How does monetary policy affect the income class structure?

Evidence from the Eurozone

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Abstract

This work provides evidence on the potential effects of monetary policy on the income class structure via stimulating economic activity and employment in the Eurozone countries over the period 2007Q3-2016Q1. Based on European Union Statistics on Income and Living Conditions (EU-SILC) data, we compute the size of income classes (lower, lower-middle, upper-middle, and upper) for the stats that originated the Economic and Monetary Union (EMU-11) and analyse the impact of monetary policy impulses under a Bayesian Vector Autoregressive approach. We focus on the earnings heterogeneity and the income composition channel and find that a monetary easing shock involving a decrease short-term nominal interest rate has diverse effects on the different income classes, which seems to have led to a more equal income distribution. As theoretically argued by these monetary policy transmission mechanisms, our results confirm the GDP growth and the decrease in unemployment caused by the monetary policies implemented by the European Central Bank since the onset of the financial crisis have had a positive effect for those households located at the bottom of the income-class structure as well as for the middle class.

Key words: Eurozone; monetary policy; class structure; income inequality; Bayesian Vector Autoregressive approach.

JEL codes: D63, E52

1. Introduction

In recent years there is an overall concern about the situation of the middle class and its future prospects in economically advanced countries (see e.g. Cowen, 2013 or Vaughan-Whitehead, 2016). Over the last decades, the middleclass share of the population has fallen and income and wealth inequality has increased in numerous countries (Pew Research Center, 2017), locating the question of income distribution at the core of the economic analysis (see e.g. Stiglitz, 2012; Deaton, 2013; Piketty, 2014; Atkinson, 2015; Galbraith, 2016). The arising of theories supporting advanced economies do not inevitable evolve toward more egalitarian societies, such as Piketty (2013), which oppose to the traditional view based on Kuznets (1955) has further sparked this debate.

Many studies have recently investigated the drivers of income distribution in order to facilitate policy-making for the sake of equity, and most of them have focused on the structural features of economies. The deepening of globalization (Katz and Autor, 1999), skill-biased technological progress (Katz and Murphy, 1992; Acemoglu, 20002, Autor, 2014), demographic trends, changes in labour market institutions, financialisation or the low ability of the tax-benefit systems to reduce market income inequality (sometimes due to a tendency toward less progressive tax systems, as supported by Alvaredo et al., 2013) are some of the major drivers addressed in the literature (see e.g. OECD, 2011 and 2015; Dabla-Norris et al., 2015; Bourguignon, 2017).

Although the narrowing of the middle class and the increasing within-country inequality is a long-term trend and primarily the result of deep structural changes, in a number of countries this process has intensified since the onset of the financial and economic crisis in 2007/2008. Since then, most major central banks, including the European Central Bank (ECB), have implemented various unprecedented monetary easing measures both through conventional interest rate cuts and through unconventional measures, such as forward guidance about intended future monetary policy actions, and extensive long-maturity assets' purchases, mostly as an attempt to circumvent the obstacles of the lower bound on nominal interest rates. These unparalleled decisions have considerably increased the concern about the distributive effects of monetary policy among academics and policy makers.

Although monetary policy is focused on stability rather than on equity, monetary policy decisions are not neutral for income and wealth inequality. From an academic perspective, the distributive effects of monetary policy are not a novelty and various theoretical channels through which monetary policy can affect income and wealth inequality have been argued in the literature by a number of authors (Coibion et al., 2017, Ampudia et al., 2018). In recent years, nevertheless, the distributive effects of monetary policy have also drawn the attention of central bankers, concerned by the potential distributive effects of their extraordinary monetary policy decisions, essentially, via changes in asset prices and in the general macroeconomic environment (e.g. Bernanke, 2013, 2015; Yellen, 2014; Draghi, 2016; Constâncio, 2017).

According to Bernanke (2015), monetary policy is not a key driver of increased inequality, as "monetary policy is neutral or nearly so in the longer term, meaning that it has limited long term effects on *real* outcomes like the distribution of income and wealth". Nonetheless, given that monetary policy typically operates over a limited horizon, its influence on income distribution in the short- and medium-term should not be ignored and, to the extent possible, taken into consideration for its optimal design.

This paper evaluates how monetary policy affects the income class structure by stimulating economic activity and employment for the panel of countries that originated the Economic and Monetary Union that originated the Union (EMU-11). We examine the effect of monetary policy on the different classes of the income distribution. Our interest on the lower income class lies in the substantial dependence of these households on labour income and their likelihood to react significantly to monetary policy impulses that stimulate the economic activity. In comparative terms, we are interested also on studying the effect of monetary policy on the upper part of income distribution, which relies relatively more on business and capital income. In particular, we distinguish between lower, lower-middle, upper-middle and upper classes. We apply a Bayesian vector autoregressive (BVAR) model to assess possible impacts of monetary policy on the size of the respective income classes over the period 2007Q3-2016Q1. Our findings suggest a non-homogeneous effect of monetary policy on the income classes, although the impact of other intermediate variables does seem to have had a rather uniform effect on the distribution of income.

The remainder of the paper is structured as follows. Section 2 briefly reviews the theoretical channels through which monetary policy affects income and wealth inequality and previous empirical evidence. Section 3 describes the data and the methodology. Section 4 presents and discusses the results. Finally, some concluding remarks are offered in section 5.

2. Literature review

2.1. Theoretical framework

Although the distributive effects of inflation on economic inequality have been traditionally more considered by the literature than the impacts of monetary policy themselves (Galli and von der Hoeven, 2001; Albanesi, 2007), some specific channels through which monetary policy impacts income and wealth distribution have been clearly identified in the literature (see e.g. Coibion et al., 2017, Amaral, 2017). Most of the channels primarily affect wealth distribution, either via inflation, such as saving redistribution channel or portfolio channel, or via the transmission process of monetary impulses, such as interest rate exposure channel or financial segmentation channel. Nonetheless, two major channels operate affecting income distribution through transmission mechanisms of monetary policy: income composition channel and earnings heterogeneity channel. The former focuses on the main source of households' earnings and underlines that an expansionary monetary policy may exert significant pressure on interest rates and financial assets prices, so that its effect on income (and wealth) may be different for those agents who receive a large fraction of their income from wage earnings compared to those who receive a large part of their income from financial asset holdings and business gains, frequently upper-income households. Based on data from the Household Finance and Consumption Survey, Lenza and Slacalek (2019) highlights how the lower the income class, the greatest the percentage of its total income that is derived from employment remuneration.

