behavior could be defined as unconventional because, before the crisis, central banks and bankers tended to be very close and rather mysterious, without communicating their decisions and actions often. With the Great Recession, central bank communication changed radically, passing from former Bank of England Governor Montagu Norman's "never explain, never apologize", to European Central Bank President Mario Draghi's "whatever it takes" speech that immediately decreased European sovereign bond spreads[4] (Orioli, 2016).

The Federal Reserve implemented its first quantitative easing program (QE1) in November 2008, by purchasing long-term Treasury securities, mortgage-backed securities (MBS) and agency securities. Its first official end was in June 2009, but due to the

[3]See the June 2009 FOMC statement.
[4]https://www.reuters.com/article/eurozone-markets-draghi-idUSL5N1KG434

Figure 7: IS-MP model: policy in a liquidity trap



(a) GDP growth

(b) Unemployment rate

Note: The shaded area represents the Great Recession and the black lines represent the beginning of the QE programmes.
Source: FED St. Louis

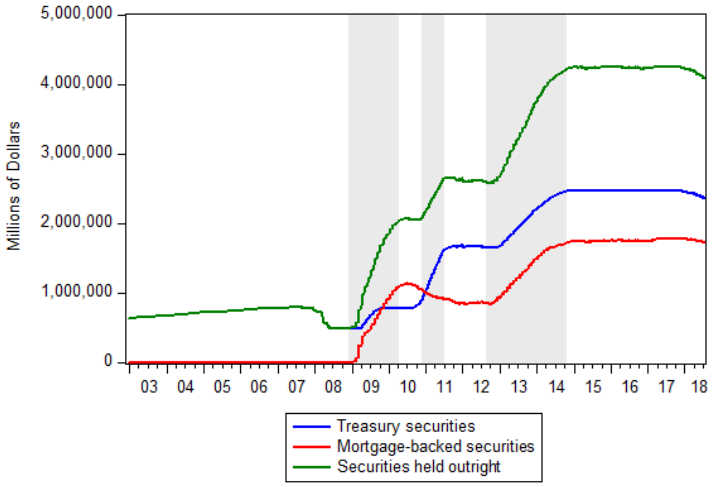
severe economic conditions, it actually only ended after sixteen months, in March 2010. Then, in August 2010, the Federal Open Market Committee (FOMC), the main FED policymaking body, launched a reinvestment programme in order to reinvest the payments on agency securities and MBS, by purchasing new Treasury, securities and to replace the matured assets[5]. A second quantitative easing phase (QE2) consisting in the purchase of $600 billion long-term Treasury securities was implemented from November 2010 to June 2011. Lastly, in September 2012 the FED launched its third and last program (QE3) and purchased Treasury and mortgage-backed securities until October 2014.

The three quantitative easing programs have had a large impact on the Federal Reserve balance sheet. Analyzing the total amount of securities and assets held by the central bank, it is possible to see three clear and steep increases during the QE programs. Figure 8 shows the amount of securities held outright by the Federal Reserve resulting from the open market operations. In the graph, two of the main components of these assets are also present: Treasury and mortgage backed securities. The sum of these two types of assets is almost the total amount of outright securities. Until the beginning of QE1, Treasury securities were the only securities held outright by the Federal Reserve. Then, during the first asset purchase program, the FED also bought a large amount of mortgage backed securities. This shows how abnormal it was for the FED holding this kind of assets in its balance sheet before the Great Recession.

Gagnon et al. (2011) found that the asset purchase programs implemented by the Federal Reserve had the desired effects on the interest rates. The 10-year term premium

[5]See the August 2010 FOMC statement.

Figure 8: FED's balance sheet



Note: The shaded area represents the QE periods.
Source: FRED, Federal Reserve Bank of St. Louis

decreased by 30-100 basis points and the decrease in the long-term interest rate on agency and mortgage-backed securities was even larger. The analysis of Christensen and Rudebusch (2012) leads to similar results: a decrease of circa 50-100 basis points on 10-year yields. In addition, they attributed this decline mostly to the lower policy expectations. In fact, the FED's statements were clearly announcing a long period of low federal refunds rate due to the weak economic conditions.

Therefore, it seems that Quantitative Easing worked in the US and led to general lower interest rates. However, this policy could also have had other implications for the US society. The relation between monetary policy and inequality is relatively new and has been studied mainly since the Great Recession. However, since the early '00s, the literature has focused on how macroeconomic variables influenced by monetary policies, in turn, affect inequality.

2.3 Monetary policy and inequality

Romer and Romer (1998) analyzed the impact of expansionary shocks on inflation and output. They found that the economic boom generated by this kind of policies could reduce poverty mainly through a reduction of unemployment. However, the reduction is only temporary and monetary policy cannot generate a permanent boom. Then, the strict monetary policy necessary to reduce the higher level of inflation will increase unemployment and consequently poverty, offsetting the benefits obtained by the economic boom. Moreover, the authors found that the best scenario for low-income households is

low inflation and stable aggregate demand. Doepke and Schneider (2006) analyzed the effects of inflation on wealth redistribution. Their results show that moderate inflation leads to reduction in wealth inequality: the main losers are the rich and old households and the winners are young and poor households with mortgage debt. In fact, the real value of the mortgage debt is lower with higher inflation. Wolff (2017) found that the majority of asset's worth of the middle three wealth quantiles is highly concentrated in their house value. This feature characterized minorities as well, especially African-American households and young households. Then these minorities and not only young households could also benefit from higher inflation. Moreover, Erosa and Ventura (2002) analyzed the redistributional effect of inflation: they found that high-income households are better off in times of high inflation. By consuming more, they face lower costs in credit purchases and consequently they benefit from higher inflation, which reduces the real value of their debts.

Coibion et al. (2012) summarized the ways through which monetary policy, conventional and unconventional, can affect income and consumption inequality into five channels. These channels do not influence inequality in the same way: three of them tend to increase it while the other two work in the opposite direction. Thus the relation between monetary policy and inequality could vary in this framework, based on which channels prevail.

The first is the *income composition channel* and it is related to the heterogeneity in households' sources of income. While wage and salary are the main or only sources of income for many households, others rely more on financial returns. If expansionary monetary shocks increase financial assets' value and return more than wages, the households who have a larger share of income from financial revenues benefit disproportionately more. Wolff (2017) found that the individuals who own financial assets are mainly the wealthiest: in 2016, the top 1% owned 40% of all stocks and the top 20% owned 93%. Therefore, the rise in assets value caused by an expansionary shock through this channel would lead to higher wealth, but also income inequality through larger capital gains and dividends. In addition, since consumption inequality is driven by income and wealth inequality, the consumption distribution, in particular the durable expenditures, would also be more concentrated at the top.

Another channel which works in the same direction is the *financial segmentation channel*. The access to financial markets is not the same across households: there are people with more information and skills that have an easier access. Lusardi, Mitchell, and Curto (2010) analyzed financial literacy among teenagers in US and found that less than one third of young adults have the basic financial knowledge. In addition, there are considerable differences based on individual and family features. Women and minorities

are less likely to answer correctly to financial questions than men and white people, respectively. Moreover, parents' education has an important role: teenagers whose mother is graduated from college have almost a 20% higher correct response rate. These households could have an advantage from an expansionary monetary policy. In fact, since they have better knowledge and access to the financial markets, they are affected by the changes in monetary policies prior than households with no knowledge or access to the markets and could take advantage of it. Therefore, an expansionary measure will distribute more to those households who are closely related to financial markets and less to the ones who do not have access to it (Coibion et al., 2012). This channel is slightly different from the previous one because, while in the *income composition channel* the increase in inequality is given by the difference in portfolios, in the *financial segmentation channel* this is given by the difference in opportunities caused by different levels of knowledge and accessibility to the market. This channel should lead to higher wealth inequality; since in this paper wealth inequality is not measured, this effect could be captured by an increase in consumption inequality.

The third and last channel which leads to higher inequality is the *portfolio channel*. This is related to how people with different income sources are affected by the inflationary actions of the central banks. Low-income households tend to hold relatively more currency and fewer assets than high-income households and consequently are affected more by an increase in inflation. In fact, cash is not hedged against inflation and, when there is a price increase, the real value of money decreases. On the other hand, holding assets allows not only to diversify and hedge from inflation, but also to benefit from the increase in value. In fact, assets such as treasury bonds and real estate allow to hedge against expected, and in some cases unexpected, inflation (Fama and Schwert, 1977). The nominal return of the T-bill varies with the expected inflation so the real return is unrelated to the expectations on price level. In addition, a general increase in price is caused by, and also causes, an increase in the price of houses. This channel then affects the wealth held by households and it could be captured by increases in consumption inequality.

The first of the two channels, which work in the opposite direction and lead to less inequality when an expansionary policy is implemented, is the *saving redistribution channel*. A decrease in interest rate and an increase in inflation tend to benefit borrowers and hurt savers. A lower interest rate implies lower borrowing cost and higher inflation means that the real value of the loan is reduced. Assuming that low-income households are more likely to be borrowers and the high-income households savers, then an expansionary monetary policy will lead to a reduction in consumption inequality.

The second channel is the *earnings heterogeneity channel*. The share of wage and salary of total income is similar for most of the US population. For households with

annual income below $200.000 (circa 98% of the population [6]) wages and salary are 70% of the total income. Above the $200.000 threshold, the wage share decrease to 58% and above $1 million per year, the share is smaller than 30% and investment income is more than 40% [7]. However, lower income groups tend to be more sensitive to the business cycle and tend to suffer more from an increase in unemployment. Carpenter and Rodgers (2004) found that a FED's contractionary monetary policy increase the unemployment of minorities and less-skilled households. Therefore, if expansionary monetary policies reduce unemployment, low income households are the ones who benefit the most and this could lead to a decrease in salary, income and consumption inequality.

2.3.1 Empirical Evidence

Since the Great Recession and especially during the last couple of years, the literature changed its focus from analyzing how variables influenced by monetary policy affect inequality, to assess the direct impact of monetary measures on inequality.

Coibion et al. (2012), in addition to explaining the channels through which monetary policy affect inequality, also assessed the impact of contractionary shocks in the US. The authors found that interest rate shocks have significant long-run effects on inequality. In particular, by using a household survey from 1980 to 2008, before the implementation of UMP, they conclude that a restrictive monetary policy shock leads to higher inequality across households in labor earnings, income, consumption and expenditures. Therefore, an increase in the interest rate to fight high inflation and a low inflation target, what central banks in developed countries did since the end of the 20^{th} century, makes the households at the bottom of the distribution worse off. Furceri, Loungani, and Zdzienicka (2018) obtained similar results: they analyzed unexpected changes in the short term interest rate during conventional monetary policy regimes in 32 developed and developing countries and concluded that contractionary shocks increase income inequality, while expansionary ones are statistically insignificant. Particularly, an unexpected decrease of 100 basis points in the policy rate leads to a 1.25% increase in the income Gini coefficient after 1 year and an increase of 2.25% after 5 years. Moreover, Montecino and Epstein (2015) found that tight monetary policy increases inequality because the reduction in employment and the higher mortgage refinancing cost offset the benefits of reduced asset prices growth. However, the two authors also analyzed QE and concluded that it leads to higher inequality as well. In this case, the disequalizing effects of the rise in asset value and equity returns outweighs the benefit given by the increase in employment. The paradox of higher inequality with

[6] Source: The Wall Street Journal, http://graphics.wsj.com/what-percent/

[7] Source: Internal Revenue Service, Statistics of Income, https://www.irs.gov/statistics/soi-tax-stats-individual-statistical-tables-by-size-of-adjusted-gross-income

both contractionary and expansionary monetary policy rather poorly investigated by the existing literature, which is mostly focused on the effect of the latter.

Saiki and Frost (2014) are among the firsts to assess the impact of expansionary policy, and in particular of unconventional monetary policy, on inequality. They implemented a vector auto regression model to evaluate the impact of quantitative easing in Japan. Their results show that, while QE finally seemed to have a positive impact on economic growth, it also contributed to an increase in income inequality. A one standard deviation shock leads to a cumulative 0.010 increase in the Gini coefficient. In addition, after 2008, when the policy became more aggressive, there is a larger impact on inequality. In this case there is a 0.013 cumulative upward impact. The authors attributed this negative effect to the portfolio channel: a larger monetary base tends to increase asset prices, which are mostly held by high-income households. Moreover, Saiki and Frost concluded that the effect in Japan could be lower than that in other countries such as the US, the UK and some Eurozone countries, where citizens hold larger shares of savings in financial assets. In addition, Inui, Sudou, and Yamada (2017) analyzed the impact of Japan's monetary policy, but they focused on the period from 1981 to 2008. They found that expansionary monetary policy raised inequality in Japan before the 2000s. The larger inequality is mainly due to an increase in income and earnings inequality, but the effect of QE on consumption inequality is insignificant.

