How Does Monetary Policy Affect Income and Wealth Inequality? Evidence from Quantitative Easing in the Euro Area

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Abstract

This paper studies the effects of quantitative easing on income and wealth of individual euro area households. The aggregate effects of quantitative easing are estimated in a multi-country VAR model of the four largest euro area countries, in which key variables affecting household income and wealth are included, such as the unemployment rate, wages, interest rates, house prices and stock prices. The aggregate effects are distributed across the individual households by means of a reduced-form simulation on micro data from the Household Finance and Consumption Survey, capturing the income composition, the portfolio composition and the earnings heterogeneity channels of transmission. We find that the earnings heterogeneity channel plays a key role: quantitative easing compresses the income distribution since many households with lower incomes become employed. In contrast, monetary policy has only negligible effects on wealth inequality.

Keywords Monetary Policy, Household Heterogeneity, Inequality, Income, Wealth, Quantitative Easing, Great Recession

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1 Introduction

The collection of reliable cross-country data over the recent years has allowed researchers to characterize the evolution of wealth and income distributions across countries and time. In particular, Piketty (2013) shows that, contrary to the traditional view based on Kuznets (1955), developed economies do not inevitably evolve toward more egalitarian societies. These facts have sparked an intense debate about the origins and the implications of economic inequality. In general, inequality is seen as related to the development in the structural features of the economies such as, for example, the emergence of skill-biased technological progress, the deepening of globalization and the tendency toward the reduction in the progressivity of tax systems (see, for example Alvaredo et al., 2013; Autor, 2014; Boushey et al., 2017, among others).

Recently, as central banks have undertaken extensive asset purchase programmes to circumvent the lower bound on nominal interest rates, monetary policy has also been put forth as a possible driver of economic inequality.[1] This paper investigates how unconventional monetary policy in the euro area affects the distribution of income and wealth across individual households. The analysis focuses on the effects of the quantitative easing (QE) program of the European Central Bank[2] and proceeds in two steps, relying on both aggregate and household-level data.

First, we estimate the aggregate effects of quantitative easing on a set of relevant financial and macroeconomic variables. Since we aim to capture, on the one hand, a euro area-wide QE shock and, on the other hand, its potentially cross-country heterogeneous transmission mechanism, we estimate a large multi-country VAR model which includes both euro-area and country-specific variables from the four largest euro area countries (France, Germany, Italy and Spain). The euro area variables cover most notably short-term and long-term interest rates, on which our strategy to identify monetary policy shocks partly hinges on. The country-specific variables include, among others, those affecting the components of household income and wealth: the unemployment rate, wages and house prices.

The main identifying assumption for the QE shock is that it generates a negative correlation between the term spread (defined as long-term minus short-term interest rate) and real GDP in the four countries. We normalize the impulse responses to reflect a 30-basis-point drop in the term spread, on impact. Allowing for cross-country heterogeneity in the transmission mechanism turns out to be important, as the impulse responses of unemployment rates and asset prices vary across countries: for example, the unemployment rate in Spain responds considerably more to the QE shock than in Germany.

However, this cross-country heterogeneity is not the only relevant—and probably not the most important—dimension to capture the potential differences in the impact of

[1] See Colciago et al. (2018) for a comprehensive survey of the theoretical and empirical literature on the effects of conventional and unconventional monetary policy on inequality.

[2] The QE program of the European Central Bank is defined as the Asset Purchase Programme (APP). The APP started in January 2015 in order to address the risks of a long period of low inflation. The APP includes various purchase programmes under which private sector securities and public sector securities (including sovereign bonds) are bought. For an early assessment of the APP see Andrade et al. (2016).

QE across euro area households. Indeed, the aggregate effects of QE may result in heterogeneous impacts on individual households also because of substantial differences in the composition of their sources of income (e.g., employment status, labor vs financial income) and their portfolios (holdings of real estate, shares and bonds). Consequently, in our second step, we distribute the aggregate effects estimated in the VAR across the individual households surveyed in the Household Finance and Consumption Survey (HFCS), using the information on their holdings of assets and income composition.