Regarding the earnings heterogeneity channel, it points out that the risk of unemployment is distributed unequally across the population and it is precisely low- and middle-income groups those who usually have higher odds of being or becoming unemployed. Therefore, and bearing in mind they rely considerably on wage earnings (as stated by the income composition channel), an expansionary monetary policy does not affect the employment situation of all income groups homogeneously. In this line, a better macroeconomic environment improving economic activity and employment as a result of an expansionary monetary policy might tend to narrow the low-class size and broaden the middle-class size, therefore compressing income inequality, as the employment status of households at the lower part of the income distribution is likely to react more significantly to monetary policy impulses. Thus, an aggregate decline in unemployment disproportionately affects groups with a higher share of unemployment, frequently low- and middle-income households. In fact, according to Heathcote et al. (2010), earnings at the bottom of the distribution are mainly affected by changes in hours worked and the unemployment rate, while earnings at the top are mostly affected by changes in hourly wages. This may favour the mobility of some individuals from the lower to the middle class, or hinder middle class individuals from falling into the lower class, resulting in an increase of the size of the middle class. Furthermore, the effect of monetary stimulus on the bottom part of the income distribution may also be substantially magnified due to a stronger impact on consumption via the larger marginal propensity to consume of these (constrained) household.

Recently, nonetheless, Dolado et al. (2018) has examined the earnings heterogeneity channel based on a New Keynesian model in which they study how capital-skill complementarity interacts with monetary policy in affecting inequality between high- and low-skilled workers. They find that an unexpected expansionary monetary policy shock increases earnings inequality by lowering the labour share of income received by low-skilled workers and raising it for high-skilled workers, as the increase in capital demand amplifies this wage divergence due to skilled workers being more complementary to capital than substitutable unskilled workers are. This way, in contrast to the arguments exposed above, a monetary easing may raise the relative income share of high-skilled workers, favouring individuals at the upper part of the income distribution.

2.2. Empirical literature

From an empirical point of view, there is a significant amount of work concerning monetary policy and income inequality (see Colciago et al., 2018). Earlier studies focused on the impact of the inflation channel on income distribution, despite this channel is mainly associated with wealth distribution in theoretical studies (e.g. Easterly and Fischer, 2001). Overall, they find inflation significantly increases income inequality as it hurts poor households who are more reliant on state-determined income that is not fully indexed to inflation.

Most recent empirical studies on the redistributive effects (in terms of income inequality) of monetary policy shocks focus essentially on the income composition channel and the earnings heterogeneity channel. Some papers highlight that expansionary monetary policy reduces income inequality in the U.S. (Coibion et al., 2017), the U.K. (Mumtaz and Theophilopoulou, 2017), the euro area (Guerello, 2018) and in advanced and emerging countries (Furceri et al., 2016). They argue that expansionary monetary policies tend to stimulate economic activity, employment and wages, favouring low-income households inasmuch as labour earnings constitute their main source of income, while high-income households are less likely to become unemployed and lose their labour income. As remarked by Lenza and Slacalek (2019) he effect is asymmetric, tightening of policy raises inequality more than easing lowers it, and depends on the state of the business cycle.

Other studies, however, support that expansionary monetary policy is associated with higher income inequality or that its distributional effects may be negligible. For instance, for Japan, Inui et al. (2017) reveal that expansionary monetary policy may lead to higher income inequality due to labour market rigidities and nominal wage stickiness, which increases earnings inequality by dispersing wages. Likewise, O'Farrel et al. (2016) conclude that the distributional effects of expansionary monetary policy on average are negligible, but differ considerably across OECD countries. While a house price increase reduces wealth inequality, higher bonds and equity prices tend to exacerbate it, so that the effects of monetary policy easing on both income and wealth inequality are widely unequal across countries.

Regarding the effects of non-standard policy measures implemented since 2008 by most major central banks (forward guidance, low/negative interest rates, large-scale asset purchases, etc.) on income distribution, the empirical evidence is scarcer and mostly focused on the effects of quantitative easing (QE). Regarding the earnings heterogeneity channel, we find evidence on QE reducing income inequality by stimulating the economic activity, job creation and wages growth in the U.S. (Bivens, 2015), Italy (Casiraghi et al., 2018) and the euro area (Guerello, 2018; Lenza and Slacarek, 2018). By contrast, concerning the income composition channel, Saiki and Frost (2014) for Japan, Montecino and Epstein (2015) for the U.S. and Mumtaz and Theophilopoulou (2017) for the U.K. highlight that the increase in asset prices caused by the QE raises financial incomes of high-income households and thus exacerbates income inequality. Lenza and Slacalek (2019) focuses on France, Germany, Italy and Spain and concluded QE substantially contributed to support vulnerable households since many households with lower incomes became employed, thus compressing the income distribution. They remark the stimulating effect of QE on aggregate consumption disproportionately boots income in the lower part of the distribution. Therefore, given that there are two contrasting effects on income distribution, from the earnings heterogeneity and income composition channels, the overall effect of unconventional policies seems to depend on the relative strength of both channels, which is related, in turn, to the economic structure and the socio-demographic composition of each country.

Overall, these studies use annual inequality measures from national or international sources such as Gini index or measures related to income of individuals at the top end of the distribution. To the best of our knowledge, our proposal is the first attempt in the literature to investigate the effects of monetary policy specifically on the income class structure, providing empirical evidence for the EMU-11 over the period of 2007Q3-2016Q1 and attempting to improve our understanding of how both theearnings heterogeneity and the income composition channel actually work through the employment via.[1]

3. Data and methodology

3.1. Data

In order to examine the distributive effects of monetary policy on the income class structure, we adopt a relative definition of the income class that establishes thresholds in relation to percentages of the median income of the distribution. To delimit the lower-middle class, we consider the income limits that are conventionally accepted (see, e.g., Thurow, 1987; Birdsall et al., 2000; Ravallion, 2010; Atkinson and Brandolini, 2013): 75% and 125% of the median income. These cut-offs demarcate the lower-middle class as those "comfortably" clear of being at-risk-of-poverty (below 60% of the median). Similarly, we define the upper-middle class as the share of the population whose income is between 125% and 200% of the median income. Conveniently, the share of households belonging to the lower part of the income distribution (below 75% of the median income) are considered lower class, whereas those at the top (above 200% of the median income) compose the upper class.

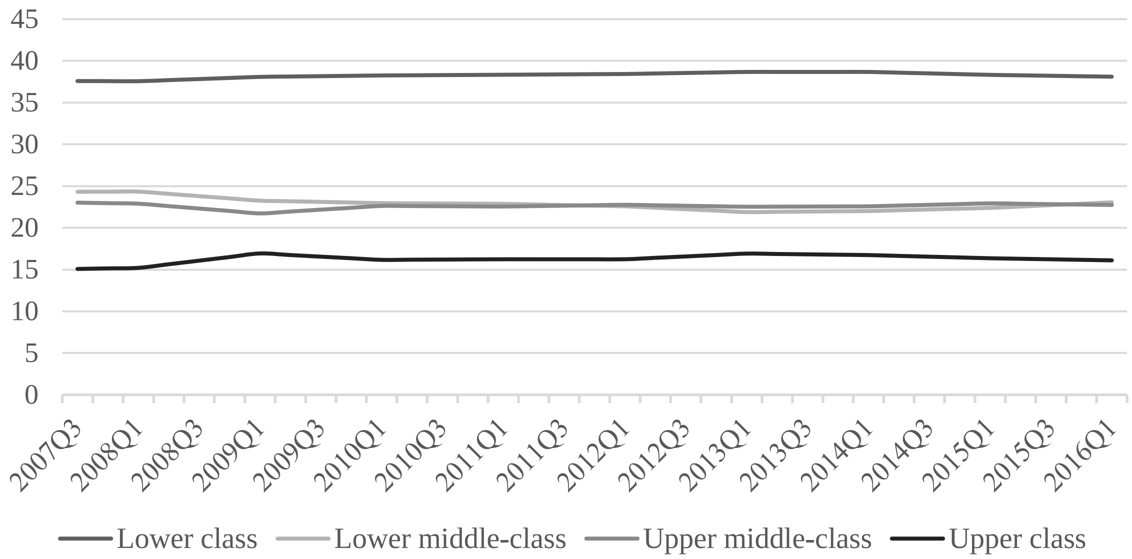
We estimate the proportion of the population within each income class (size) using data from the European Statistics on Income and Living Conditions (EU-SILC), which has been carried out since 2004 and is the reference source for comparative statistics on the distribution of income in Europe. The EU-SILC has the advantage of collecting detailed information on individual and household income and data is comparable across the participating European countries. We use data from cross-sectional files for the waves 2008[2] to 2017for the 11 EMU countries.