Japan was one of the first states to be examined because the Bank of Japan already implemented unconventional monetary policies in 2001 to fight domestic deflation. Consequently, there is more data and evidence available. However, recently, more studies about other countries and central banks have been published. Mumtaz and Theophilopoulou (2017) investigated the relation between monetary policy and inequality in the UK from 1969 to 2012, analyzing both conventional and unconventional measures. The authors used an approach similar to that of Saiki and Frost (2014), using survey data to calculate inequality measures and a structural VAR model. They concluded that during conventional policy regime, a monetary policy shock contributes to a significant proportion of the fluctuations in income, salary, consumption and expenditures inequality. However, the effects are not in the same direction: the shocks decreased inequality in the '70s, but then they had the opposite impact in the late '90s. A reason for this results could be that, during the inflation-target period, there were several contractionary shocks because the authorities wanted to keep a low inflation level. These contractionary shocks could have exerted an upward pressure on inequality. The authors slightly changed their model to assess the impact of unconventional monetary policy and Quantitative Easing. They assumed that QE affects the economy by reducing the 10-year government bond yield by 100 basis points. Then, with the same structural VAR model used for conventional policy,

they carried out two conditional forecasts: one which assumed that the long-term spread and the short interest rate are equal to the actual values and the other with the actual short interest rate, but with the path of the bond yield spread 100 basis points higher. The second forecast tried to estimated a scenario where the Bank of England did not implement QE. From this simulation they concluded that QE led to an increase in income and non-durable consumption inequality, but it barely affected wage and consumption inequality.

Domanski, Scatigna, and Zabai (2016) studied European advanced economies and the US to simulate how unconventional monetary policies affect the wealth distribution. They constructed households balance sheets based on survey data and they computed the growth rate for all asset classes. Finally, they calculated the inequality measures of the new wealth distribution and compared it with the distribution given by the surveys. The authors concluded that wealth inequality increased since the Great Recession and that unconventional monetary policy is one of the drivers. In particular, the simulation showed that a close to 0 interest rate, forward guidance and the bond price have had a modest impact on inequality. The main causes of the increase in inequality are the rise in equity returns and house prices and their unequal distribution among the population.

3 Data

3.1 Inequality coefficients

As discussed in chapter 2, there are several inequality measures to quantify inequality. The one used in this paper is the Gini coefficient. Following the same approach as most of the literature on this topic, the inequality measures are constructed from household surveys[8]. In this paper, the Gini coefficient is calculated using data from the Consumer Expenditures Survey (CEX) released by the Bureau of Labor Statistics of the United States. In addition, in order to obtain consistent estimates, I decided to use only data from the CEX which were calculated and obtained following the same criteria and methodology. For this reason, the sample period starts in 2004Q1, when the process to calculate income and salary was modified, to 2016Q4, the most recent data available.

The Consumer and Expenditures Survey collects information about income, expenditures and consumer characteristics. It is composed of two different parts: a diary survey and an interview survey. The first is self-administered and gathers information about small and frequently purchased items. The second one consists of households' quarterly interviews: it collects detailed data on both income and consumption. The

[8]See Coibion et al. (2012)), Saiki and Frost (2014) and Mumtaz and Theophilopoulou (2017)

difference with the diary survey is that the interviews also capture large and infrequent purchases and that the small expenditures are at a more aggregate level (e.g. quarterly expenditures for grocery store purchases). Due to its features, only the interview survey is used.

The Consumer Expenditure Survey is the most comprehensive and detailed data source on households expenditures in the US (Coibion et al., 2012; Pistaferri, 2015) and it has been extensively used for research purposes. However, since the beginning of the '00s its representativity and accuracy have been questioned. Sabelhaus et al. (2013) analyzed if the interviewed sample correctly represents the income groups from the US society. By comparing the CEX to other household surveys, the authors found that there is an under-representation of very high income families. The scarcity of the top income households in the survey has different implication on the accuracy of the inequality measures used in this paper. Attanasio, Battistin, and Ichimura (2004) compared the wage inequality measure obtained using the CEX to the one which relies on data from the Current Population Survey (CPS), a survey conducted by The Bureau of Labor Statistics which analyzed the employment status of the interviewed households, to assess its accuracy. They found evidence that the two surveys present similar results on the dynamics of wage inequality. Therefore, the authors claimed that the CEX is reliable and pertinent to calculate a wage inequality measure.

Heathcote, Perri, and Violante (2009) found similar results for income. In fact, they compared the income data from the CEX to the ones from the CPS and the Panel Study of Income Dynamics (PSID), a survey conducted by the University of Michigan to measure economic and social factors at a household level. They claimed that the income inequality measure obtained by the CEX is reliable because the variances of pre-tax income in the three surveys are closely aligned. However, using the same approach, the author found that this result does not hold for consumption. They compared the CEX with the National Income and Product Accounts (NIPA) and they discovered that the survey-based estimates of the former are lower than the ones of the NIPA. The different definitions and the conceptual differences in categorizing and calculating the expenditures are only part of the discrepancy between the two data sets. The authors claimed that another reason is the under-representation of the upper-tail of the consumption distribution and the relevant role of this group in the increasing of the aggregate consumption. Aguiar and Bils (2015) supported the same conclusion and they also calculated that the under-representation of the largest spenders in the CEX increased by 27 log points from 1980 to 2005. Bee, Meyer, and Sullivan (2012) further analyzed the quality of the Consumer Expenditure Survey data. They compared aggregate expenditure categories calculated from the CEX with micro and macro data from other data sets. Their results show that the Diary

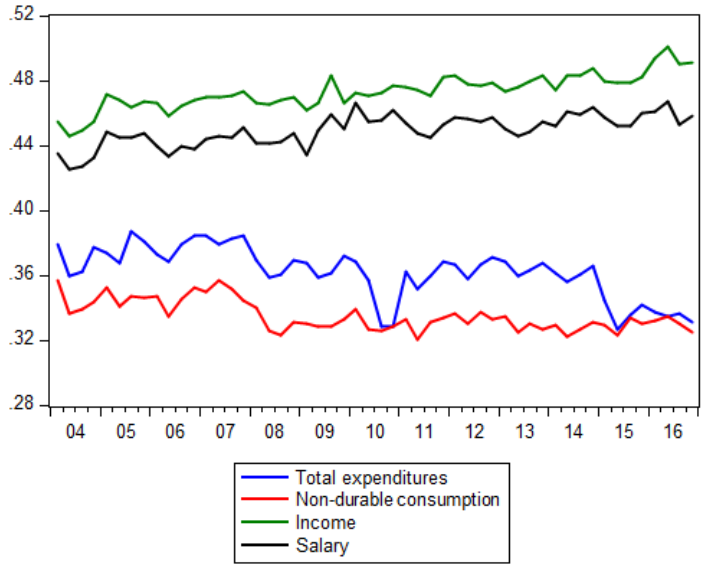
Survey of the CEX performs very poorly, with respondents under-reporting expenditures and often reporting zero expenditures on categories such as rent and utilities. On the other hand, the Interview Survey performs significantly better overall, even if some categories are under-reported. In particular, the largest components of consumption such as rent, utilities and motor vehicles are well represented and in line with the national accounts data. Other categories such as clothing, alcohol and furniture are poorly represented if compared to the share these categories have in the national accounts, highlighting an under-reporting problem (Bee, Meyer, and Sullivan, 2012).

The under-representation of the upper-tails of income and consumption distribution could be an issue for estimating inequality measures. In fact, if the number of interviewed top-income households is not proportional to the actual number for this group in the US society, the estimated Gini coefficients could be biased. In particular, since they are less than proportionate, the estimated coefficients are downward biased, meaning that they are smaller than the actual ones. This issue affects the inequality measures of non-durable goods and total consumption more than the ones of wage and income, since the CEX distributions of the last two are in line with other surveys. Hence, these should be more accurate and reliable. The under-reporting of high-income households is only a small concern, since for the purpose of this paper what matters is not the total amount of consumption, but its distribution. However, both issues regarding the accuracy and representativity of the CEX are caveats to take into account while analyzing the results.

There are many reasons to calculate an inequality measure from households surveys, rather than using the ones provided by several databases (OECD, FED, etc). First, these databases have data on inequality only for recent years and they are often incomplete, not having observations for every year. Moreover, to estimate the impact of UMP on inequality, it is better to use high frequency data. The CEX allows to obtain a quarterly Gini coefficient, while the other databases provide only annual data. Moreover, a higher frequency is necessary to assess the short-term impact of UMP on inequality: using annual data, the effects which happen within a year are not visible. Finally, the CEX provides enough data to estimate four different inequality measures: salary, income, consumption and expenditures inequality. Unfortunately, the Consumer Expenditure Survey does not provide data on wealth and there are no other databases containing this data on a quarterly basis. Figure 9 shows the four Gini coefficients obtained from the consumer survey.

The salary inequality measure is simply calculated using the data on the total amount of income received from labor income before any tax or other deductions. The income inequality is slightly more complex since it takes into account different income sources. In fact, it comprises salary and wages, financial returns, interests on pensions

Figure 9: Gini coefficients



Source: Consumer Expenditures Survey

savings, Social Security benefits and other sources of income. The consumption and expenditures inequality measures are based on Parker (1999) and Coibion et al. (2012). The first could be interpreted as a narrow measure of consumption inequality: it is made mostly by non-durable goods and it includes food and beverage, apparel, tobacco, transportation, small appliances and furniture, services and utilities. Expenditures, instead, is a broader definition of consumption: it includes the previously defined measure of consumption as well as purchases of cars, mortgages, medical payments, school tuitions and insurances. The differentiation between narrow and broad consumption is important because every-day consumption and purchase of durable goods follow different trends and are affected differently by the business cycle. Non-durable consumption is pro-cyclical but, consistent with the permanent income hypothesis, it is not very volatile. On the other hand, durable consumption is more pro-cyclical and also more volatile than non-durable consumption (Stock and Watson, 1999).

The data regarding quarterly income and salary of every surveyed household are readily available in the Consumer Expenditure Survey. In these cases, I used Stata to calculate the Gini coefficients, applying the formula described by equation (1) from Section 2.1.2, based on the thousands of observations provided by the survey. However, quarterly aggregate data for non-durable and total consumption are not readily available from the CEX. Therefore, I calculated them by summing all the expenditures in a certain category (i.e. food, clothes etc.) made in a quarter by every interviewed household.

Then, for every respondent, I aggregated the total quarterly expenditures in the different categories previously calculated. In this way I obtained the amount of dollars spent by every households in every quarter of the sample. Once I had these data I applied the same aforementioned methodology using Stata to calculate the quarterly Gini coefficients for non-durable and total consumption.

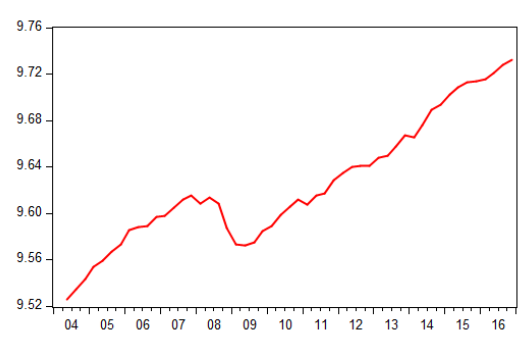
3.2 Economic and monetary policy variables

In addition to the four Gini coefficients, the model includes other four variables, represented in Figure 10. These variables are macroeconomic indicators such as the growth rate of the Gross Domestic Products (GDP), inflation and indicators to model the monetary policy shocks and their effects. In particular, the variables used are the monetary base and the share price. Moreover, all the data are at a quarterly level and the source for all variables is the Federal Reserve Bank of St. Louis, the subsidiary of the FED which maintains the research department and its main database: the Federal Reserve Economic Data.

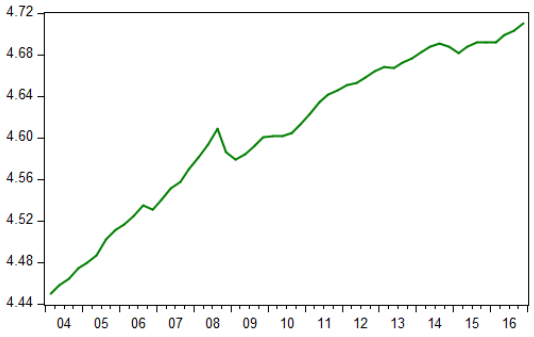
The GDP used is the Real Gross Domestic Product, seasonally adjusted at an annual rate. The growth rate of the GDP is obtained by taking the first difference of the logarithms. Inflation is measured by the Consumer Price Index (CPI) and it is the change in price of a basket of goods and services; it is measured as an index and 2010 is the base year. The monetary base used is the one adjusted for the effects of changes in statutory reserve requirements on the quantity of base money held by depositories. Since it is available only at a monthly frequency, it has been aggregated to quarterly data by calculating the mean of the three months of every quarter. The Monetary Base measures the highly liquid funds: it is the sum of currency in circulation outside the FED and the US Treasury, and the deposits of financial institutions at the central bank. The share price measures the total price for all the US shares. It is calculated monthly by the FED, therefore it has been aggregated to quarterly data with the aforementioned process, also used for the monetary base.

These four variables have been transformed by taking the natural logarithm. This transformation allows to remove data dimensions and to use different types of variables in the same model: both indices and observations in real dollars. Furthermore, the economic interpretation after the logarithmic transformation is easier and more informative. Small changes in the natural logarithm of a variable are directly interpretable as a percentage change. Therefore, the interpretation of a change in the monetary base is not a variation of a certain amount of dollars anymore but a percentage variation.