Precisely, our analysis captures the transmission of QE to individual households via three channels: (i) income composition, (ii) portfolio composition and (iii) earnings heterogeneity. The first two channels operate via the heterogenous reaction of various income and wealth components to monetary policy. Figure 1 shows that the share of key income components varies substantially with the level of household income. Households in the lowest income quintile earn only roughly 20 percent of their gross income as employee income, while those in the top quintile about 60 percent. Similarly, the share of financial and rental income increases from 2 percent to almost 10 percent. In contrast, the share of transfers and unemployment benefits declines across income quintiles from almost 20 percent to about 3 percent. Quantitative easing affects the distribution of income via the different responses of various income components, characterizing the income composition channel. Figure 2 documents that the composition of household wealth is similarly varied, giving rise to the portfolio composition channel. For example, the share of self-employment business wealth and stock market wealth (shares) on total assets in the top net wealth quintile is substantially larger, while the share of real estate is lower. The earnings heterogeneity channel, instead, consists of the heterogeneous reaction of the employment status and hours worked to monetary policy.

To empirically capture the two composition channels, we update the components of income and wealth at the household level in the data from the Household Finance and Consumption Survey (HFCS) using the aggregate impulse responses for wages and for house, stock and bond prices. In the baseline setup we assume that household portfolios are not rebalanced in response to the announcement of QE. This assumption is supported by the empirical evidence on considerable inertia in household portfolios, e.g., Ameriks and Zeldes (2004), Fagereng et al. (2018) and others. To capture the earnings heterogeneity channel, instead, we follow Ampudia et al. (2016) and run a reduced-form simulation which redistributes the aggregate decline in unemployment across individuals depending on their demographic characteristics: some unemployed individuals become employed and receive a substantial increase in (labor) income, as they start earning wages rather than unemployment benefits. The simulation ensures that the reduction of the unemployment rate in the household data is consistent with the aggregate drop in unemployment in the VAR impulse responses.

We find that quantitative easing affects differently individual households. For income, the overall effect of quantitative easing is dominated by the earnings heterogeneity channel: transitions from unemployment to employment account for about 75% of the effect on mean income across households. Importantly, the contribution of this extensive margin is particularly pronounced in the lower part of the income distribution. For example, among households in the bottom income quintile, for which the unemployment

rate drops by 2 percentage points and mean income increases by more than 3 percent, the extensive margin accounts for more than 90% of the increase in total income. Hence, QE reduces income inequality via the earnings heterogeneity channel, while the income composition channel works in the opposite direction, increasing more incomes at the top, but is substantially smaller.

Summing the effects of the two channels just described, QE noticeably compresses the income distribution: the Gini coefficient for gross household income declines from 43.1 to 42.9 percent, one year after the shock. To put these results in perspective, notice that the well-known increases in income inequality which occurred in many advanced economies over the last couple of decades amount to roughly 2–3 percentage points (or more) and, hence, the impact of QE is relatively modest in comparison. Also, the effects of QE are likely to fade away over longer horizons, given the likely temporary nature of the effects of monetary policy. Still, our evidence suggests that quantitative easing substantially contributed to support vulnerable households, mainly via the earnings heterogeneity channel. The main robustness checks we undertake for the results pertain to alternative scenarios in which financial income strongly increases due to QE. While the increase in financial income is particularly beneficial for the top tail of the income distribution, its contribution to the changes in total income is limited and it does not significantly change our results on income inequality.

We then investigate how QE changes the wealth distribution via the portfolio composition channel. The policy temporarily increases the value of stocks and self-employment businesses, both mostly held by wealthier households. However, our estimates of the effects on net household wealth are essentially driven by housing wealth, which reflects the fact that the euro area home-ownership rate is 60% and, overall, real assets account for about 70–80 percent of total assets across the wealth distribution. As expected, the effects of quantitative easing on net wealth tend to be stronger for leveraged households, relatively to their wealth level although, by definition, poorer households have a lower level of net wealth and the effects of QE relative to the wealth level do not immediately translate in the effects on inequality. To gauge the latter, once again we compute the change in the Gini index implied by the effects of QE on asset prices and find that inequality in the net wealth distribution declines, but only by a negligible amount. This conclusion remains unaffected also if we allow for some rebalancing of financial portfolios and for more differentiated responses of house prices to QE.