[1]We focus on the effects expansionary monetary policy applied since the onset of the financial crisis may have had in terms of boosting economic activity and thus employment, leaving aside other effects related to the income composition channel, such as the potential financial gains of the upper classes arising from quantitative easing measures such as the assets purchase program.

[2]Each wave contains information related to the previous year.

The concept of income used to compute the limit of the income classes is that of household market income, that is, income before transfers and taxes, in order to exclude, to the extent possible, the significant redistribute effects of the tax and transfer system. It includes: all income from work (salaries of employees and income of self-employed workers), income from capital and property, transfers between households, as well as income from private pension plans. The variable income is collected with reference to the previous calendar year (with the exception of Ireland, among the countries analysed).[3]Solely taking into account market income implies that households that live on transfer payments such as retirees cannot be included in the analysis as their market income is close to zero in most cases. For this reason, we drop from our sample those individuals with zero market income whose market income does differ from their disposable income. This way, we avoid analysing individuals whose disposable income comes only from transfer payments.

Figure 1. Evolution of the income class structure in average terms of the EU-11



In the EU-SILC the basic unit for collecting information is the household and this is usually taken as a unit of measure, since the level of life of an individual is influenced by his income and by the people with whom he/she lives. Although the unit of measurement is the household, we analyse the distribution of the income of the individuals, unit of analysis, whenever we try to examine the economic position of the people. To adjust household income according to its size, we use the modified OECD equivalence scale[4]and then we attach the equivalent household income to each member of the household.

We work with a panel of 11 countries (EMU-11) for the period between 2007Q3, the beginning of the financial crisis, and 2016Q1, the latest available data. We compute the size of income classes

[3] As argued by Böheim and Jenkins (2006), the differences in income reference periods are unlikely to be a major source of non-comparability across countries.

[4] A value of 1 to the first adult in the household, 0.5 to each remaining adult, and 0.3 to each member younger than 14.

for each year and interpolate it into quarterly frequency, in addition all the variables are both seasonally and calendar adjusted data. In accordance with the literature (see, for example, Peersman, 2011 and Coibion et al., 2017), apart from the size of the income classes as a way of measuring income distribution, the following macroeconomic variables are included in our models: short-term nominal interest rates (OECD, 2019)[5], as a proxy variable for the monetary policy; real gross domestic product growth (Eurostat, 2019a)[6]; inflation rate measured as the percentage change of the gross domestic product deflator (Eurostat, 2019b)[7]; private sector consolidated credit flow, as a percentage of GDP (Eurostat, 2019c)[8]; and unemployment rate (Eurostat 2019d)[9].[10]As we assume EMU1999 is a group of countries with high mutual integration and similarity relative to other countries that joined EMU later in the twenty-first century, this allows us to avoid the need to address a wide range of socioeconomic variables for the sake of simplicity. This assumption allows condensing a complex phenomenon and makes it tractable from an empirical approach. We estimate a single model for all countries[11] and thus do not account for cross country dynamic heterogeneity, therefore our results cover the general dynamic for the set of considered countries, bearing in mind certain individual characteristics may be responsible for differences not accounted in our analysis.

Concerning monetary policy, it is commonly proxied either by short-term or policy interest rates (e.g., Furceri et al., 2016; Mumtaz and Theophilopolou, 2017; Coibion et al., 2017),central bank assets (Saiki and Frost, 2014; Guerello, 2018),or government bond spreads (Baumeister and Benati, 2010; Ampudia et al. 2018; Lenza and Slacalek, 2019)when intending to examine specifically unconventional monetary policy. In our case, in order to capture, as far as possible, the overall effects of the wide variety of monetary policy decisions adopted by the ECB since the onset of the financial crisis, which includes both standard and non-standard tools implemented to circumvent the lower bound on nominal interest rates, we take the short-term nominal interest rates as a proxy variable of monetary policy. In particular, we use the 3-month Euribor, from the European Central Bank Statistical Data Warehouse (2019).

[5] OECD Data (2019). https://data.oecd.org/interest/short-term-interest-rates.htm*[accessed on 17.05.2019]*

[6] Eurostat (2019a). http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do *[accessed on 17.05.2019]*.

[7] Eurostat (2019b). http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do*[accessed on 17.05.2019]*.

[8] Eurostat (2019c)https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tipspc20&plugin=1*[accessed on 17.05.2019]*.

[9] Eurostat (2019d). http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do*[accessed on 17.05.2019]*.

[10] The variables concerning the income classes have been interpolated from the annual frequency to the quarterly series.

[11]The short period covered by our panel dataset would make drawing comparisons from single unit estimation of the parameters difficult and even uninformative, since estimates may be biased and estimation uncertainty would be large (Canova, 2007).

The credit has played a crucial role in the monetary transmission mechanisms, given that it has determined whether the monetary easing and credit facilities have reached the real economy. Thus, we include a variable related to private credit (Eurostat, 2019a)which refers to the net amount of liabilities in which non-financial corporations, households and non-profit institutions serving households have incurred along the year (as a percentage of the gross domestic product).The effect of prices is included in our model through the GDP deflator change rate. In addition, as measures of economic activity and employment, we consider the real GDP growth rate and the total unemployment rate, both from Eurostat (2019b, 2019c). The unemployment rate (Eurostat, 2019d) represents unemployed persons as a percentage of the labour force and comprises persons aged 15 to 74 who were without work during the reference period, currently available for work and actively seeking work.

The unstable and shifting period of time considered in our analysis defines marked trends in our data which may cause spuriousness in our analysis as well as induce the necessity for more explanatory factors than the considered regressors to avoid specification errors. Since the effects of monetary policy on the real economy are situational and strongly shaped by the business cycle, we model the cyclical behaviour of the variables in terms of temporary departures from steady state value (measured for the period between 2007Q3 and 2016Q1). The cycles are isolated using the Hodrick-Prescott filter for annual data.[12]The descriptive statistics of the original variables as well as its cyclical components (through Hodrick-Prescott filter, calculated as the deviation from that period's trend) are shown in Table 1.