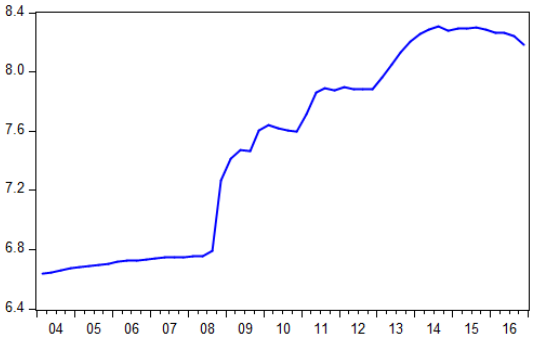
Figure 10: Economic variables



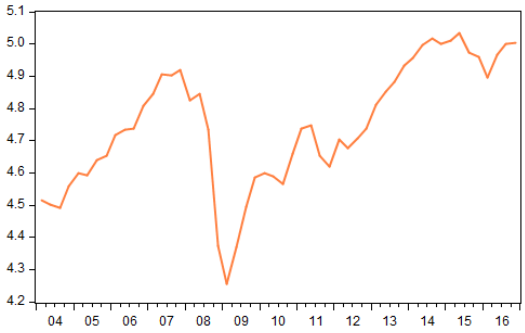
(a) Log(GDP)



(b) Log(consumer price index)



(c) Log(monetary base)



(d) Log(share price)

Source: FED St. Louis

4 Methodology

In order to estimate the impact of US's Quantitative Easing on inequality, I used a vector autoregression model (VAR). A VAR model is a system of multivariate models in which each variable is explained by its own lags and by the lags of the other variables used in the model. A simple VAR model can be written as:

$$Y_t = C + A_i Y_{t-i} + \epsilon_t, \qquad i = 1 \tag{5}$$

where Y_t is a matrix of variables; C is a vector of constants, A_i is a matrix with a structural coefficient and ϵ_t is a vector of random errors.

The VAR model has been used in macroeconomic analysis ever since it was pioneered by Sims (1980) as an alternative to structural macroeconomic models. VAR models are often used because they are simple to estimate and convenient for forecasting: even if they have a relatively small size, using few variables, they can generate results as good

as those obtained by more complicated models (Carnot, Koen, and Tissot, 2011). In addition, VAR models are a useful instrument to analyze the relationship between the variables of interest. In fact, these models allow to assess how an impulse given to one of the variables influences the others through the impulse response function. If the VAR model is not subject to endogeneity and the variables respond to the impulse given to one specific variable, it is possible to conclude that the variable which was given a shock to has a causal effect on the others. Particularly, endogeneity could be casued by reverse causality, when the independent variable is actually caused by the dependent one, or by omitted variable bias, the case when there are unobserved variables correlated with the dependent and independent variables. Therefore, the results of the models used in this paper can be considered causal if there is no evidence of these two issues. The reverse causality problem is solved if the theoretical assumptions on which the variables' order is based hold. In fact, this order defines the causal relations between the variables, determinig which one affects the others. The omitted variables bias problem is slightly more delicate, because the size of the sample does not allow to include too many variables. In order to have causal effects, two assumption are necessary: the first is that the monetary base should be affected only by the GDP growth and inflation. The second one is that the Gini coefficients are affected by the change in the monetary base through the share appreciation and there are no other variables correlated with these two variables. The second assumption could be questioned, since there are also other channels, such as bond interest rate, that could link the monetary base to the Gini coefficients. However, when including the 10-years Treasury Bond in the VAR model, the results thus obtained are almost identical to the ones yielded by the a model which excludes this variable. Therefore, I decided to use only the share price, to have more degrees of freedom and to be able to compare my results with the ones obtained by Saiki and Frost (2014).

In addition, these models have some further limitations, especially regarding stationarity and the number of lags used. In order to use the OLS estimation method the variables should be stationary, otherwise a transformation is needed before running the VAR. A more serious issue is the choice of lags since different numbers of lags, could affect the final result. These two issues are addressed later in this section. Another shortcoming is that, often, the VAR coefficients are not straightforward to interpret in economic terms (Carnot, Koen, and Tissot, 2011).

4.1 The model

In this paper I used two different VAR models for each inequality dimension, in order to assess the impact of Quantitative Easing on inequality. These two models are similar but they differ on the number of variables and the sample period used.

The first model is based on the one implemented by Saiki and Frost (2014) and it is composed of all the variables discussed in Section 3, for the whole sample, from 2004Q1 to 2016Q4. This sample period also contains years with conventional monetary policies. In fact, until the last quarter of 2008, the Federal Reserve was influencing the US economy by changing the interest rate and in late 2015 the former FED chairman, Janet Yellen, changed for the first time the Federal Funds Rate since it was brought to zero in 2008[9] (see Figure 6). The basic VAR model described in equation (5) then becomes:

$$Y_t = C + A_i Y_{t-i} + \epsilon_t, \qquad i = 1 \tag{6}$$

where Y=[Δ Log(GDP), Δ Log(CPI), Δ Log(monetary base), Δ Log(share price), Δ Gini]

The four different inequality measures are used separately in the model one at a time: only the Gini coefficient is changing, all the other features of the model remain unchanged. This model exploits all the observations available to assess how a shock in the monetary base affects the economy and, in particular, inequality.

However, the model described in (6) does not allow to assess the impact of an increase in monetary base using a sample period which covers only the unconventional monetary policy years. In fact, the unconventional monetary policy period is too short and there not sufficient observation to be included in the aforementioned model such taht there are enough degrees of freedom to obtain significant results. Therefore, I also ran a shorter model, with only three variables. The model in equation 6 is then shortened to obtain:

$$Y_t = C + A_i Y_{t-i} + \epsilon_t, \qquad i = 1 \tag{7}$$

where Y=[Δ Log(GDP), Δ Log(monetary base), Δ Gini]

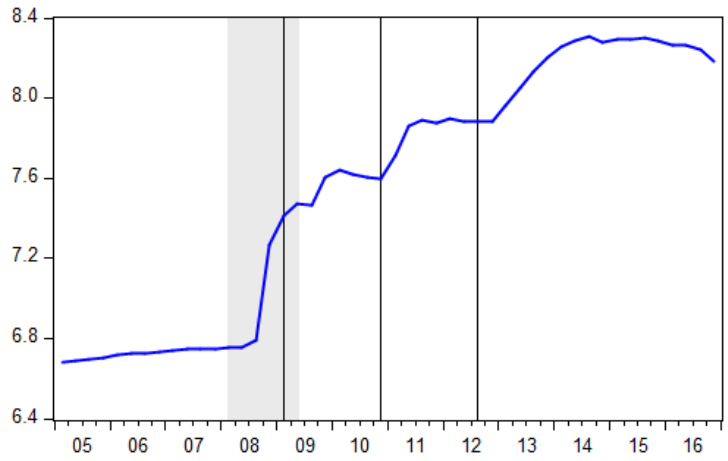
Similar to the extended model, I plugged in the model one inequality measure at a time. Moreover, in order to better assess the impact of quantitative easing on inequality, I ran this short model with the whole sample as well. In this way it is possible to compare the results, since they are obtained from the same model: if QE has an impact on inequality, the response of Gini to a shock in the monetary base should be stronger when the sample period only covers the unconventional policy years and its impact is not also spread over the years with a conventional monetary policy regime.

The VAR models are used to obtain the impulse response functions (IRF), which describe how a shock in the monetary base affects inequality. In order to give a shock a variable keeping the others fixed, a transformation is required: the most used one is the Cholesky decomposition. This imposes a causal structure from the first variable, to

[9] https://www.nytimes.com/2015/12/17/business/economy/fed-interest-rates.html

the ones at the end, but not the other way around (Lin, 2006). Therefore, the way in which the variables are ordered in the impulse response function affects the final results. I applied the same Cholesky order used by Saiki and Frost (2014). This disposition makes some assumptions on what variables affect monetary policy and what variables are affected by it. The first and second variables are GDP and inflation: they are the main drivers of monetary shocks, hence they are at the beginning of the model. Price stability is included in the FED's mandate, consequently the FOMC decides its policies based on its inflation target and the current inflation level: if the current level is higher than the target, there will be a contractionary monetary policy, while if it is lower, as it was the case for the Great Recession, there will be an expansionary one. In addition to inflation, there is also the GDP, because the severe recession and the low level of output were incentives for the FED to pursue aggressive expansionary measures, switching from conventional to unconventional monetary policy. The third variable in the model is the monetary base: it is a proxy for the Quantitative Easing, since one of the main effects of this tool is the large increase in the currency circulating in the economy (see Figure 11). The fourth variable is a link between expansionary monetary policy and inequality: it

Figure 11: QE and monetary base



Note: The shaded area represents the Great Recession and the black lines represent the beginning of the QE programmes.
Source: FED St. Louis

is the channel through which quantitative easing affects income, consumption and salary distribution. The research found that the main links are the stock market and the asset values[10], therefore the shares price is used in the model. Finally, the last in the order is the variable of interest, the Gini coefficient. The Cholesky order is the same for both the

[10]See: Saiki and Frost (2014) and Domanski, Scatigna, and Zabai (2016)

extended and the short versions of the model even if in the latter one inflation and share price are missing.

4.2 Testing the models

Before running the model, I conducted some tests specifically aimed at checking whether the variables are stationary and at deciding on the optimal number of lags.

As mentioned above, in order to obtain a valid VAR model, the variables used should be stationary. If there are both stationary and non-stationary variables, the regression could yield a correlation even if there is none bdue to the random walks. A variable is stationary if its statistical properties (i.e. mean, median, etc.) are constant over time. Many economic variables are non-stationary, hence I tested the variables of the model using the Augmented Dickey-Fuller test (ADF). This procedure developed by Dickey and Fuller (1979) tests the null hypothesis that the variable has a unit root, which means that it follows a random walk and it is not stationary. The ADF test shows that inflation, monetary base, share price and Gini coefficients all have a unit root and, consequently, are non-stationary. Therefore, in order to make them stationary I took the first difference. The ADF test confirms that the variables are stationary in their first difference, meaning that they are difference-stationary.

Once all the variables are stationary, the next step is deciding the right number of lags to use in the model. There are several tests to determine this: the one that I used is the Akaike Information Criterion (AIC). In addition I also followed Carnot, Koen, and Tissot (2011), who suggest to first try four or eight lags when using quarterly data, since there might be a yearly cyclical pattern. The AIC for the short model described in equation (7) concluded that three lags should be used, as shown in Table A.1 in the Appendix; I also checked the model with four lags, to evaluate if it improves. However, it performs worse than the model with three lags. For the extended model defined by equation (6) the AIC test determined 6 lags are optimal (see Table A.2 in the Appendix). However, the larger number of lags could be a problem due to the insufficient number of observations that might lead to a lack of degrees of freedom. In addition, the coefficients of the fifth and the sixth lag are not statistically significant. Therefore, following Carnot, Koen, and Tissot (2011) I tried to run the model with four lags. In this case the coefficients are more often statistically significant, hence I decided to use four lags for the extended model.

5 Results

Since, in order to assess the impact of US quantitative easing programmes on inequality, I have used four inequality measures, the results of my analysis are presented in separate individual sections, based on the Gini coefficient used in the model.

5.1 Income inequality

The coefficients retrieved from the VAR models (see Table A.3 in the Appendix) when using the income Gini coefficient show that an expansion in the monetary base has different effects on income inequality, depending on the lag. The first, the second and the fourth lags have a minus sign, but the third one, the only significant, has a positive sign, meaning that there is an increase in inequality. Monetary base also has a positive effect on the share price. However, the interpretation of the coefficients is not very easy and direct and, as aforementioned, a more useful and straightforward tool to interpret the results of VAR models is the impulse response function. In particular, I focused on the IRF of the Gini coefficients to a one percentage point change in the monetary base. This shows how much the Gini coefficient increases or decreases as a consequence of a shock in the monetary base. Figure 12 represents the IFR obtained by using the extended model described in equation(6), which uses the whole sample period and includes GDP, inflation, monetary base, share price and the Gini coefficient.

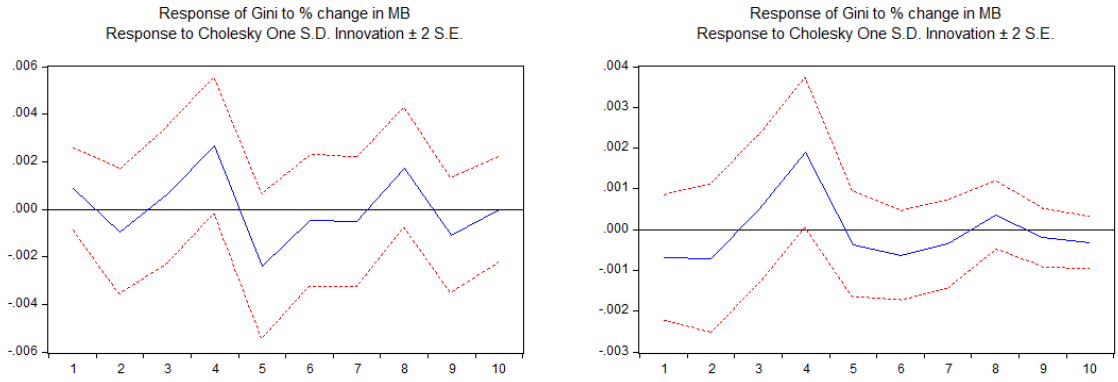
Figure 12: Impulse response function of VAR analysis: Extended model

The IRF in figure 12 shows that the expansion in the monetary base leads to a slightly lower inequality in the first three quarters and from the fourth to the seventh

quarter. Inequality is higher in the fourth, eighth and ninth quarters. However, even if there are more quarters with a lower inequality level, the only significant effect is the four-quarter-lag increase of 0.0026 points in the Gini coefficients. In fact, for all the other periods, the value 0 is included in the 95% confidence interval and hence the responses are not significant.

Similar results are also obtained by using the short model, composed only of GDP, monetary base and the Gini coefficient, as shown in Figure 13. However, the results of the two sample periods are slightly different. As expected, the impact of the shock in the monetary base in the period that takes into account the quarters with an unconventional monetary policy regime only is stronger. In this sample period, inequality increases by 0.0027 while in the whole period it rises by 0.0019. However, as in the extended model, the responses are not statistically significant at the 95% confidence interval.