Our work is related to several strands of research on monetary policy and heterogeneity in the transmission mechanisms to countries and households. The large dimension of the model (25 variables) coupled with the relatively short available sample (quarterly frequency spanning the period 1999Q1 to 2016Q4) is handled by using Bayesian estimation methods with informative priors which, as suggested by De Mol et al. (2008) and Bańbura et al. (2010), controls for overfitting while at the same time extracting the valuable information in the sample. The informativeness of the prior distributions is set according to the hierarchical BVAR procedure developed in Giannone et al. (2015). A few papers lend further support to this strategy to model cross-country macroeconomic data, showing that VAR models of the type we adopt in this paper provide accurate out-of-sample forecasts of macroeconomic and financial variables in the euro area (see,

for example, Angelini et al., 2018; Capolongo and Pacella, 2018). A similar framework has been also used to estimate the effects of common euro area monetary policy shocks on various countries by Altavilla et al. (2016) (for both standard monetary policy and outright monetary transactions, OMT) and Mandler et al. (2016) (for standard monetary policy shocks). To appropriately capture the transmission channels of QE to different components of household wealth and income, we add more variables such as house prices to the existing frameworks.

For the identification of the QE shocks, we impose a combination of zero and sign restrictions using the algorithm of Arias et al. (2018), borrowing some elements of the identification scheme in Baumeister and Benati (2013). Less evidence exists about the effects of asset purchase shocks than about the effects of standard monetary policy actions. To provide a term of comparison for our results, existing estimates of the effects of various unconventional monetary policy actions on financial and macroeconomic variables (based on event studies and VAR models) are discussed in the section on empirical results. Although a precise comparison among estimates is impossible because of the differences in the policy actions and the size of the impulses, our calibration of the effects of the QE shock on the term spread (30 basis points) is in the ballpark (at the lower boundary, for the euro area) other studies have estimated. The comparison with alternative estimates also shows that existing studies find similar aggregate effects for the real and nominal variables in our model and, notably, they generally conclude that QE and, in general, asset purchase programs have noticeable effects on the real economy.

For what concerns the literature on monetary policy and inequality, Coibion et al. (2017) use quarterly data from the US Consumer Expenditure Survey (CEX) in a VAR with narrative shocks to estimate the effects of conventional monetary policy on the Gini coefficients for consumption and income, but not for wealth.[3] We find that the response of income inequality to QE in the euro area is qualitatively similar to that of income to standard policy in the US (as estimated by Coibion et al. (2017)). In addition, we provide a decomposition of the effects on income into the extensive and the intensive margins, and we also study the impact of QE on household wealth. Considering the effects on both income and wealth is important for estimation of direct and indirect effects of monetary policy on consumption (see Ampudia et al., 2018).

A few papers follow in the steps of Coibion et al. (2017) for other countries. Mumtaz and Theophilopoulou (2017) provide similar evidence for the UK. Guerello (2018) finds that in the euro area standard expansionary monetary measures typically reduce the dispersion in the income distribution (in the data from the European Commission Consumer Survey). In aggregate panel data from 32 advanced and emerging market countries, Furceri et al. (2018) find that contractionary monetary policy shocks increase income inequality, on average. The effect is asymmetric—tightening of policy raises inequality more than easing lowers it—and depends on the state of the business cycle. Hafemann et al. (2017) estimates the effects of monetary policy on income inequality in

[3] Aladangady (2014) and Aladangady (2017) estimate the effects of monetary policy on house prices and eventually household consumption in the US using a two-step procedure combining a structural VAR with regional data and micro data from the CEX.

US, Canada, South Korea, Sweden, the Czech Republic and Hungary to investigate how the degree of redistribution affects the transmission.