Table 1. Descriptive statistics (original variables and cyclical components included in the model)

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
Short-term nominal interest rates	385	1.292	1.608	-0.186	4.982
Cyclical component of interest rates	*385*	*0.000*	*0.697*	*-1.430*	*1.678*
Real GDP growth	385	0.175	1.587	-6.800	22.600
Cyclical component of real GDP growth	*385*	*0.049*	*1.377*	*-6.489*	*19.459*
GDP deflator (percentage change)	385	0.317	0.736	-3.300	6.900
Cyclical component of GDP deflator	*385*	*0.000*	*0.684*	*-3.318*	*6.205*
Private credit	385	4.804	8.833	-22.500	70.300
Cyclical component of private credit	*385*	*0.000*	*5.247*	*-30.906*	*57.199*
Unemployment rate	385	9.271	4.833	3.600	26.200
Cyclical component of unemployment rate	*385*	*0.000*	*0.767*	*-2.919*	*2.733*
Lower class size	381	38.277	1.191	34.398	40.939
Cyclical component of lower class	*381*	*0.000*	*0.322*	*-1.247*	*1.024*
Lower-middle class size	381	22.815	1.819	18.404	27.461
Cyclical component of lower-middle class	*381*	*0.000*	*0.502*	*-1.972*	*1.598*

[12]All the variables are stationary, supporting results derived from the VAR methodology.

Upper-middle class size	381	22.602	2.154	13.351	27.575
Cyclical component of upper-middle class	*381*	*0.000*	*0.711*	*-6.600*	*3.246*
Upper class size	381	16.306	2.921	10.677	20.042
Cyclical component of upper class	*381*	*0.000*	*0.799*	*-3.304*	*7.158*

Source: Own elaboration based on EU-SILC, AMECO (Annual macro-economic database of the European Commission), Eurostat and The World Bank data.

3.2. Methodology

Macroeconomic analyses and policies evaluations are increasingly requiring taking into account the existing interdependencies among the different economic variables, with the purpose of assessing the impacts from a global perspective. Monetary policies effects are distributed through numerous transmission mechanisms, giving rise to both direct and indirect impacts of different nature. The existence of interactions between the analysed variables constitutes the main reason why a simultaneous equation system appears to be the most accurate way to approach our analysis, bearing in mind their endogeneity. Initially developed by Sims (1980), the vector autoregression approach considers each variable as endogenous, and they are included in the system as functions of lagged values of all endogenous variables, thus tackling the endogeneity issue allows us to study their interrelations. A priori, the vector autoregressive (VAR) methodology is thought to be minimalist in the sense that economic theory is barely used in the inferential process, as it does not require a strong theory supporting the model.

The dynamic interactions among the set of macroeconomic endogenous variables collected in the vector (gx1) of endogenous variables, Y_{it}, is governed by the following system of autoregressive simultaneous equations in reduced-form:

$$Y_{it} = C + A_1 Y_{it-1} + A_2 Y_{it-2} + \cdots + A_p Y_{it-p} + \varepsilon_{it} \quad (1)$$

$$Y_{it} = C + \sum_{j=1}^{p} A_j Y_{it-j} + \varepsilon_{it} \quad (2)$$

$$\varepsilon_{it} \sim N(0, \Sigma) \quad (3)$$

where i = *1…, N* indicates countries. In our case N=11, corresponding to the 11 countries of the European Monetary Union in 1999. Time is t = *1…, T*, with T= 35, the quarters from 2007Q3 to 2016Q1. Here c denotes a (gx1) vector of constants, and $A_j$are (gxg) matrices of coefficients on the p lags of the variables. Σ is the covariance distribution of the VAR errors. The model is specified in terms of the quarterly levels of the cyclical components. In particular, the vector Y_{it}, is composed of the variables in the following order: real gross domestic product growth, GDP deflator, short-term nominal interest, domestic credit to private sector, unemployment rate, and the size of each income-class. Therefore, the vector of endogenous variables is specified as follows: $Y_{it} = (GDPG_{it}, DEF_{it}, STIR_{it}, PC_{it}, UR_{it}, IN_{it})'$, g being equal to 6 for each of the four models corresponding to each income class.

We apply a Bayesian Vector Autoregressive (BVAR)[13] methodology with traditional normal-Wishart identification strategy for the sake of extracting the valuable information from the sample while controlling for overfitting (De Mol et al., 2008; Banbura et al., 2010).[14]We apply a pooled estimator that considers country-specific variables are only affected by themselves, not by those of other countries, and a single VAR is estimated for a whole set of units.[15] This implies the variance covariance matrix of residuals is both time invariant and common to all cross-sectional units. The informative priors for the autoregressive coefficients follow (conditional on Σ) a multivariate normal, while the prior for Σ is inverse Wishart; both are assumed to be unknown. The normal-Wishart variance-covariance matrix of the autoregressive parameters are a special case of the Minnesota variance-covariance matrix where Σ is diagonal and the cross-variable weighting parameter is constrained to take a value of $1(\lambda_2)$, this implies a lack of extra shrinkage, i.e. tighter priors cannot be imposed on cross-variable parameters, thus it is advisable to set the overall tightness parameter(λ_1)between 0.01 and 0.1. For the remaining hyperparameters, values assumed by the Minnesota prior may be attributed, therefore the lag decay (λ_3) may be given values of 1 or 2 (Dieppe et al., 2018). Results under this specification prove to be robust to any of the recommended specifications of the hyperparameters. As stated by Dieppe et al. (2018), in presence of co-movement, the information contained in the data "conjures" against the prior and allows the parameters to reflect sample information even if very tight prior beliefs are enforced.

The reduced-form VAR above does not account for direct contemporaneous relationship among the variables, since there are no time endogenous variables on the right-hand side. In fact, the error terms in the reduced form are typically correlated (matrix Σ) can and indeed tends to have non-zero off-diagonal elements), and thus does not have a clear economic interpretation. Impulse-response functions are meant to measure the change in a shock ceteris paribus, so if the shocks are correlated one cannot hold other shocks constant when a shock occurs (Ouliaris et al., 2016). To solve this problem, we use the estimated reduced-form model and recover from it the structural model, which cannot be directly estimated (it is unobservable and relies on the interpretation of historical data). The structural VAR considers that the correlations between shocks arise due to contemporaneous correlations between variables, and so includes the contemporaneous dependence among them. If the

[13]This empirical analysis is performed using the Bayesian estimation, analysis and regression (BEAR 4.2.) toolbox developed by Dieppe, Legrand and van Roye (2016), from the External Developments Division form the European Central Bank. We accept the End User Licence Agreement (EULA) and acknowledge we have no rights in or to the Software other than the licence to use it in accordance with the terms of the EULA.

[14] The large number of parameters to be estimated, relative to the available sample implies a potential "curse of dimensionality", this is, classical techniques would very likely result in large estimation uncertainty and data overfitting. These authors showed that since most macroeconomic variables tend to co-move, bayesian reduces the estimation uncertainty without biasing the estimates via imposing priors that push the parameter values of the model toward those of naïve representations.