Figure 13: Impulse response function of VAR analysis: Short models



(a) Sample period: 2008Q4-2014Q4 (b) Sample period: 2004Q1-2016Q4

The fact that the effect of QE is stronger only when the QE period is considered could imply that the results of the extended model, which use the whole sample, are slightly downward biased. Moreover, as discussed in Section 3, the CEX under-represents the top-income households. Then, even if the income distribution of the CEX is similar to the ones of other datasets, the effects of the increase in value of financial assets, mostly held by rich households, could be underestimated. Therefore, the results obtained by the long and short models can be considered as conservative estimates and it is likely that the actual impact is higher.

The increase in inequality means that the benefits given to low and middle classes by an expansionary monetary policy, such as lower interest rate and less unemployment, does not offset the benefits given to the richest households, such as the increase in asset values. Then, in this case, the *income composition* and *financial segmentation channels*

prevail over the *earnings heterogeneity channel*.

5.2 Salary inequality

The models which analyzed salary inequality produced coefficients similar to the income inequality ones (see Table A.4). The coefficients show both negative and positive relations between the monetary base and the salary Gini coefficient. They are not, however, statistically significant.

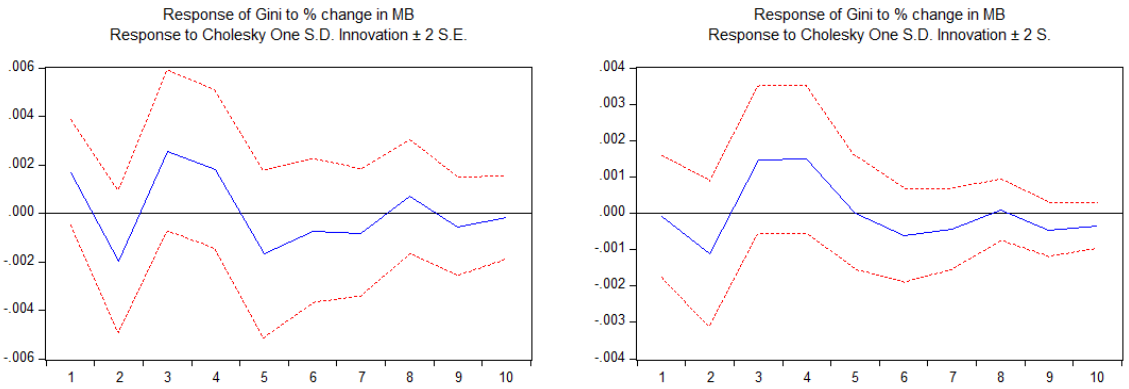
Analyzing the IRF in Figure 14, it is clear how a one percentage point change in the monetary base increases salary inequality in the third, fourth and fifth quarters after the the impulse. However, the values of the responses are very close to 0 and in all periods it is included in the confidence intervals. Therefore, the expansion in the monetary base does not have a statistically significant impact on salary inequality.

Figure 14: Impulse response function of VAR analysis: Extended model

The results of the short models represented in Figure 15 are similar to the ones obtained in Section 5.1. The model which analyzes only the years where the QE programmes were implemented by the FED yields stronger results compare to the one which uses the whole sample. The paths of the three IRFs presented are similar: they all show an increase in inequality from the third to the fifth quarter and then inequality decreases as a response to the shock in the monetary base. However, in the short model the responses are also not statistically significant.

This discrepancy between the two sample periods could mean, as in the case of the model with income inequality, that the extended model results are downward biased. Nevertheless, the under-representation of the top incomes in the CEX should be a smaller

Figure 15: Impulse response function of VAR analysis: Short models



(a) Sample period: 2008Q4-2014Q4

(b) Sample period: 2004Q1-2016Q4

concern in this case. In fact, since one of the main channels through which QE increases inequality is the rise in asset value, and this does not affect salaries. Since the top-income class is less sensitive to business cycles, there should not be a disproportionate increase in rich households' salaries that is not captured by the CEX data.

5.3 Consumption inequality

The VAR coefficients of the consumption inequality long model shows a positive but non-significant relation between money base and inequality (see Table A.5). However, the money base has an impact on the share price and this, in turn, significantly affects non-durable consumption inequality.

Analyzing the IRF in Figure 16, it is clear how one percentage point impulse in the money base causes an increase in the Gini coefficient of consumption inequality. After a 0.0012 points decrease in the first quarter after the impulse, inequality increases by 0.0015 in the second quarter and it keeps increasing by circa 0.001 points per period, from the fourth to the sixth quarters as well. However, none of the periods presents significant responses, since the value 0 is included in the 95% confidence intervals for all quarters.

The short model is also used with consumption inequality, to confront the results yielded using a different sample period. The IRFs presented in Figure 17 are similar to the ones of the short models previously discussed. When only the quarters with an unconventional monetary policy regime are used, the results are stronger. Therefore, once again, the results of the long model could be slightly downward biased and should be interpreted as conservative estimates of the rise in consumption inequality. In addition, as discussed in Section 3, the CEX under-represents the largest spenders and the under-representation of this group increased during the years. Because of this feature, it is

likely that the increase in consumption inequality is larger than the 0,0014 cumulative rise estimated by the VAR model.

Figure 16: Impulse response function of VAR analysis: Extended model

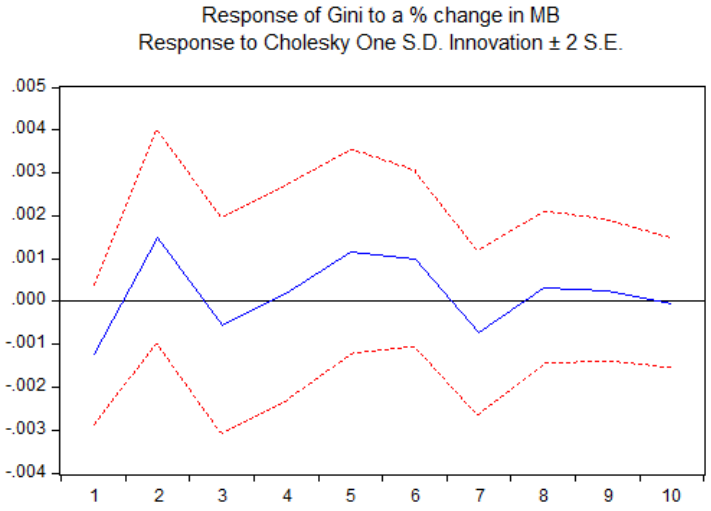
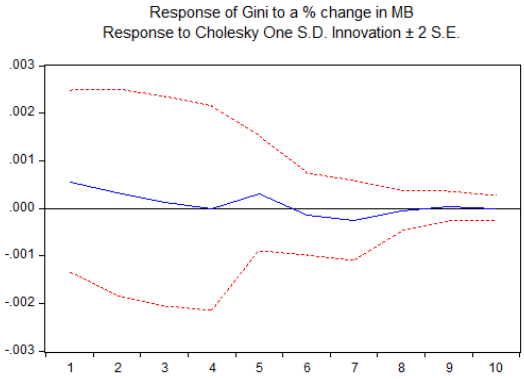


Figure 17: Impulse response function of VAR analysis: Short models

(a) Sample period: 2008Q4-2014Q4



(b) Sample period: 2004Q1-2016Q4

5.4 Expenditure inequality

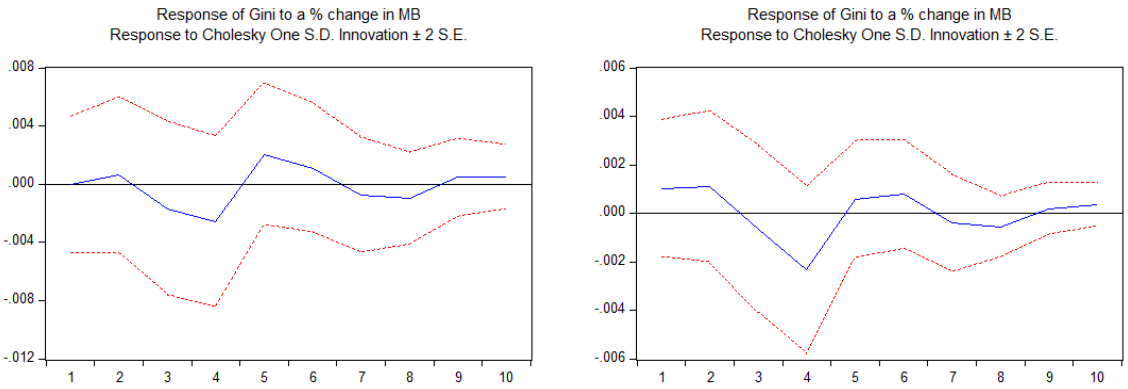
The total expenditure inequality model presents some coefficients which are in line with what was already found for the other inequality measures (see Table A.6). In fact, the money base is positively related to GDP, inflation and share price. Similarly to non-durable consumption, total expenditures is also positively affected by the money base.

Figure 18 represents the impulse response function of expenditures consumption to money base. A one percentage point impulse in the latter leads to an increase in the former. In particular, in the first three quarters after the shock, the Gini coefficient increases by almost 0.005 points. As expected, the increase in total expenditures is larger than the non-durable consumption one. Total expenditure also takes into account durable consumption, which is more pro-cyclical and more volatile than the non-durable one (Stock and Watson, 1999). However, as already discussed for salary and non-durable consumption inequality, also the responses of the Gini coefficient of total expenditure are not statistically significant, since the 95% confidence interval shows that there is the possibility that the responses were 0.

Figure 18: Impulse response function of VAR analysis: Extended model

The comparison between sample periods used in the model yields different results from the previous analysis. In fact, even if the IRF of the short model, using the QE period only, presents higher peaks, the cumulative response is similar to the one obtained using the whole period, as shown in Figure 19. Therefore, the results of the long model seem reliable and not downward biased by the addition of conventional monetary policy quarters in the sample period. However, it is necessary to take into account the under-representation of top-income households in the CEX. Then, even if the data on durable consumption are found to be more reliable, there could still be a downward bias and the results should be considered conservative estimates.

Figure 19: Impulse response function of VAR analysis: Short models



(a) Sample period: 2008Q4-2014Q4

(b) Sample period: 2004Q1-2016Q4

6 Conclusion

The paper analyzes how the Quantitative Easing programmes implemented by the Federal Reserve in the US affect inequality. The analysis is performed through a vector autoregression model where the unconventional monetary policy is proxied by the monetary base. In addition, in order to have a better overview on how inequality reacted to the policy, four different inequality measures are considered. In particular, due to the availability of the data from the Consumer Expenditure Survey, the models use the Gini coefficients measuring income, salary, non-durable and total consumption inequality. The results obtained by the VAR models show two different effects: income and salary inequality decrease, while inequality in consumption, both non-durable and total consumption, increases. Moreover, the response of inequality to an increase in the monetary base is stronger when only the unconventional monetary period is taken into account.

There are two main results of this paper. The Quantitative Easing programs implemented by the Federal Reserve temporary increased income inequality, but did not significatly affect consumption inequality. In particular, the higher Gini coefficient for income inequality is mainly due to the returns of financial assets and to their unequal distribution among the US population. This channel is the main theory behind how QE could affect inequality, the results also presenting evidence to support it. Income inequality increases, but there is no significant effect on salary inequality, meaning that the changes in the salary distribution did not contribute to the higher inequality level. Then, financial income, the other main source of income, could be considered the cause of the increase, since financial assets are already unevenly distributed and capital gains are affected by QE. The impact of unconventional monetary policies on income inequality

in the US is in line with the increases found by Saiki and Frost (2014) and Mumtaz and Theophilopoulou (2017) studying the QE programs implemented in Japan and the UK.

Therefore, even if it has been found that the QE implemented in the US delivered the desired effects, decreasing the interest rates [11], these results come with some downsides on income distribution. However, since the appreciation of financial assets, which leads to higher income inequality, is intrinsic to this policy and strictly connected to asset purchases and low interest rate, it is difficult to design a similar monetary measure which does not affect the income distribution. Then, in order to offset, or at least limit, the undesired effects of QE on inequality, it is necessary to implement collateral policies aimed at limiting the unproportianal benefits given to the rich households who hold most of the financial assets. In particular, taking into account the already high inequality level in the US, an income tax reform could be considered to reduce it and especially a restructuring of capital gain tax could be appropriate to offset the impact of the unconventional monetary policies. In addition, the fact that consumption inequality is not affected by the QE could imply that the increase in income for the richest households is not used to consume more but to save more. More saving from this category of individuals could make the asset distribution even more uneven across the US' population and lead to even more income inequality in the future. However, even if QE contributes to increasing income inequality, it is not the only cause for this increase. Hence, adopting measures to also solve the other causes discussed in Section 2.1.1 is necessary to effectively tackle the problem of rising inequality.

While analyzing the results, it is important to bear in mind two limitations. The first one is related to the source of the data. The Consumer Expenditure Survey underrepresents the richest households. This implies that the results could be downward biased. The second limitation is that there is not much data on the period when QE was implemented. In fact, QE did not last that many years in the US and the UK and in other countries, such as Japan and the Eurozone, there is no high-frequency individual data on income, wealth or consumption.

Therefore, it would be interesting to repeat the analysis of this paper in the future, when more US data will be available and maybe from other countries will also exist. In addition, since nowadays some central banks, such as the FED, already started the tapering[12], the reverse to the QE process, to reduce the monetary base, it would be interesting to analyze how this contractionary monetary policy affects inequality.