Casiraghi et al. (2018) (on Italian data) and Bunn et al. (2018) (on UK data) focus on unconventional monetary policy. Casiraghi et al. (2018) report that larger benefits from ECB's unconventional monetary policy measures accrue to households at the bottom of the income scale, as the effects via the stimulus to economic activity and employment outweigh those via financial markets. Bunn et al. (2018) find that the overall effect of monetary policy on income and wealth inequality has been rather small. The two papers use elasticities from a large-scale econometric model of the Italian and UK economy, respectively, to assess the aggregate effects of QE, while we estimate them in a VAR for four euro area countries. In addition, our approach to distribute the aggregate impulse responses, which borrows from Ampudia et al. (2016), differs from how the households' responses, in particular the response of income components, are modelled in these papers: Bunn et al. (2018) do not model the transitions from unemployment to employment (the extensive margin) and Casiraghi et al. (2018) do not separate the earnings heterogeneity and the income composition channels.

Finally, using hypothetical scenarios, Adam and Tzamourani (2016) quantify the effects of prices of various assets (stocks, bonds, house prices) on wealth of euro area households. Adam and Tzamourani (2016) also evaluate the impact of standard monetary policy on wealth by exploiting the impulse response of asset prices estimated by Peersman and Smets (2001) on synthetic euro area data for the pre-euro period, 1980–1998. Our VAR below instead estimates country-specific responses on data until 2016, focusing on the effects of quantitative easing.

The remainder of the paper is organized as follows. Section 2 outlines our empirical approach, based on a multi-country VAR model and a simulation on household-level income and wealth data. Section 3 describes and interprets the empirical results and the main robustness checks. Section 4 concludes.

2 Empirical Methodology

We estimate the effects of monetary policy on wealth and income of individual households in two steps: First, we estimate a Bayesian VAR with aggregate data and identify the effects of monetary policy shocks at the aggregate level. Second, we undertake a reduced-form simulation using micro data to distribute the aggregate effects on components of income and wealth across individual households. This section describes both steps in detail.

2.1 The BVAR Model and the Identification of Monetary Policy

We identify the effects of nonstandard monetary policy using a large vector autoregression (VAR) with country-specific variables for four large countries, euro-area-wide

variables and US variables.[4] Such setup allows us to estimate possibly heterogeneous country responses to a common euro-area QE shock. In more detail, to capture the dynamic interrelationships among the variables, we adopt the following (standard) VAR setting:

$$\begin{aligned} y_t &= C + B_1 y_{t-1} + \cdots + B_p y_{t-p} + \epsilon_t, \\ \epsilon_t &\sim \mathcal{N}(0, \Sigma), \end{aligned}$$

where y_t is an N-dimensional vector of time-series, $B_1, \ldots, B_p$ are $N \times N$ matrices of coefficients on the p lags of the variables, C is an N-dimensional vector of constants and Σ is the covariance matrix of the errors. The model is specified in terms of the annualized (log-)levels of the variables and, in our specification, we have $N = 25$ and $p = 5$. In particular, for each of the four countries (France, Germany, Italy and Spain) we include real GDP, the GDP deflator, the unemployment rate, house prices and wages. Then, we have short- and long-term interest rates and stock prices for the euro area. Finally, we include US real GDP and short-term rates. The variables are available at the quarterly frequency, for the sample 1999Q1 to 2016Q4.

The model may potentially be subject to the "curse of dimensionality" due to the large number of parameters to be estimated, relative to the available sample. In such circumstances, the estimation via classical techniques would very likely result in overfitting the data and large estimation uncertainty. De Mol et al. (2008) and Bańbura et al. (2010) showed that imposing informative priors which push the parameter values of the model toward those of naïve representations (as, for example, the random walk model) reduces estimation uncertainty without introducing substantial bias in the estimates, thanks to the tendency for most macroeconomic and financial variables to co-move. In fact, in presence of comovement, the information in the data strongly "conjures" against the prior and it allows the parameters to still reflect sample information even if very tight prior beliefs are enforced.