[15]The BEAR 4.2. toolbox, used to estimate the model, does not handle unbalanced datasets. Therefore, the missing information, related to the income class structure of Ireland between 2015Q2 and 2016Q1, has been replaced by its forecast based on past values.

model successfully captures the contemporaneous effects, the errors in the structural equations will be uncorrelated.

The reduced-form VAR is the result of pre-multiplying the structural VAR by ${D_0}^{-1}$, so that the reduced-form coefficients are $A_m = {D_0}^{-1} D_m$.[16]To be more specific, the resulting structural-form (SVAR) system of order p will be:

$$D_0 Y_{it} = \eta + D_1 Y_{it-1} + D_2 Y_{it-2} + \cdots + \ D_p Y_{it-p} + \ u_{it} \quad (4)$$

$$D_0 Y_{it} = \eta + \sum_{j=1}^{p} D_J Y_{it-j} + \ u_{it} \quad (5)$$

Where D_0 is a (gxg) contemporaneous coefficient matrix, this is the structural matrix that permits to recover structural innovations from the reduced-VAR form residuals. Now the structural shocks,$u_{it} \sim N(0, \Gamma)$, are taken to be uncorrelated, i.e. E (u_{it}) = 0, and the variance-covariance matrix is a diagonal matrix (all the elements off the main diagonal are zero). Therefore, by assuming the shocks inu_{it} are mutually orthogonal we can overcome the shock correlation issue. In fact, the reduced form (VAR) errors are linear combinations of the structural errors, they are indeed the result of pre-multiplying by ${D_0}^{-1}$ the SVAR, so that $\varepsilon_{it} = \ {D_0}^{-1} u_{it}$.[17]

Once the structural model is identified, we formally test the model indeed satisfies the stability condition, this is, eigenvalues of the coefficient matrices are in modulus less than one, i.e. the model is stationary.[18]Therefore, $Y_{it}$is linear, stationary and invertible, and hence there exists an infinite lag VAR representation as specified above, also known as Wold (1949, 1951) representationand the contributions of $Y_{it-1}$to Y_{it} gets to zero when qtends to infinity:

$$Y_{it} = A(L)^{-1} {D_0}^{-1} C + \ \psi_0 u_{it} + \psi_1 u_{it-1} + \cdots \quad (6)$$

$$Y_{it} = A(L)^{-1} {D_0}^{-1} C + \ \sum_{q=0}^{\infty} \psi_q u_{it-q} \quad (7)$$

where $\psi_0 u_{it} = \ {D_0}^{-1} D_0 \varepsilon_{it}$ and $\psi_q u_{it-q} = \overline{\psi_q} {D_0}^{-1} D_0 \varepsilon_{it-q}$. Then $\psi_0 = \ {D_0}^{-1}$ and $\psi_q = \overline{\psi_q} {D_0}^{-1}$, for i = 1, 2, 3, …The existence of a Wold representation for our process allows us to trace the effects of structural shocks on the endogenous variables, this is, to elaborate impulse-response functions from coefficients ψ_q. The series ${D_0}^{-1}$, ψ_1, ψ_2,… represents the response of the VAR variables to structural innovations, and they result from independent shocks (meaningful economic interpretation) as long as Γ is diagonal.

[16] The reduced-form constant term, c, is related to the structural-form constant such as $c = \ {D_0}^{-1} \eta$.

[17] This also implies $\Sigma = E(\varepsilon_{it} {\varepsilon_{it}}') = E\left({D_0}^{-1} u_{it} {u_{it}}' {D_0}^{-1\prime}\right) = {D_0}^{-1} E(u_{it} u'_{it}) {D_0}^{-1\prime} = \ {D_0}^{-1} \Gamma {D_0}^{-1\prime}$, which means $\Sigma = \ {D_0}^{-1} \Gamma {D_0}^{-1\prime}$.

[18] Taking into account the country-specific variables, plus the one common to all countries (yield curve), we check our panel dataset tends to be stationary. Although there exist country-specific variables exceptions (for some countries some specific variable may be first-order integrated) this does not raise a spurious regression issue since the estimated error terms are indeed stationary, and so it is the model. This enables the impulse-response analysis because, according to the Wold representation theorem (1954), every covariance-stationary time series can be written as the sum of two time series, in our case, one deterministic panel time series, η_{it} and one stochastic, $\sum_{q=0}^{\infty} \psi_q u_{it-q}$.

For the structural identification of the shocks,$D_0{}^{-1}$ comprises g^2 elements to identify, and Γ, which comprises $g(g+1)/2$. Both hence makes a total of $(g/2)(3g+1)$ elements to identify. Sincethe known elements of$\Sigma = D_0{}^{-1}\Gamma D_0{}^{-1'}$ provide $g(g+1)/2$ restrictions on $D_0{}^{-1}$ and Γ, g^2 additional restrictions have to be implemented to fully identify $D_0{}^{-1}$. To do this we use what is known as a triangular factorization, under the assumptions that Γ is a triangular but not an identity matrix[19]and $D_0{}^{-1}$ is lower triangular and its main diagonal is made of ones[20], which imposes a unit contemporaneous response of variables to their own shocks. In practice, this identification arises from the result in Hamilton (1994), according to which any positive definite symmetric gxg matrix Σ has a unique representation $\Sigma = D_0{}^{-1}\Gamma D_0{}^{-1'}$ where $D_0{}^{-1}$ is a lower triangular matrix with ones along the principal diagonal and Γ is a diagonal matrix. The uniqueness of the decomposition permits to integrate it into the Gibbs sampling process. The fact that $D_0{}^{-1}$ is a lower triangular matrix implies the implicit order in which our endogenous variables in vector Y_{it}affects the contemporaneous relationships among them. In our case, we impose $Y_{it}^{'} = (GDP_{it}, DEF_{it}, STIR_{it}, PC_{it}, UR_{it}, IN_{it})'$ meaning the cyclical component of the real gross domestic product growth rate can be conceived as the most endogenous of our variables, i.e. a shock on it causes a contemporaneous impact on all the variables, thus monetary policy is assumed to react and make decisions based on this magnitude as well as on the price level. On the other end of the spectrum, the variables related to the income class structure are perceived as the most exogenous one, since a structural shock on any of them affects only itself, leaving untouched all the rest. Therefore, each variable's contemporaneous shock has an effect on that variable itself and all the variables that come afterward in the specified vector. The ordering that we apply is therefore in line with the theoretical hypothesis tested. In this case, we establish as the main shocks transmitter the proxy variable of the monetary policy.