[11] See Gagnon et al. (2011) and Christensen and Rudebusch (2012).

[12] For more information see this Bloomberg.com article: https://www.bloomberg.com/news/articles/2017-10-13/long-awaited-fed-balance-sheet-taper-begins-today-with-mortgages

References

Aguiar, Mark and Mark Bils (2015). "Has consumption inequality mirrored income inequality?" In: *American Economic Review* 105.9, pp. 2725–56.

Allison, Paul D (1978). "Measures of inequality". In: *American sociological review*, pp. 865–880.

Attanasio, Orazio, Erich Battistin, and Hidehiko Ichimura (2004). *What really happened to consumption inequality in the US?* Tech. rep. National Bureau of Economic Research.

Auerbach, Alan J and William G Gale (2009). *The economic crisis and the fiscal crisis: 2009 and beyond*. Urban-BrookingsTax Policy Center.

Autor, David et al. (2017). "Concentrating on the Fall of the Labor Share". In: *American Economic Review* 107.5, pp. 180–85.

Bee, Adam, Bruce D Meyer, and James X Sullivan (2012). *The validity of consumption data: are the consumer expenditure interview and diary surveys informative?* Tech. rep. National Bureau of Economic Research.

Bellù, Lorenzo Giovanni and Paolo Liberati (2006). "Policy Impacts on Inequality Welfare based Measures of Inequality: The Atkinson Index". In: *Easypol, Modulo* 50.

Benford, James et al. (2009). "Quantitative easing". In: *Bank of England. Quarterly Bulletin* 49.2, p. 90.

Bernanke, Ben S and Mark Gertler (1995). "Inside the black box: the credit channel of monetary policy transmission". In: *Journal of Economic perspectives* 9.4, pp. 27–48.

Bernanke, Ben S et al. (2007). *The financial accelerator and the credit channel*. Tech. rep.

Bierbrauer, Felix J and Pierre C Boyer (2015). "Efficiency, welfare, and political competition". In: *The Quarterly Journal of Economics* 131.1, pp. 461–518.

Blau, Peter M (1977). "A macrosociological theory of social structure". In: *American journal of sociology* 83.1, pp. 26–54.

Borio, Claudio and Piti Disyatat (2010). "Unconventional monetary policies: an appraisal". In: *The Manchester School* 78, pp. 53–89.

Bostic, Raphael, Stuart Gabriel, and Gary Painter (2009). "Housing wealth, financial wealth, and consumption: New evidence from micro data". In: *Regional Science and Urban Economics* 39.1, pp. 79–89.

Carnot, Nicolas, Vincent Koen, and Bruno Tissot (2011). *Economic forecasting and policy*. Springer.

Carpenter, Seth B and William M Rodgers (2004). "The disparate labor market impacts of monetary policy". In: *Journal of Policy Analysis and Management* 23.4, pp. 813–830.

Christensen, Jens HE and Glenn D Rudebusch (2012). "The response of interest rates to US and UK quantitative easing". In: *The Economic Journal* 122.564, F385–F414.

Clouse, James et al. (2003). "Monetary policy when the nominal short-term interest rate is zero". In: *topics in Macroeconomics* 3.1.

Cohan, W (2014). "How Quantitative Easing Contributed to the Nation's Inequality Problem". In: *New York Times* 22.

Coibion, Olivier et al. (2012). *Innocent bystanders? Monetary policy and inequality in the US*. Tech. rep. National Bureau of Economic Research.

Dickey, David A and Wayne A Fuller (1979). "Distribution of the estimators for autoregressive time series with a unit root". In: *Journal of the American statistical association* 74.366a, pp. 427–431.

Doepke, Matthias and Martin Schneider (2006). "Inflation and the redistribution of nominal wealth". In: *Journal of Political Economy* 114.6, pp. 1069–1097.

Domanski, Dietrich, Michela Scatigna, and Anna Zabai (2016). "Wealth inequality and monetary policy". In: *BIS Quarterly Review* March, pp. 45–64.

Eggertsson, Gauti B et al. (2003). "Zero bound on interest rates and optimal monetary policy". In: *Brookings papers on economic activity* 2003.1, pp. 139–233.

Elsby, Michael WL, Bart Hobijn, and Ayşegül Şahin (2013). "The decline of the US labor share". In: *Brookings Papers on Economic Activity* 2013.2, pp. 1–63.

Erosa, Andrés and Gustavo Ventura (2002). "On inflation as a regressive consumption tax". In: *Journal of Monetary Economics* 49.4, pp. 761–795.

Fama, Eugene F and G William Schwert (1977). "Asset returns and inflation". In: *Journal of financial economics* 5.2, pp. 115–146.

Fawley, Brett W, Christopher J Neely, et al. (2013). "Four stories of quantitative easing". In: *Federal Reserve Bank of St. Louis Review* 95.1, pp. 51–88.

Feenstra, Robert and Gordon Hanson (2001). *Global production sharing and rising inequality: A survey of trade and wages*. Tech. rep. National Bureau of Economic Research.

Fisher, Jonathan et al. (2018). *Inequality in 3-D: Income, Consumption, and Wealth*.

Furceri, Davide, Prakash Loungani, and Aleksandra Zdzienicka (2018). "The effects of monetary policy shocks on inequality". In: *Journal of International Money and Finance* 85, pp. 168–186.

Gagnon, Joseph et al. (2011). "The financial market effects of the Federal Reserve's large-scale asset purchases". In: *international Journal of central Banking* 7.1, pp. 3–43.

Goldin, Claudia and Lawrence F Katz (2007). *The race between education and technology: the evolution of US educational wage differentials, 1890 to 2005*. Tech. rep. National Bureau of Economic Research.

Haitsma, Reinder, Deren Unalmis, and Jakob de Haan (2016). "The impact of the ECB's conventional and unconventional monetary policies on stock markets". In: *Journal of Macroeconomics* 48, pp. 101–116.

Heathcote, Jonathan, Fabrizio Perri, and Giovanni L Violante (2009). *Unequal we stand: An empirical analysis of economic inequality in the United States, 1967-2006*. Tech. rep. National Bureau of Economic Research.

Hicks, John R (1937). "Mr. Keynes and the" classics"; a suggested interpretation". In: *Econometrica: Journal of the Econometric Society*, pp. 147–159.

Inui, Masayuki, Nao Sudou, and Tomoaki Yamada (2017). "The effects of monetary policy shocks on inequality in Japan". In: *Bank of Japan Working Paper Series*.

Jacobson, Margaret, Filippo Occhino, et al. (2012). "Labor's declining share of income and rising inequality". In: *Economic Commentary* 13.

Joyce, Michael, Matthew Tong, and Robert Woods (2011). "The United Kingdom's quantitative easing policy: design, operation and impact". In: *Bank of England Quarterly Bulletin* 51.3, pp. 200–212.

Krishnamurthy, Arvind and Annette Vissing-Jorgensen (2011). *The effects of quantitative easing on interest rates: channels and implications for policy*. Tech. rep. National Bureau of Economic Research.

Krueger, Dirk and Fabrizio Perri (2006). "Does income inequality lead to consumption inequality? Evidence and theory". In: *The Review of Economic Studies* 73.1, pp. 163–193.

Krugman, Paul (2009). "Competition, Coordination, and the crisis". In: *speech at the Conference on Industrial Competitiveness, EU Commission, Brussels*. Vol. 17.

— (2014). "Notes on easy money and Inequality". In: *The New York Times*.

Krugman, Paul R, Kathryn M Dominquez, and Kenneth Rogoff (1998). "It's baaack: Japan's slump and the return of the liquidity trap". In: *Brookings Papers on Economic Activity* 1998.2, pp. 137–205.

Lin, Jin-Lung (2006). "Teaching notes on impulse response function and structural VAR". In: *Institute of Economics, Academia Sinica, Department of Economics, National Chengchi University*, pp. 1–9.

Lukkezen, J, B Jacobs, and C Kool (2015). "Macro-economics of balance sheet problems and the liquidity trap". In: *CPB Netherlands Bureau for Economic Policy Analysis*.

Lusardi, Annamaria, Olivia S Mitchell, and Vilsa Curto (2010). "Financial literacy among the young". In: *Journal of consumer affairs* 44.2, pp. 358–380.

Mankiw, N Gregory (2015). "Yes, r> g. So what?" In: *American Economic Review* 105.5, pp. 43–47.

Meyer, Bruce D and James X Sullivan (2017). *Consumption and Income Inequality in the US Since the 1960s*. Tech. rep. National Bureau of Economic Research.

Montecino, Juan Antonio, Gerald Epstein, et al. (2015). "Did Quantitative Easing Increase Income Inequality?" In: *Institute for New Economic Thinking*.

Mumtaz, Haroon and Angeliki Theophilopoulou (2017). "The impact of monetary policy on inequality in the UK. An empirical analysis". In: *European Economic Review* 98, pp. 410–423.

OECD (2013). *Crisis squeezes income and puts pressure on inequality and poverty*.

Orioli, Alberto (2016). *Gli oracoli della moneta: l'arte della parola nel linguaggio dei banchieri centrali*. Il Mulino.

Parker, Jonathan A (1999). "The reaction of household consumption to predictable changes in social security taxes". In: *American Economic Review* 89.4, pp. 959–973.

Piketty, Thomas (2014). *Capital in the 21st Century*. Harvard University Press Cambridge, MA.

Pistaferri, Luigi (2015). "Household consumption: Research questions, measurement issues, and data collection strategies". In: *Journal of Economic and Social Measurement* 40.1-4, pp. 123–149.

Priftis, Romanos and Lukas Vogel (2017). "The macroeconomic effects of the ECB's evolving QE programme: a model-based analysis". In: *Open Economies Review* 28.5, pp. 823–845.

Rodrik, Dani (2008). "The real exchange rate and economic growth". In: *Brookings papers on economic activity* 2008.2, pp. 365–412.

Romer, Christina D and David H Romer (1998). *Monetary policy and the well-being of the poor*. Tech. rep. National bureau of economic research.

Romer, David (2013). *Short-run fluctuations*. mimeo: University of California, Berkeley.

Sabelhaus, John et al. (2013). *Is the Consumer Expenditure Survey representative by income?* Tech. rep. National Bureau of Economic Research.

Saiki, Ayako and Jon Frost (2014). "Does unconventional monetary policy affect inequality? Evidence from Japan". In: *Applied Economics* 46.36, pp. 4445–4454.

Schneider, Dorothee (2011). *The labor share: A review of theory and evidence*. Tech. rep. SFB 649 discussion paper.

Sims, Christopher A (1980). "Macroeconomics and reality". In: *Econometrica: Journal of the Econometric Society*, pp. 1–48.

Smaghi, Lorenzo Bini (2009). "Conventional and unconventional monetary policy". In: *Speech at the Center for Monetary and Banking Studies, Geneva* 28.

Spiegel, Mark M et al. (2006). "Did quantitative easing by the Bank of Japan" work"?" In: *FRBSF Economic Letter*.

Stock, James H and Mark W Watson (1999). "Business cycle fluctuations in US macroeconomic time series". In: *Handbook of macroeconomics* 1, pp. 3–64.

Taylor, John B (1993). "Discretion versus policy rules in practice". In: *Carnegie-Rochester conference series on public policy*. Vol. 39. Elsevier, pp. 195–214.

— (2009). "The need to return to a monetary framework". In: *Business Economics* 44.2, pp. 63–72.

Ugai, Hiroshi et al. (2007). "Effects of the quantitative easing policy: A survey of empirical analyses". In: *Monetary and Economic Studies-Bank of Japan* 25.1, p. 1.

Viñals, Jose, Olivier Blanchard, and Tamim Bayoumi (2013). *Unconventional monetary policies—recent experience and prospects**.

Williamson, Stephen D (2017). "Quantitative Easing: How Well Does This Tool Work?" In: *Regional Economist, Third Quarter* 25.3, pp. 8–14.

Wolff, Edward N (2017). *Household Wealth Trends in the United States, 1962 to 2016: Has Middle Class Wealth Recovered?* Tech. rep. National Bureau of Economic Research.

Young, Andrew T and Maria Y Tackett (2018). "Globalization and the decline in labor shares: Exploring the relationship beyond trade and financial flows". In: *European Journal of Political Economy* 52, pp. 18–35.

Zoutman, Floris, Bas Jacobs, and Egbert Jongen (2016). *Redistributive politics and the tyranny of the middle class*. 16-032/VI.