For this reason, we estimate the model with Bayesian techniques. The prior for the covariance matrix of the residuals Σ is Inverse-Wishart, while the prior for the autoregressive coefficients is (conditional on Σ) normal. As it is standard in the BVAR literature, we follow Litterman (1979) and parameterize the prior distribution to shrink the parameters toward those of the naïve and parsimonious random walk with drift model, $X_{i,t} = \delta_i + X_{i,t-1} + e_{i,t}$. Moreover, in order to address the tendency of VARs to overfit the data via their deterministic component (see Sims, 1996, 2000; Giannone et al., 2018, for an extensive discussion of this pathology of VARs), we also impose two priors on the sum of the VAR coefficients. The full specification and the estimation method used for the VAR model follows Giannone et al. (2015). The setting of the prior distributions depends on the hyperparameters which describe their informativeness for the model coefficients. For these parameters, we follow the theoretically grounded approach proposed by Giannone et al. (2015), which suggests to treat them as random, in the spirit of hierarchical modelling, and conduct posterior inference also on them. As

[4] See Appendix A for more details on the macroeconomic database, our estimation strategy and the identifying assumptions for the monetary policy shocks.

hyper-priors (i.e., prior distributions for the hyperparameters), we use proper but almost flat distributions.

To estimate the effects of quantitative easing, we identify an exogenous asset purchase shock similarly to Baumeister and Benati (2013). In addition, we offset the response of the euro area policy interest rate via a series of standard monetary policy shocks. This scenario captures the fact that standard monetary did not react, over the course of the recent crises, to offset the effects of the asset purchases—instead, the policy rate remained at the (zero) lower bound. We identify the effects of asset purchases using a combination of zero and sign restrictions (employing the algorithm of Arias et al., 2018). The main identifying assumption is that an expansionary asset purchase shock decreases the term spread (defined as long-term minus short-term interest rate)[5] and has a positive impact on the real economy of the four countries under analysis. The decrease in the term spread on impact is entirely accounted for by the drop in the long-term interest rates, given that standard monetary policy (captured by the short-term interest rates) is assumed not to react on impact to the asset purchases. For what concerns the macroeconomic environment, we impose a positive sign on the responses of GDP. The responses of all other variables, i.e., the GDP deflator, the unemployment rate, wages and house prices in the four countries, the US variables and stock prices, are left unrestricted. Notice that all the identifying assumptions are only imposed on impact, i.e., for the same quarter in which the shock materializes. The standard monetary policy shock is identified via standard zero restrictions. In particular, we assume that a change in the short-term interest rate can only affect, on impact, the long-term interest rate and the stock prices.

2.2 The Reduced-Form Simulation on Household-Level Wealth and Income Data

Table 1 provides a general overview of the methodology we adopt to distribute the aggregate effects estimated in the BVAR across individual households.

For what concerns the data, we use the second wave of the Household Finance and Consumption Survey (HFCS). The HFCS is a unique ex ante comparable household-level dataset, which contains rich information on the structure of income and household balance sheets and their variation across individual households. The dataset also collects information about socio-demographic variables, assets, liabilities, income and indicators of consumption. For most countries, the reference year of the HFCS wave 2 is 2014, which matches quite well the start of the Asset Purchase Programmes.

We focus on the four largest euro area countries, in which the HFCS (net) sample ranges roughly between 4,500 households (Germany) and 12,000 households (France).[6] For Spain the reference year is 2011, for the other three countries 2014. To adequately

[5] The short-term rate is the 3-month Euribor; the long-term rate is the euro area 10-year government benchmark bond yield.

[6] See Household Finance and Consumption Network (2016), in particular Table 1.1, for information on the second wave of the HFCS.

capture the top tail of the distribution, wealthy households are over-sampled in most countries (including Spain, France and Germany).

2.2.1 Estimating the Effects of QE on Household Wealth: Portfolio Composition Channel

To simulate the effects of quantitative easing on wealth, i.e., to capture the portfolio composition channel, we use the detailed *quantitative* information about holdings of various asset classes by each household in the HFCS (i.e., we know the nominal market value of each asset class owned by households). The effects of monetary policy on household wealth are obtained by multiplying the holding of each asset class (in EUR) by the corresponding change in asset prices given by the VAR impulse response.