4. Results

Results from the estimated panel VAR are the average responses of the endogenous variables (expressed in terms of cyclical components), for all the countries considered and the period covered by our sample, to exogenous shocks in the short-term nominal interest rates (as a proxy variable for monetary policy) after controlling for the time-invariant characteristics of each country.[21]Four different models are estimated, each of them includes Y_6as the size of the lower class, lower-middleclass, upper-middleclass and upper class, respectively. It is tested that no root lies outside the unit circle, so the VAR model satisfies the stability condition. All the specified models agree on the

[19] Zeros below the diagonal impose $g(g-1)/2$ over the g^2 required to identify $D_0{}^{-1}$ and Γ.
[20] Zeros above the main diagonal combined with the diagonal of ones generate another $g(g+1)/2$ constraints.
[21]As stated by Canova (2007), it is rare and cumbersome to report estimated VAR coefficients, since they are poorly estimated (except for the first own lag, they are all insignificant), and the displayed impulse-response functions of these VAR coefficients summarize information better.

model selection criteria, six lags are the optimum to be included, and the results concerning the common variables in the four models (each one for an income class) are robust.

The extent to which the impulse-response functions are reliable depends on the real causal effect between two variables, in other words, the related coefficients of the regressors' matrices have to be significantly different from zero, confirming the existence of Granger causality among each pair of variables. This occurs when the impulse-response confidence intervals are above or below the zero axis in Figure 2. These figures show the impact of a one standard deviation impulse in the short-term nominal interest rates. Note that the impulse-response functions are displayed for the cyclical components in variables and not for the original variables, what will influence the interpretation.

Figure 2 shows that the most immediate response to an expansionary monetary policy[22] is displayed by the real gross domestic product growth rate. Specifically, one standard deviation cut on the (cyclical component of the) short-term nominal interest rates leads to an immediately increase of the gross domestic product growth rate. It achieves the maximum in the third quarter after the shock showing a peak at 0.5 percentage points above the growth rate trend. The effect persists over two period sand then fades away. According to the results, a negative shock on short-term nominal interest rates seems to have caused no significant impact on the GDP deflator change rate (second row of Figure 2); the almost non-existent inflationary pressures during the analysed period may back this finding. Similarly, lower interest rates also cause a diluted increase in the private credit, however this effect is not immediate but starts six quarters after the shock and then seems to last until the eleventh quarter.[23]A standard deviation cut on the (cyclical component of the) short-term nominal interest rates leads to an immediate increase in unemployment followed by an intense and persistent decrease in unemployment, between the fifth and 10th quarter, to slightly increase again for a short period. This decrease on the unemployment rate achieves its lower peak around seven quarters after the shock, when it seems to decrease approximately up to 0.3 points below its trend.

If we focus on the income-class structure we perceive that a cut in the short-term nominal interest rates leads to small changes in the income class sizes, around 0.1 percentage points. Specifically, the immediate non-significant effect on the lower-class size is an increase followed by a persistent decrease of the size, slightly significant around the 10th quartile after the shock and then it vanishes. That is, an expansionary monetary policy provokes a hump-shaped impact on lower tail of the distribution. The effect over the lower-middle income class size is the opposite, first an immediate non-significant decrease followed by a persistent increase of the size of the lower income class, slightly significant around the 10th quartile after the shock. The effect on the upper-middle class size is similar to the one for the lower-middle class size, an immediate and this time significant decrease

[22] The results display the response of a positive shock; we assume shocks are symmetric and interpret the consequences of a negative shock i.e. expansionary monetary policy.

[23] Note that the impulse response function shows the effect of a positive shock in long-term real interest rates, so that our interpretation is in the opposite direction.

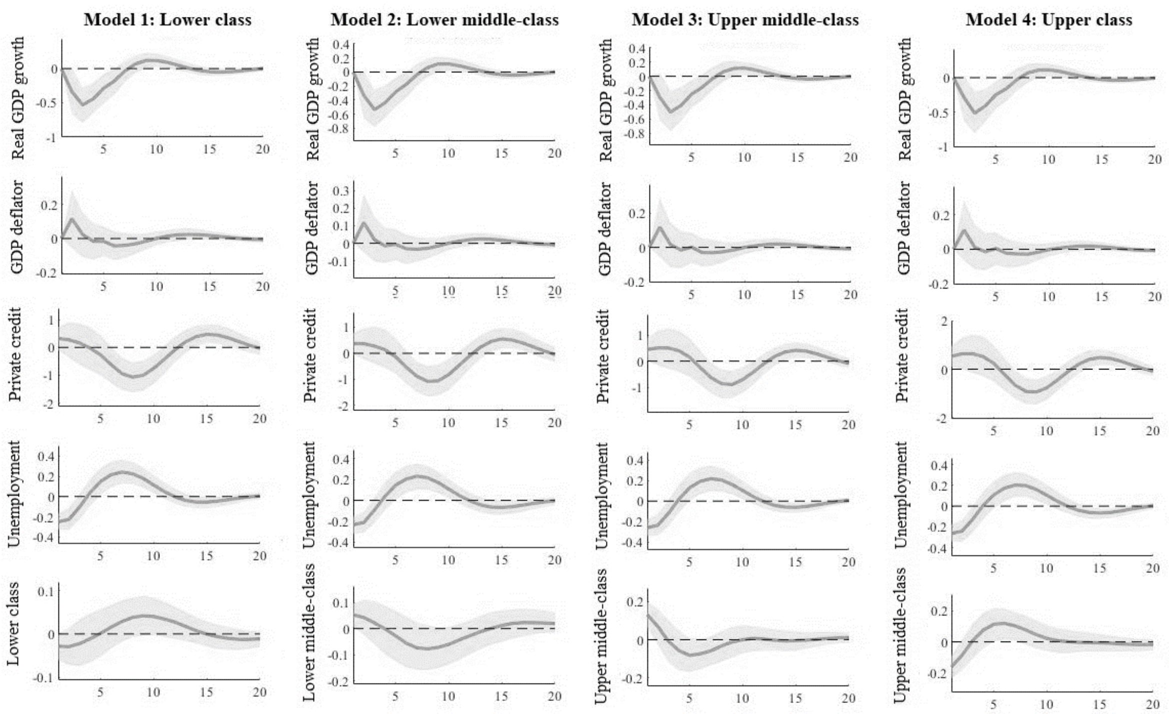
followed by an increase (of shorter duration). Finally, the effect a cut in the short-term nominal interest rates on the upper class leads to an immediate and significant increase in the size for two quarter and then to a more persistent decrease of the size until the 10thquarter.

This reveals that the greater economic activity, mainly through more employment opportunities, has been unevenly distributed among the different income classes, in fact, it has particularly favoured the middle class, both the lower-middle and the upper-middle classes, contributing to a stronger middle class at the same time that reduced that upper and lower income class size and hence contributing to a more equal income distribution. The monetary easing measures have had an effect throughout the income distribution but in relative terms the lower and middle classes have benefited (enlarged) more than the upper class, that has seen its size reduced.

this economic boost perceived by the upper class via the earnings heterogeneity and the income composition channel has been comparatively smaller. These conclusions agree with those of Heathcote et al. (2010), Coibion et al. (2012), Watkins (2014) and Furceri et al.'s (2016).

Notwithstanding the foregoing, a negative impact on the short-term nominal interest rates have a clear and significative impact on the GDP growth rate. Furthermore, our results indicate an expansionary monetary policy slightly increases the private credit and, most notably the employment, all of which not only contribute to a fairer distribution but also are important predictors of higher real GDP growth rates.