A Appendix

Table A.1: Lag length criteria - Short model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	207.0178	NA	1.64e-11	-16.32142	-16.17516*	-16.28085*
1	216.3738	15.71815	1.61e-11	-16.34990	-15.76484	-16.18763
2	222.0650	8.195317	2.17e-11	-16.08520	-15.06134	-15.80123
3	236.8401	17.73008*	1.51e-11*	-16.54721*	-15.08455	-16.14153
4	244.4368	7.292896	2.05e-11	-16.43495	-14.53350	-15.90757
5	253.9780	6.869665	2.85e-11	-16.47824	-14.13800	-15.82916

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table A.2: Lag length criteria - Extended model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	612.6149	NA	6.97e-19	-27.61886	-27.41611*	-27.54367*
1	644.8208	55.62843	5.06e-19*	-27.94640	-26.72991	-27.49527
2	660.6493	23.74263	8.04e-19	-27.52951	-25.29927	-26.70243
3	678.6449	22.90355	1.25e-18	-27.21113	-23.96715	-26.00811
4	698.3681	20.61972	2.03e-18	-26.97128	-22.71355	-25.39231
5	728.2804	24.47368	2.57e-18	-27.19456	-21.92309	-25.23965
6	804.2116	44.86842*	5.86e-19	-29.50962*	-23.22440	-27.17876

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table A.3: Coefficients of the VAR model income inequality

Vector Autoregression Estimates
Sample (adjusted): 2005Q3 2016Q4
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_GDP)	D(L_CPI)	D(L_MB)	D(L_SHARE)	D(GINI)
D(L_GDP(-1))	−0.234842	−0.329196	−0.736553	−4.604738	−0.060275
	(0.25271)	(0.31429)	(3.33074)	(3.27032)	(0.23710)
	[-0.92930]	[-1.04742]	[-0.22114]	[-1.40804]	[-0.25422]
D(L_GDP(-2))	−0.213027	−0.414363	−0.228137	−3.027423	−0.113476
	(0.26024)	(0.32365)	(3.42997)	(3.36775)	(0.24416)
	[-0.81859]	[-1.28026]	[-0.06651]	[-0.89895]	[-0.46475]
D(L_GDP(-3))	0.284879	0.217397	−0.591791	4.305677	−0.223808
	(0.23495)	(0.29220)	(3.09663)	(3.04046)	(0.22044)
	[1.21254]	[0.74400]	[-0.19111]	[1.41613]	[-1.01530]
D(L_GDP(-4))	0.256655	0.428489	−3.170008	1.738002	0.128953
	(0.22311)	(0.27748)	(2.94058)	(2.88724)	(0.20933)
	[1.15038]	[1.54424]	[-1.07802]	[0.60196]	[0.61604]
D(L_CPI(-1))	−0.221176	0.002674	5.938338	−5.183516	0.048416
	(0.19961)	(0.24825)	(2.63088)	(2.58315)	(0.18728)
	[-1.10805]	[0.01077]	[2.25717]	[-2.00667]	[0.25852]
D(L_CPI(-2))	−0.097804	0.005867	−2.059121	−0.295412	−0.145318
	(0.23096)	(0.28725)	(3.04414)	(2.98891)	(0.21670)
	[-0.42346]	[0.02043]	[-0.67642]	[-0.09884]	[-0.67060]
D(L_CPI(-3))	−0.044278	0.218818	2.635200	−2.209357	0.066656
	(0.22823)	(0.28385)	(3.00814)	(2.95357)	(0.21414)
	[-0.19400]	[0.77089]	[0.87602]	[-0.74803]	[0.31128]
D(L_CPI(-4))	−0.103029	−0.172734	−0.330210	0.472376	−0.307410
	(0.22412)	(0.27873)	(2.95391)	(2.90033)	(0.21028)
	[-0.45971]	[-0.61971]	[-0.11179]	[0.16287]	[-1.46194]
D(L_MB(-1))	−0.025206	−0.014524	0.551480	−0.354502	−0.015865
	(0.01970)	(0.02450)	(0.25968)	(0.25497)	(0.01849)
	[-1.27934]	[-0.59275]	[2.12370]	[-1.39038]	[-0.85825]
D(L_MB(-2))	0.020491	−0.009702	−0.142250	0.239895	−0.015491
	(0.02051)	(0.02551)	(0.27031)	(0.26541)	(0.01924)
	[0.99912]	[-0.38038]	[-0.52624]	[0.90387]	[-0.80503]
D(L_MB(-3))	0.036011	0.036400	−0.377279	0.294510	0.048732
	(0.01930)	(0.02401)	(0.25441)	(0.24980)	(0.01811)
	[1.86561]	[1.51625]	[-1.48295]	[1.17900]	[2.69085]
D(L_MB(-4))	0.019755	0.008698	0.076753	0.203068	−0.028695
	(0.01826)	(0.02272)	(0.24074)	(0.23637)	(0.01714)
	[1.08158]	[0.38290]	[0.31882]	[0.85912]	[-1.67444]
D(L_SHARE(-1))	0.019002	0.035741	−0.169768	0.554668	−0.013902

Table A.3 Continued

	(0.02064)	(0.02567)	(0.27203)	(0.26709)	(0.01936)
	[0.92069]	[1.39237]	[-0.62408]	[2.07668]	[-0.71793]
D(L_SHARE(-2))	0.043991	0.007359	0.220408	0.149403	0.002240
	(0.02220)	(0.02760)	(0.29254)	(0.28723)	(0.02082)
	[1.98196]	[0.26659]	[0.75342]	[0.52014]	[0.10759]
D(L_SHARE(-3))	0.020346	0.009371	−0.502306	0.162608	0.005979
	(0.02356)	(0.02930)	(0.31053)	(0.30490)	(0.02211)
	[0.86358]	[0.31982]	[-1.61756]	[0.53332]	[0.27050]
D(L_SHARE(-4))	0.016353	0.004453	0.164738	0.094420	0.020217
	(0.02204)	(0.02741)	(0.29046)	(0.28519)	(0.02068)
	[0.74206]	[0.16246]	[0.56717]	[0.33108]	[0.97778]
D(GINI(-1))	0.174092	0.056172	1.144448	1.639836	−0.417926
	(0.17777)	(0.22109)	(2.34302)	(2.30052)	(0.16679)
	[0.97932]	[0.25407]	[0.48845]	[0.71281]	[-2.50571]
D(GINI(-2))	0.236730	0.307906	−2.036929	3.104314	−0.270397
	(0.18075)	(0.22480)	(2.38238)	(2.33916)	(0.16959)
	[1.30968]	[1.36967]	[-0.85500]	[1.32711]	[-1.59441]
D(GINI(-3))	0.293518	0.400900	−4.500031	2.453979	−0.012278
	(0.17469)	(0.21726)	(2.30246)	(2.26069)	(0.16390)
	[1.68022]	[1.84524]	[-1.95444]	[1.08550]	[-0.07491]
D(GINI(-4))	0.123767	0.055404	0.286569	−0.851613	−0.164276
	(0.16685)	(0.20751)	(2.19914)	(2.15925)	(0.15655)
	[0.74178]	[0.26699]	[0.13031]	[-0.39440]	[-1.04937]
C	0.002203	0.002839	0.025885	0.021458	0.004055
	(0.00317)	(0.00394)	(0.04174)	(0.04098)	(0.00297)
	[0.69563]	[0.72092]	[0.62019]	[0.52361]	[1.36478]
R-squared	0.588595	0.397419	0.555289	0.548421	0.610386
Adj. R-squared	0.259471	−0.084646	0.199521	0.187158	0.298694
Sum sq. resids	0.000757	0.001171	0.131502	0.126774	0.000666
S.E. equation	0.005503	0.006844	0.072527	0.071211	0.005163
F-statistic	1.788370	0.824409	1.560817	1.518066	1.958300
Log likelihood	188.0694	178.0374	69.44836	70.29053	191.0018
Akaike AIC	−7.263888	−6.827712	−2.106450	−2.143066	−7.391382
Schwarz SC	−6.429074	−5.992898	−1.271636	−1.308252	−6.556568
Mean dependent	0.003763	0.004859	0.032561	0.008951	0.000494
S.D. dependent	0.006394	0.006571	0.081063	0.078985	0.006165

Determinant resid covariance (dof adj.)	$2.23E-19$
Determinant resid covariance	$1.06E-20$
Log likelihood	731.5467
Akaike information criterion	−27.24116
Schwarz criterion	−23.06709
Number of coefficients	105

Table A.4: Coefficients of the VAR model for non-durable salary inequality

Vector Autoregression Estimates
Sample (adjusted): 2005Q3 2016Q4
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_GDP)	D(L_CPI)	D(L_MB)	D(L_SHARE)	D(GINI)
D(L_GDP(-1))	−0.208351	−0.329459	−0.551549	−4.221478	0.139790
	(0.26245)	(0.32458)	(3.33877)	(3.37044)	(0.27412)
	[-0.79386]	[-1.01502]	[-0.16520]	[-1.25250]	[0.50995]
D(L_GDP(-2))	−0.105488	−0.196961	−2.549173	−1.415938	0.033113
	(0.26236)	(0.32447)	(3.33760)	(3.36927)	(0.27403)
	[-0.40207]	[-0.60702]	[-0.76377]	[-0.42025]	[0.12084]
D(L_GDP(-3))	0.333972	0.277567	−1.539049	4.198541	−0.347565
	(0.24111)	(0.29819)	(3.06723)	(3.09632)	(0.25183)
	[1.38516]	[0.93085]	[-0.50177]	[1.35598]	[-1.38017]
D(L_GDP(-4))	0.189396	0.280539	−1.826336	0.438334	−0.088765
	(0.22900)	(0.28321)	(2.91322)	(2.94085)	(0.23918)
	[0.82705]	[0.99056]	[-0.62691]	[0.14905]	[-0.37112]
D(L_CPI(-1))	−0.234817	−0.001696	5.934964	−5.438078	0.234559
	(0.21072)	(0.26060)	(2.68062)	(2.70605)	(0.22009)
	[-1.11437]	[-0.00651]	[2.21403]	[-2.00960]	[1.06576]
D(L_CPI(-2))	0.002349	0.123078	−3.695638	0.228355	−0.131244
	(0.24716)	(0.30568)	(3.14426)	(3.17409)	(0.25815)
	[0.00950]	[0.40264]	[-1.17536]	[0.07194]	[-0.50840]
D(L_CPI(-3))	−0.111695	0.105045	3.831426	−2.927957	−0.140605
	(0.25156)	(0.31111)	(3.20019)	(3.23055)	(0.26275)
	[-0.44401]	[0.33764]	[1.19725]	[-0.90633]	[-0.53514]
D(L_CPI(-4))	−0.086413	−0.120795	−0.532585	0.918488	−0.121179
	(0.23604)	(0.29192)	(3.00273)	(3.03122)	(0.24653)
	[-0.36610]	[-0.41380]	[-0.17737]	[0.30301]	[-0.49153]
D(L_MB(-1))	−0.029848	−0.014856	0.583994	−0.368250	−0.025789
	(0.02069)	(0.02559)	(0.26321)	(0.26570)	(0.02161)
	[-1.44264]	[-0.58057]	[2.21876]	[-1.38594]	[-1.19335]
D(L_MB(-2))	0.029010	−0.000297	−0.348100	0.263858	0.014826
	(0.02071)	(0.02561)	(0.26346)	(0.26596)	(0.02163)
	[1.40076]	[-0.01159]	[-1.32125]	[0.99209]	[0.68542]
D(L_MB(-3))	0.029524	0.026372	−0.241497	0.180358	0.024718
	(0.01938)	(0.02397)	(0.24652)	(0.24886)	(0.02024)
	[1.52355]	[1.10042]	[-0.97963]	[0.72475]	[1.22126]
D(L_MB(-4))	0.018957	0.008989	0.136989	0.236687	−0.009340
	(0.01891)	(0.02339)	(0.24055)	(0.24283)	(0.01975)
	[1.00257]	[0.38440]	[0.56949]	[0.97471]	[-0.47290]
D(L_SHARE(-1))	0.022638	0.044160	−0.240906	0.594279	−0.031189

Table A.4 Continued

	(0.02159)	(0.02670)	(0.27461)	(0.27722)	(0.02255)
	[1.04871]	[1.65412]	[-0.87725]	[2.14371]	[-1.38332]
D(L_SHARE(-2))	0.036443	−0.006547	0.327132	0.034767	−0.004238
	(0.02369)	(0.02930)	(0.30138)	(0.30424)	(0.02474)
	[1.53828]	[-0.22346]	[1.08544]	[0.11427]	[-0.17129]
D(L_SHARE(-3))	0.016439	0.004960	−0.425344	0.127205	0.011815
	(0.02501)	(0.03093)	(0.31817)	(0.32119)	(0.02612)
	[0.65727]	[0.16035]	[-1.33685]	[0.39604]	[0.45227]
D(L_SHARE(-4))	0.010500	−0.001657	0.226782	0.043739	0.019025
	(0.02246)	(0.02778)	(0.28579)	(0.28850)	(0.02346)
	[0.46741]	[-0.05963]	[0.79354]	[0.15161]	[0.81082]
D(GINI(-1))	−0.003240	−0.158011	0.657660	−0.698081	−0.444943
	(0.17111)	(0.21161)	(2.17672)	(2.19737)	(0.17872)
	[-0.01894]	[-0.74670]	[0.30213]	[-0.31769]	[-2.48968]
D(GINI(-2))	0.057636	0.066893	−0.684004	0.430613	−0.076227
	(0.16897)	(0.20897)	(2.14953)	(2.16992)	(0.17648)
	[0.34110]	[0.32011]	[-0.31821]	[0.19845]	[-0.43192]
D(GINI(-3))	0.174743	0.250331	−4.196432	1.440291	0.002244
	(0.14904)	(0.18432)	(1.89595)	(1.91394)	(0.15566)
	[1.17249]	[1.35814]	[-2.21337]	[0.75253]	[0.01442]
D(GINI(-4))	−0.009737	−0.009522	0.902284	−1.024139	−0.376404
	(0.15608)	(0.19303)	(1.98556)	(2.00440)	(0.16302)
	[-0.06238]	[-0.04933]	[0.45442]	[-0.51095]	[-2.30894]
C	0.002370	0.002843	0.030135	0.028328	0.002421
	(0.00326)	(0.00403)	(0.04149)	(0.04188)	(0.00341)
	[0.72673]	[0.70492]	[0.72639]	[0.67641]	[0.71083]
R-squared	0.560383	0.363284	0.557304	0.524812	0.596553
Adj. R-squared	0.208690	−0.146089	0.203147	0.144662	0.273795
Sum sq. resids	0.000809	0.001237	0.130907	0.133402	0.000882
S.E. equation	0.005688	0.007035	0.072362	0.073049	0.005941
F-statistic	1.593386	0.713199	1.573606	1.380538	1.848300
Log likelihood	186.5439	176.7701	69.55277	69.11844	184.5427
Akaike AIC	−7.197563	−6.772611	−2.110990	−2.092106	−7.110552
Schwarz SC	−6.362748	−5.937797	−1.276175	−1.257291	−6.275738
Mean dependent	0.003763	0.004859	0.032561	0.008951	0.000304
S.D. dependent	0.006394	0.006571	0.081063	0.078985	0.006972