In particular, our VAR includes three asset price variables: house prices, stock prices and bond prices. We multiply the holdings of housing wealth—i.e., household's main residence and other real estate—by house prices. We multiply the holdings of shares and household's self-employment businesses by stock prices.[7] Finally, we multiply the holdings of bonds by the change in the price of the 10-year bond implied by the initial decline in the long-term rate.

This calculation assumes that households do not adjust their portfolios in response to monetary policy. This assumption of no rebalancing seems a reasonable first-order approximation for two reasons. First, we consider responses to relatively *small* monetary policy shock over the short-run horizon of several quarters. Second, substantial evidence exists on the sluggishness in household portfolios. This holds not only for very illiquid assets (such as housing) but also for many financial assets. For example, a well-known paper by Ameriks and Zeldes (2004) documents that almost half of the households in their data on retirement accounts (held by TIAA-CREF) made no active changes to their portfolio of stock over the *nine-year* period they consider. Similar findings are reported in Bilias et al. (2010): The bulk of US households exhibits considerable inertia in their stock portfolios (held in brokerage accounts).[8] Fagereng et al. (2018) document evidence on the limited extent of rebalancing of illiquid and risky assets in response to receiving a lottery prize in Norwegian data. In section 3.2.3 below, we also investigate how robust the results are to assuming some rebalancing in holdings of stocks and bonds.

[7] As described in Table 1, we assume other classes of net wealth, most importantly deposits and liabilities remain unaffected by monetary policy. For the time period we focus on—since 2014—this seems reasonable as the short-run interest rate was at the zero lower bound. The HFCS also records holdings of voluntary pensions, for which we in the baseline scenario assume they are unaffected by stock prices. Data on Euro area insurance corporation and pension fund statistics, `https://www.ecb.europa.eu/press/pr/stats/icpf/html/index.en.html`, indicate that pension funds hold a small fraction of their assets in stocks, i.e., about 9% of total assets is held in equities (2016Q4). Notice however that 21.5% is held in investment funds, for which it is difficult to determine what fraction of their assets they hold in stocks.

[8] Although Bilias et al. (2010) also finds that many households with brokerage accounts exhibit a high incidence and frequency of trading, even these households hold a small share of their financial assets in those accounts. This fact suggests that trading in stocks should have limited effects on total net wealth of almost all households.

2.2.2 Estimating the Effects of QE on Household Income: Income Composition and Earnings Heterogeneity Channels

Similar to wealth, also for income we back out impulse responses of its components at household level. Figure 1 shows that the key income component for most households is income from employment and self-employment. We use impulse responses of wages to assess how these income components are affected by QE. For income from rental of properties, financial investments and pensions, instead, we assume that there is no change due to QE (Table 1). This is our baseline characterization of the income composition channel which, in subsequent discussion we will also refer to as the intensive margin of QE. As for the portfolio composition channel, in section 3.2.3 we provide a robustness analysis to gauge the relevance of the no-change assumption for some categories of income.

The earnings heterogeneity channel is instead related to the effect of monetary policy on employment. We model this extensive margin as follows. The impulse responses estimated in the VAR model imply that quantitative easing reduces aggregate unemployment rate. Household-level data on employment and income make it possible to simulate which unemployed people become employed and by how much their incomes increase. The simulation proceeds in two steps. First, we distribute the aggregate decline in unemployment across individuals, using a probit regression which takes into account their characteristics. This means some people become newly employed. Second, these newly employed individuals receive a (substantially) higher income, as they switch from receiving unemployment benefits to wages (with the latter estimated by the Heckman model). The simulation, which broadly follows the setup of Ampudia et al. (2016), is run at the individual level (not at the household level); the results are then aggregated to household level.