Figure 2. Impulse-response functions of one S.D. (positive) shock in the short-term nominal interest rates



5. Conclusions

This study analyses the impact that the monetary policy has had over the income class structure in the countries composing the EMU-11 for the period between 2007Q1 and 2016Q4. Based on income data provided by EU-SILC to compute the sizes of the income classes, our model includes a set of macroeconomic variables related to the earnings heterogeneity channel. Given the length of our panel dataset does not allow for a long-term perspective, therefore we address the impact through a bayesian vector autoregressive analysis (VAR).

The VAR approach shows how a negative shock in the short-term nominal interest rates, because of an expansionary monetary policy, seems to substantially contribute to a decrease in the unemployment rate. Similarly, lower short-term nominal interest rates increase the private credit as well as the inflation. When it comes about the income distribution, a lax monetary policy implying a cut on the short-term nominal interest rates results in broader lower-middle and upper-middle classes, whereas the tails of the distribution, this is, the lower and the upper classes, reduce their sizes.

Our results are broadly in line with the official standpoint of most central bankers, for whom, even though monetary policy is neutral or nearly in the long run, in the short-term monetary easing measures are thought to favour the middle part of the income distribution by stimulating the economic activity and employment.

Further research, therefore, is needed to unpack the pathways through which the effects of loose monetary policy on the bottom of income distribution may become adverse overtime. In any event, it seems clear that, against the widespread view, monetary policy shocks that stimulate economic activity may contribute to an enlargement of the middle class as a result of interactions of the monetary policy transmission mechanisms with diverse non-monetary factors such as socio-demographic characteristics of the labour force, labour market institutions or structural changes related to skill-biased technological progress, which should be taken into account in the future both in academic and policy terms. As theoretically argued by the income composition and the earnings heterogeneity channel, our results confirm the decrease of unemployment caused by the monetary policies implemented by the European Central Bank since the offset of the financial crisis have had a positive effect for those households located at the bottom of the income-class structure, resulting in a less polarized income distribution at least in the short-term.

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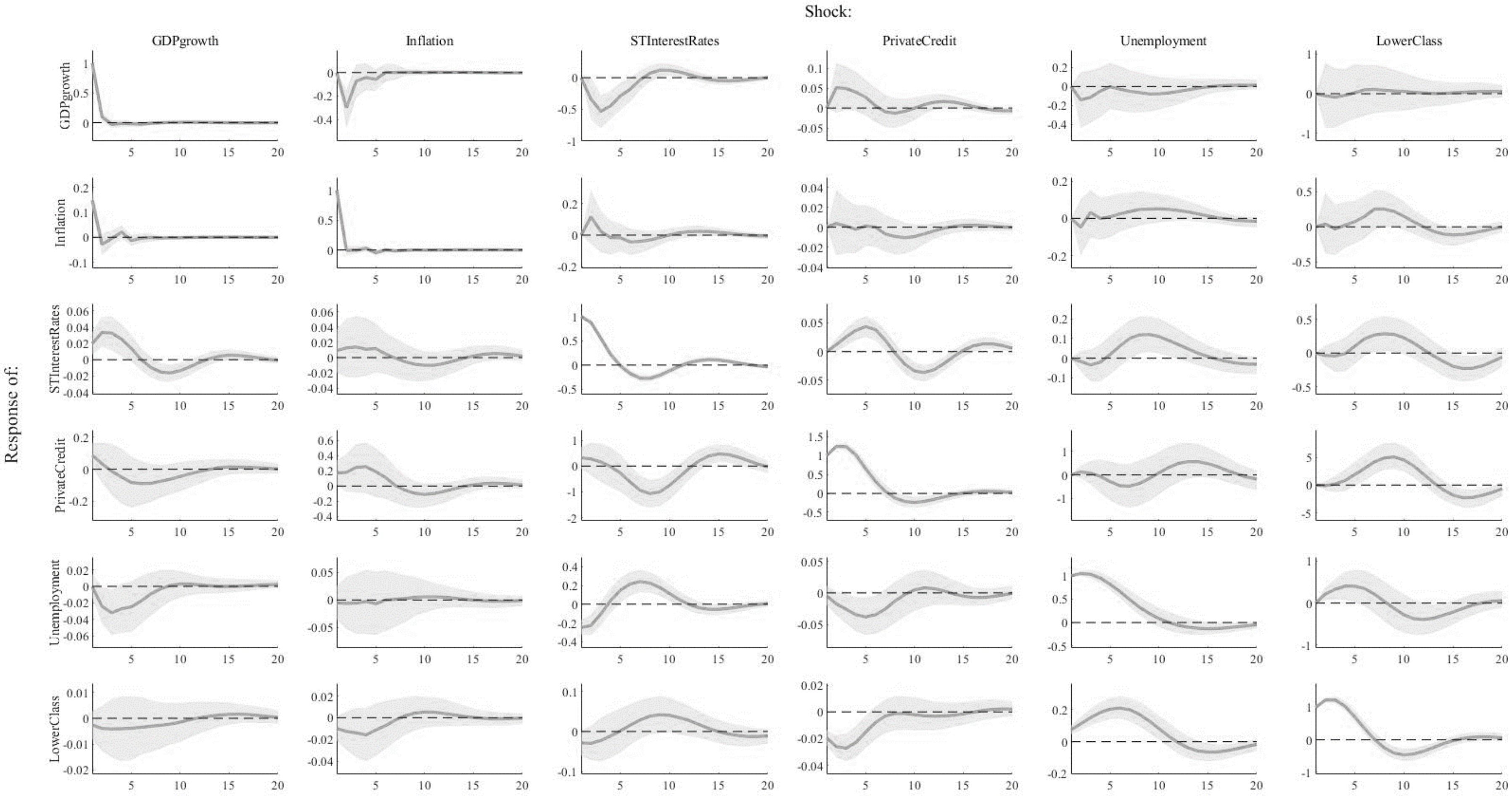
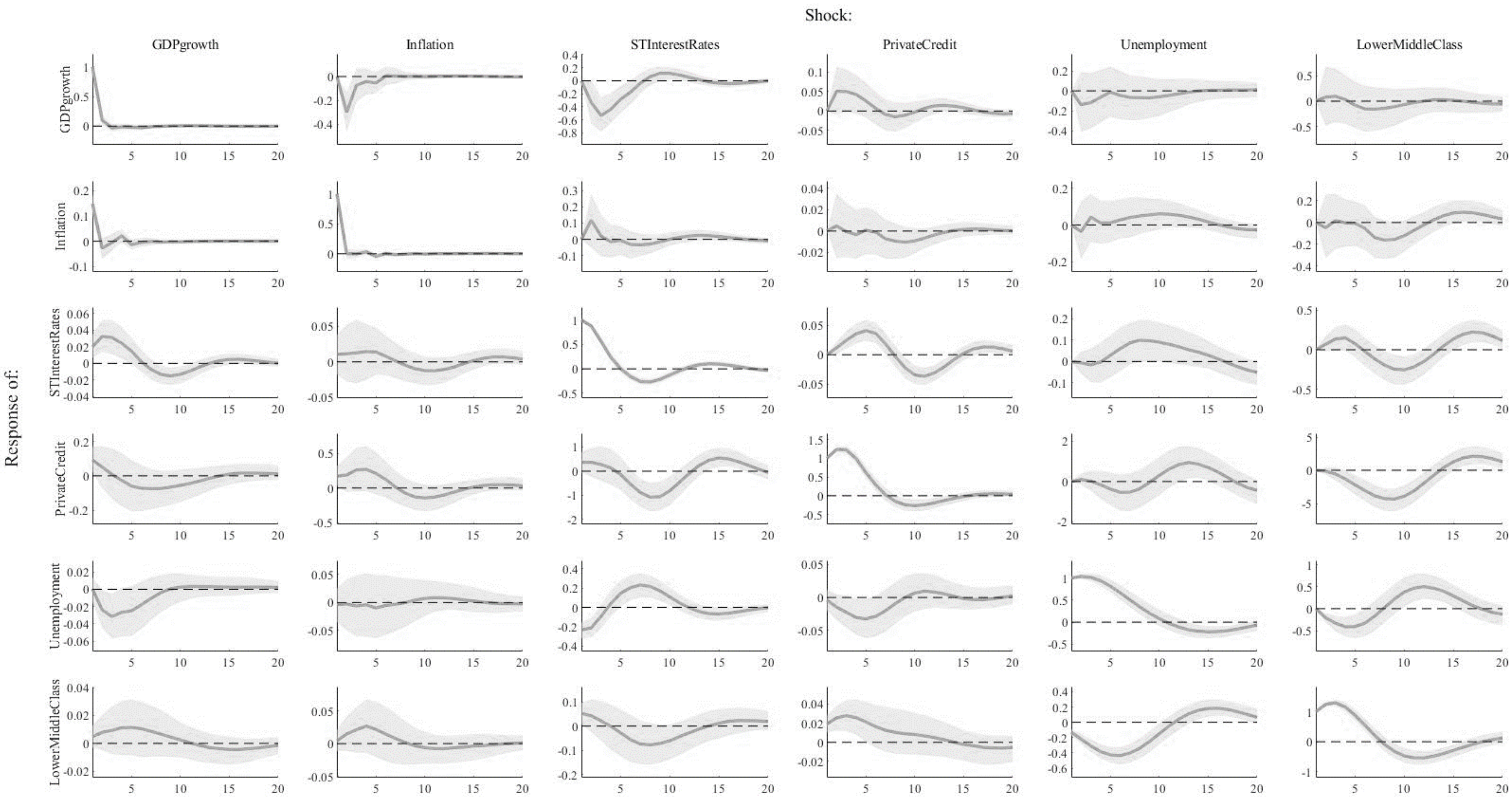
Appendix