Determinant resid covariance (dof adj.)	$3.61E-19$
Determinant resid covariance	$1.71E-20$
Log likelihood	720.4407
Akaike information criterion	−26.75829
Schwarz criterion	−22.58422
Number of coefficients	105

Table A.5: Coefficients of the VAR model for non-durable consumption inequality

Vector Autoregression Estimates
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_GDP)	D(L_CPI)	D(L_MB)	D(L_SHARE)	D(GINI)
D(L_GDP(-1))	−0.166491	−0.404716	−0.014189	−3.226453	0.550121
	(0.23062)	(0.30349)	(3.22870)	(2.89236)	(0.27556)
	[-0.72194]	[-1.33352]	[-0.00439]	[-1.11551]	[1.99634]
D(L_GDP(-2))	−0.292388	−0.160642	−2.233080	−4.356038	−0.031982
	(0.24024)	(0.31616)	(3.36349)	(3.01310)	(0.28707)
	[-1.21705]	[-0.50810]	[-0.66392]	[-1.44570]	[-0.11141]
D(L_GDP(-3))	0.416029	0.279380	−1.184300	5.898673	−0.213172
	(0.22395)	(0.29472)	(3.13540)	(2.80878)	(0.26760)
	[1.85767]	[0.94794]	[-0.37772]	[2.10009]	[-0.79660]
D(L_GDP(-4))	0.191453	0.206179	−0.888650	1.024187	0.346451
	(0.20571)	(0.27072)	(2.88000)	(2.57998)	(0.24580)
	[0.93070]	[0.76161]	[-0.30856]	[0.39697]	[1.40946]
D(L_CPI(-1))	−0.045900	0.057467	4.116312	−3.117962	0.482032
	(0.21219)	(0.27924)	(2.97070)	(2.66123)	(0.25354)
	[-0.21632]	[0.20580]	[1.38564]	[-1.17162]	[1.90118]
D(L_CPI(-2))	−0.199414	0.089227	−4.206691	−5.208732	−0.917863
	(0.24578)	(0.32345)	(3.44096)	(3.08250)	(0.29368)
	[-0.81137]	[0.27586]	[-1.22254]	[-1.68978]	[-3.12539]
D(L_CPI(-3))	0.341719	0.331580	3.000014	6.252900	0.176139
	(0.30213)	(0.39761)	(4.22994)	(3.78929)	(0.36102)
	[1.13103]	[0.83394]	[0.70923]	[1.65015]	[0.48790]
D(L_CPI(-4))	−0.262850	−0.293031	0.657840	−2.073501	0.362370
	(0.23433)	(0.30838)	(3.28072)	(2.93895)	(0.28000)
	[-1.12170]	[-0.95022]	[0.20052]	[-0.70552]	[1.29416]
D(L_MB(-1))	−0.002172	0.015018	0.237377	0.085550	0.020866
	(0.01934)	(0.02545)	(0.27071)	(0.24251)	(0.02310)
	[-0.11232]	[0.59017]	[0.87687]	[0.35277]	[0.90311]
D(L_MB(-2))	0.012610	−0.009072	−0.190946	−0.018527	−0.014095
	(0.01746)	(0.02298)	(0.24446)	(0.21899)	(0.02086)
	[0.72221]	[-0.39481]	[-0.78110]	[-0.08460]	[-0.67558]
D(L_MB(-3))	0.035285	0.022327	−0.130532	0.379612	0.013572
	(0.01740)	(0.02289)	(0.24356)	(0.21819)	(0.02079)
	[2.02821]	[0.97522]	[-0.53592]	[1.73982]	[0.65287]
D(L_MB(-4))	0.018045	0.004303	0.074142	0.144734	0.015555
	(0.01628)	(0.02142)	(0.22787)	(0.20413)	(0.01945)
	[1.10869]	[0.20088]	[0.32537]	[0.70902]	[0.79980]
D(L_SHARE(-1))	0.020398	0.054632	−0.228220	0.623812	−0.068432
	(0.02197)	(0.02891)	(0.30755)	(0.27551)	(0.02625)

Table A.5 Continued

	[0.92858]	[1.88977]	[-0.74206]	[2.26419]	[-2.60705]
D(L_SHARE(-2))	0.048714	−0.020576	0.536490	0.390385	0.056300
	(0.02349)	(0.03091)	(0.32883)	(0.29458)	(0.02807)
	[2.07403]	[-0.66569]	[1.63150]	[1.32524]	[2.00604]
D(L_SHARE(-3))	−0.015109	−0.006375	−0.388125	−0.466350	0.005225
	(0.02793)	(0.03675)	(0.39097)	(0.35024)	(0.03337)
	[-0.54106]	[-0.17348]	[-0.99273]	[-1.33152]	[0.15657]
D(L_SHARE(-4))	0.029178	0.014791	0.013525	0.285309	−0.043834
	(0.02224)	(0.02927)	(0.31138)	(0.27894)	(0.02658)
	[1.31191]	[0.50535]	[0.04344]	[1.02282]	[-1.64939]
D(GINI(-1))	0.372703	−0.153262	−0.306976	5.105956	−0.053738
	(0.15736)	(0.20709)	(2.20315)	(1.97364)	(0.18804)
	[2.36841]	[-0.74006]	[-0.13933]	[2.58707]	[-0.28578]
D(GINI(-2))	0.226089	0.190033	−4.102920	1.336123	0.047620
	(0.17581)	(0.23136)	(2.46136)	(2.20495)	(0.21007)
	[1.28601]	[0.82136]	[-1.66693]	[0.60596]	[0.22668]
D(GINI(-3))	0.363960	0.424145	−7.093972	2.324622	−0.416454
	(0.18105)	(0.23827)	(2.53483)	(2.27077)	(0.21634)
	[2.01022]	[1.78010]	[-2.79860]	[1.02372]	[-1.92497]
D(GINI(-4))	0.410115	0.443633	−3.177290	6.879383	0.155461
	(0.19843)	(0.26114)	(2.77816)	(2.48875)	(0.23711)
	[2.06675]	[1.69881]	[-1.14367]	[2.76419]	[0.65564]
C	0.001277	0.002783	0.030305	0.006445	−0.004296
	(0.00288)	(0.00379)	(0.04028)	(0.03608)	(0.00344)
	[0.44393]	[0.73515]	[0.75240]	[0.17862]	[-1.24965]
R-squared	0.664166	0.449238	0.590395	0.653765	0.522142
Adj. R-squared	0.395498	0.008628	0.262711	0.376777	0.139856
Sum sq. resids	0.000618	0.001070	0.121122	0.097201	0.000882
S.E. equation	0.004972	0.006543	0.069605	0.062354	0.005941
F-statistic	2.472072	1.019583	1.801721	2.360263	1.365841
Log likelihood	192.7375	180.1055	71.33966	76.40005	184.5464
Akaike AIC	−7.466848	−6.917632	−2.188681	−2.408698	−7.110712
Schwarz SC	−6.632033	−6.082818	−1.353866	−1.573883	−6.275897
Mean dependent	0.003763	0.004859	0.032561	0.008951	−0.000349
S.D. dependent	0.006394	0.006571	0.081063	0.078985	0.006405

Determinant resid covariance (dof adj.)	$1.40E-19$
Determinant resid covariance	$6.65E-21$
Log likelihood	742.2020
Akaike information criterion	−27.70443
Schwarz criterion	−23.53036
Number of coefficients	105

Table A.6: Coefficients of the VAR model for total expenditure inequality

Vector Autoregression Estimates
Date: 08/15/18 Time: 15:02
Sample (adjusted): 2005Q3 2016Q4
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(L_GDP)	D(L_CPI)	D(L_MB)	D(L_SHARE)	D(GINI)
D(L_GDP(-1))	−0.287547	−0.520370	−0.453857	−5.331328	0.344488
	(0.21443)	(0.31062)	(3.41788)	(3.19332)	(0.49525)
	[-1.34096]	[-1.67524]	[-0.13279]	[-1.66953]	[0.69558]
D(L_GDP(-2))	−0.078682	−0.181759	−3.976455	−2.137543	0.054792
	(0.21773)	(0.31540)	(3.47044)	(3.24243)	(0.50287)
	[-0.36137]	[-0.57628]	[-1.14581]	[-0.65924]	[0.10896]
D(L_GDP(-3))	0.509941	0.515574	−2.384282	5.900712	−0.147248
	(0.19941)	(0.28887)	(3.17850)	(2.96966)	(0.46057)
	[2.55719]	[1.78481]	[-0.75013]	[1.98700]	[-0.31971]
D(L_GDP(-4))	0.158935	0.282999	−1.150902	1.348402	0.635567
	(0.18433)	(0.26701)	(2.93799)	(2.74495)	(0.42572)
	[0.86225]	[1.05988]	[-0.39173]	[0.49123]	[1.49294]
D(L_CPI(-1))	−0.022351	0.156845	2.544869	−4.295300	0.277931
	(0.17135)	(0.24822)	(2.73125)	(2.55180)	(0.39576)
	[-0.13044]	[0.63188]	[0.93176]	[-1.68325]	[0.70227]
D(L_CPI(-2))	−0.164714	0.017390	−0.184147	−1.904377	0.381402
	(0.18235)	(0.26415)	(2.90649)	(2.71552)	(0.42115)
	[-0.90329]	[0.06583]	[-0.06336]	[-0.70129]	[0.90562]
D(L_CPI(-3))	−0.339488	0.145097	5.701001	−3.434734	−0.177867
	(0.18652)	(0.27019)	(2.97298)	(2.77764)	(0.43079)
	[-1.82011]	[0.53702]	[1.91761]	[-1.23656]	[-0.41289]
D(L_CPI(-4))	−0.439598	−0.595294	2.407448	−2.622838	0.172560
	(0.21357)	(0.30938)	(3.40416)	(3.18050)	(0.49326)
	[-2.05831]	[-1.92417]	[0.70721]	[-0.82466]	[0.34983]
D(L_MB(-1))	−0.000225	0.024397	0.205248	−0.054902	0.019169
	(0.01679)	(0.02432)	(0.26765)	(0.25007)	(0.03878)
	[-0.01338]	[1.00295]	[0.76684]	[-0.21955]	[0.49426]
D(L_MB(-2))	0.008216	−0.009229	−0.054244	0.081312	0.051026
	(0.01562)	(0.02263)	(0.24899)	(0.23263)	(0.03608)
	[0.52595]	[-0.40783]	[-0.21786]	[0.34954]	[1.41431]
D(L_MB(-3))	0.011607	0.015541	−0.085501	0.060900	−0.024881
	(0.01532)	(0.02220)	(0.24426)	(0.22821)	(0.03539)
	[0.75741]	[0.70008]	[-0.35003]	[0.26685]	[-0.70298]
D(L_MB(-4))	0.023442	−0.003190	0.161146	0.251853	0.006639
	(0.01501)	(0.02175)	(0.23932)	(0.22360)	(0.03468)
	[1.56127]	[-0.14667]	[0.67334]	[1.12636]	[0.19143]

Table A.6 Continued

D(L_SHARE(-1))	0.015112	0.056004	−0.140699	0.563696	−0.014269
	(0.01794)	(0.02599)	(0.28602)	(0.26723)	(0.04144)
	[0.84213]	[2.15450]	[-0.49192]	[2.10942]	[-0.34428]
D(L_SHARE(-2))	0.023655	−0.008551	0.500028	0.054941	0.008631
	(0.01941)	(0.02811)	(0.30934)	(0.28902)	(0.04482)
	[1.21883]	[-0.30415]	[1.61643]	[0.19010]	[0.19256]
D(L_SHARE(-3))	−0.001046	−0.017987	−0.363768	−0.067770	−0.000219
	(0.02034)	(0.02946)	(0.32413)	(0.30283)	(0.04697)
	[-0.05145]	[-0.61063]	[-1.12230]	[-0.22379]	[-0.00466]
D(L_SHARE(-4))	0.035006	0.019107	0.082949	0.236375	−0.072232
	(0.01932)	(0.02799)	(0.30797)	(0.28774)	(0.04463)
	[1.81175]	[0.68266]	[0.26934]	[0.82149]	[-1.61863]
D(GINI(-1))	0.151243	−0.070446	−0.428207	1.463212	−0.068226
	(0.08697)	(0.12598)	(1.38615)	(1.29508)	(0.20085)
	[1.73912]	[-0.55920]	[-0.30892]	[1.12982]	[-0.33968]
D(GINI(-2))	0.223731	0.101226	−3.054722	1.843360	−0.458337
	(0.08649)	(0.12529)	(1.37861)	(1.28803)	(0.19976)
	[2.58672]	[0.80793]	[-2.21580]	[1.43115]	[-2.29443]
D(GINI(-3))	0.366197	0.263792	−3.037074	2.704837	−0.054940
	(0.09552)	(0.13836)	(1.52247)	(1.42244)	(0.22061)
	[3.83381]	[1.90650]	[-1.99484]	[1.90155]	[-0.24904]
D(GINI(-4))	0.193896	0.287508	−1.373160	2.900557	0.076196
	(0.09277)	(0.13438)	(1.47862)	(1.38147)	(0.21425)
	[2.09015]	[2.13953]	[-0.92868]	[2.09962]	[0.35564]
C	0.005738	0.004722	−0.002305	0.055463	−0.009019
	(0.00265)	(0.00384)	(0.04229)	(0.03951)	(0.00613)
	[2.16270]	[1.22883]	[-0.05450]	[1.40385]	[-1.47193]
R-squared	0.730593	0.464684	0.574107	0.608413	0.477079
Adj. R-squared	0.515067	0.036431	0.233393	0.295144	0.058741
Sum sq. resids	0.000496	0.001040	0.125938	0.109933	0.002644
S.E. equation	0.004453	0.006450	0.070975	0.066312	0.010284
F-statistic	3.389814	1.085069	1.685013	1.942140	1.140417
Log likelihood	197.8066	180.7598	70.44280	73.56901	159.3014
Akaike AIC	−7.687242	−6.946078	−2.149687	−2.285609	−6.013103
Schwarz SC	−6.852427	−6.111263	−1.314872	−1.450794	−5.178288
Mean dependent	0.003763	0.004859	0.032561	0.008951	−0.000782
S.D. dependent	0.006394	0.006571	0.081063	0.078985	0.010600

Determinant resid covariance (dof adj.)	$4.46E-19$
Determinant resid covariance	$2.11E-20$
Log likelihood	715.6166
Akaike information criterion	−26.54855
Schwarz criterion	−22.37447
Number of coefficients	105

Figure A.1: Impulse response function of VAR analysis: Extended model for income inequality

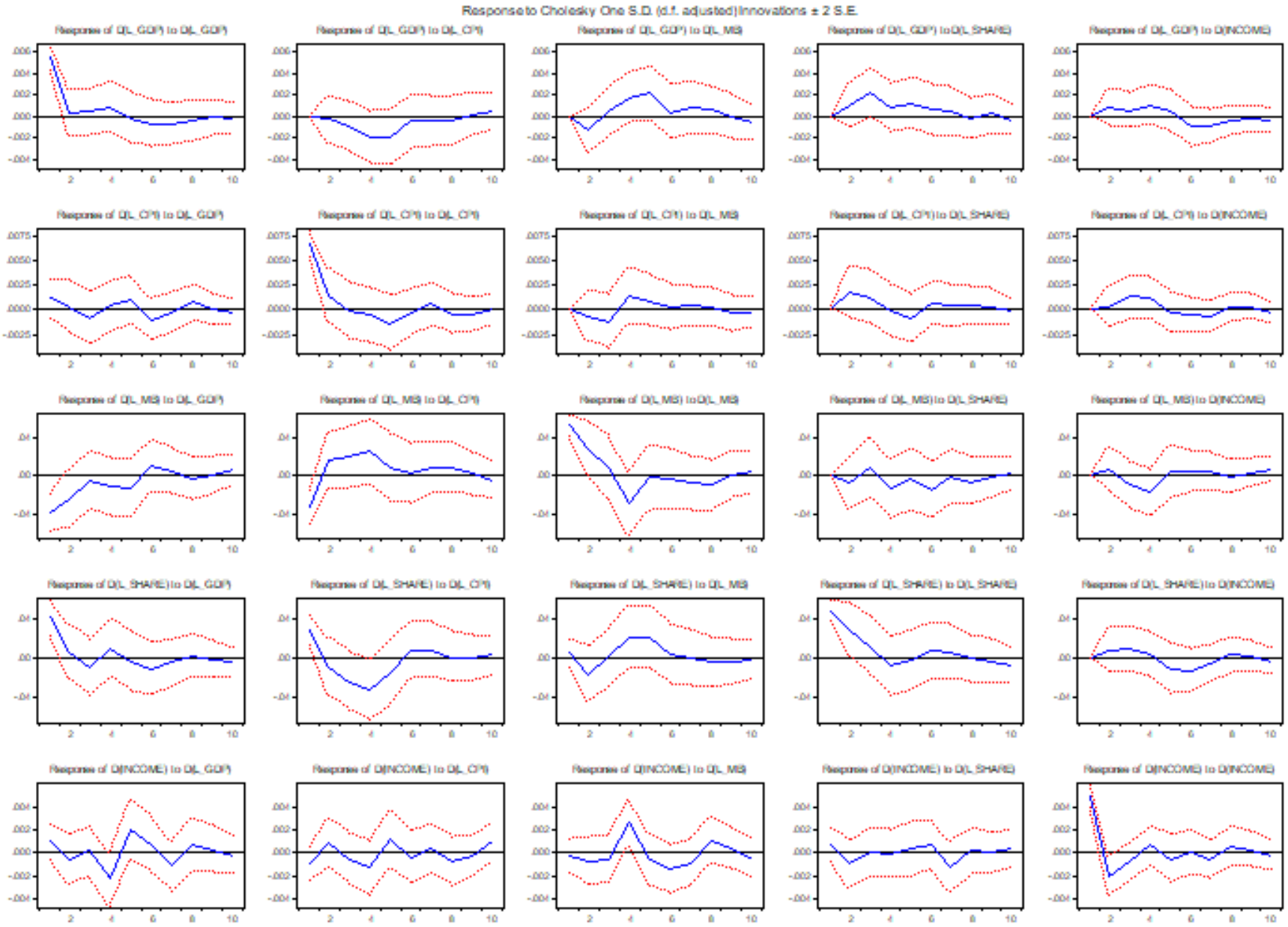


Figure A.2: Impulse response function of VAR analysis: Extended model for salary inequality

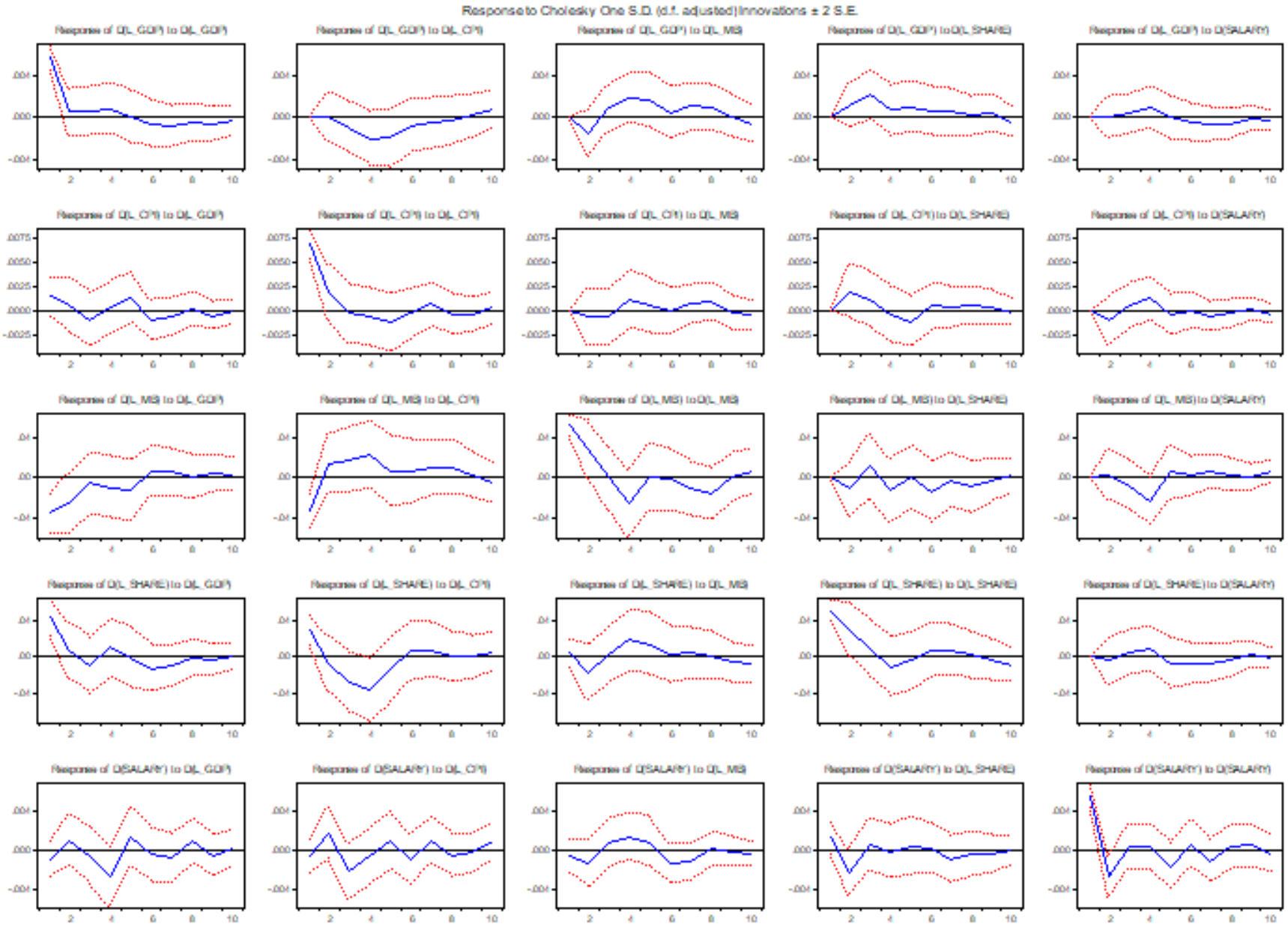


Figure A.3: Impulse response function of VAR analysis: Extended model for non-durable consumption inequality

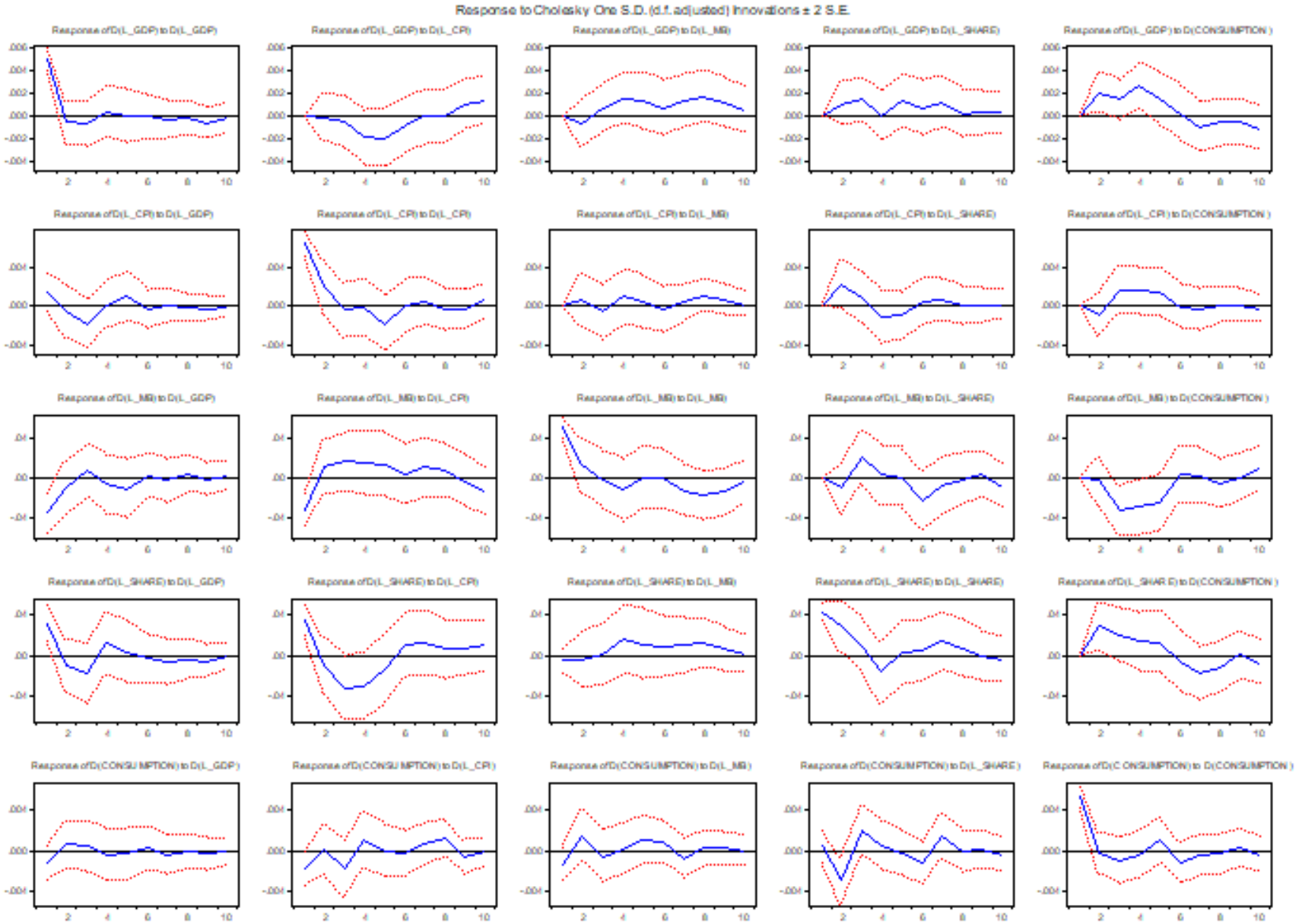


Figure A.4: Impulse response function of VAR analysis: Extended model for total expenditure inequality