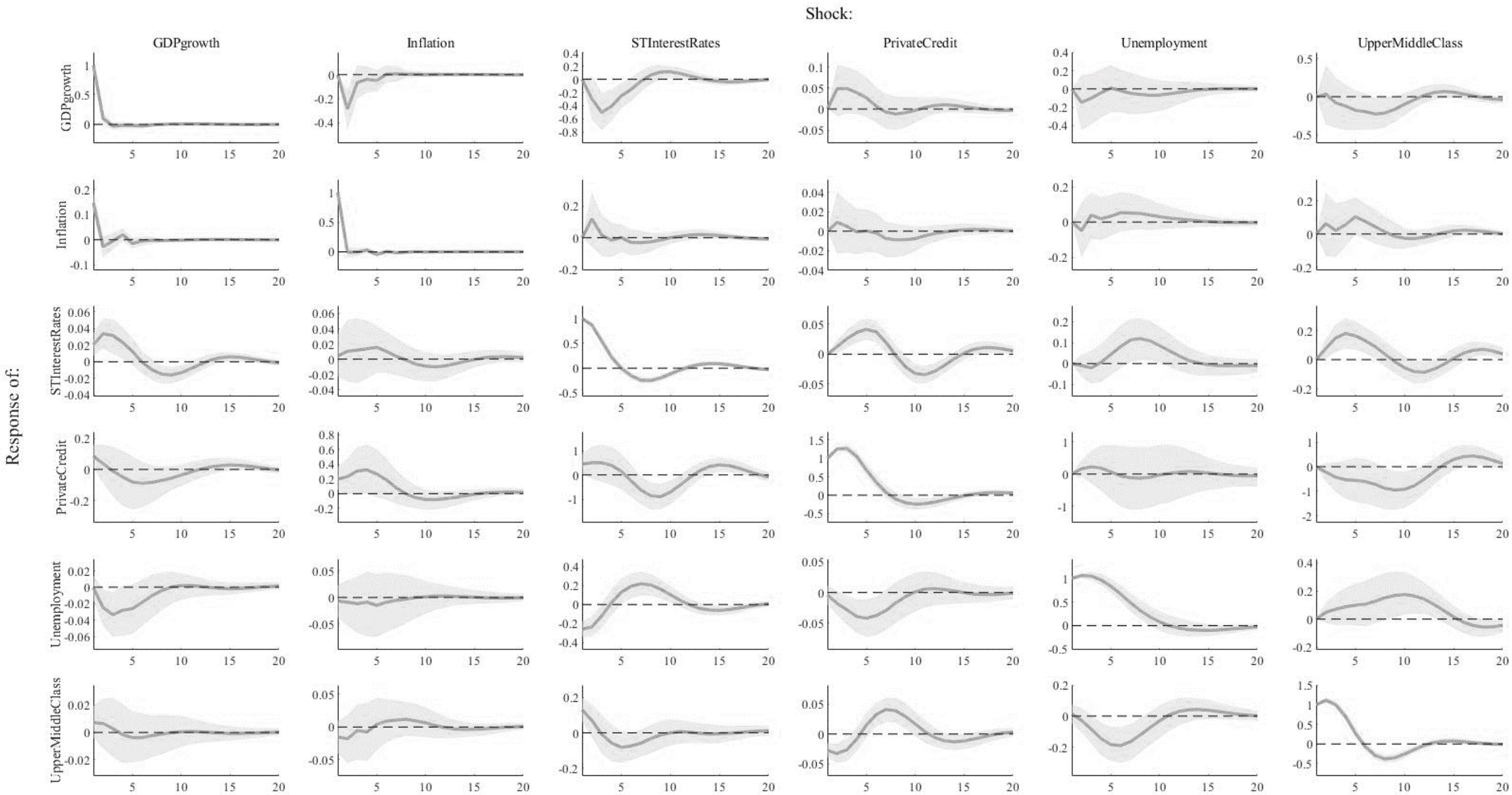
Appendix 1. Impulse-response functions. Model 1: Lower class



Appendix 2. Impulse-response functions. Model 2: Lower-middle class



Appendix 3. Impulse-response functions. Model 3: Upper-middle class



Appendix 4. Impulse-response functions. Model 4 : Upper class