Step 1: Probit Simulation for the Employment Status

For each country c, we first estimate a probit model regressing individual's i employment status Y on demographic characteristics:

$$\Pr(Y_i = 1 | X_i = x_i) = \Phi(x_i' \beta_c), \tag{1}$$

where X denotes demographics: gender, education, age, marital status and the number of children; $\Phi(\cdot)$ denotes the normal cdf. For each individual we denote the fitted values, the estimated probability of being employed, as $\hat{Y}_{c,i}$ and we use it to simulate who becomes employed thanks to QE. This is done by drawing, for each person i, a uniformly distributed random 'employment' shock ξ_i. If the value of ξ_i is sufficiently below $\hat{Y}_{c,i}$ and the person is actually unemployed, she becomes employed. The threshold for moving into employment is computed to have a number of individuals becoming employed that is consistent with the VAR impulse response of the aggregate unemployment rate in each country.[9] We repeat the simulation many times and report the average results

[9] In practice, we sort unemployed individuals by their value of $(\xi_i - \hat{Y}_{c,i})$ and those with the lowest rank become employed until the reduction in the unemployment rate matches the value given by the impulse response. We use survey weights in this calculation.

across repetitions.[10]

Step 2: Heckman Imputation of Labor Income
In the second step we replace unemployment benefits of people who are newly employed with wage, which is estimated based on their demographic characteristics. Technically, the wage of newly employed individuals is estimated by a two-step Heckman selection model. Our exclusion restrictions are the marital status and the presence of children. We assume these factors may affect the work status but not the wage of the employed. The remaining regressors in the model are gender, education and age.

3 Empirical Results

This section describes our estimates, first focusing on the effects of monetary policy on aggregate variables identified using the VAR model, then considering the effects on wealth and income of individual households via three channels we described in the previous section: (i) income composition, (ii) portfolio composition and (iii) earnings heterogeneity.[11]

3.1 Aggregate Effects of Quantitative Easing

We scale the size of the shock to a 30-basis-point drop in the term spread. This normalization roughly matches the lower boundary of the estimated QE impacts on the term spread in existing studies on the euro area (see Table 2). This normalization is imposed to offer a plausible quantification of the effects of QE on inequality.

Figure C.1 in Appendix C at the end of the paper reports all the impulse responses to the QE shock and the median response to the QE scenario in which the reaction of standard monetary policy to the QE shock is offset by standard monetary policy shocks. To put our results in perspective, Tables 2 and 3 give a quantitative summary of the existing evidence on the effects on nonstandard monetary policy on asset prices and the real economy. Our results are qualitatively in line with the previous literature, which finds relevant effects of asset purchases on the real economy. We also find that QE boosts the GDP defator, wages and asset prices, although generally these results are surrounded by a larger uncertainty. To gauge the relevance of the effects of QE, notice that our quantitative easing shock (an exogenous drop by 30 basis points in the term spread) has roughly the same effect on GDP as a 100-basis-point surprise drop in the policy rate.[12]

Figure 3 zooms on the median impulse responses of the variables that play an important role in our subsequent analysis on individual households. The term-spread shock

[10] The empirical results in the paper are based on 200 iterations.

[11] We do not consider other channels of transmission, such as the interest rate exposure channel of Auclert (2017) and the inflation channel of Doepke and Schneider (2006). The former is analyzed quantitatively in Ampudia et al. (2018), while the latter turns out to have a negligible effect on inequality.

[12] Debortoli et al. (2018) estimate that standard monetary policy and quantitative easing work as perfect substitutes (in the US).

has a relatively short-lived impact on the term spread[13] itself, whose median response is close to zero already after three quarters. The peak response of stock prices is quite large—4 %—but also quite transitory.

The country-specific impulse responses in Figure 3 document the extent of heterogeneity across the four countries. House prices increase in all countries; for example, in Spain the increase is close to two percent, while in Germany it is about a third of that size. It is plausible that these differences in impulse responses arise due to different institutional settings. For example, as also estimated by Calza et al. (2013), house price responsiveness to monetary policy is significantly stronger in countries with larger flexibility/development of mortgage markets (e.g., in terms of the size of mortgage debt, extent of adjustable-rate mortgages or availability of equity release products; see also related work of Nocera and Roma (2018)). Similarly, the reactions in the labor markets also show a marked heterogeneity across countries. The unemployment rates drop in all countries but, again, the response in Spain is about three times as large as in Germany, with Italy and France in between these two extremes. The response of wages, instead, also varies in sign, with a slight decrease in Spain and increases in other countries.

3.2 Effects of Quantitative Easing on Individual Households

We report the estimates of the effects on income and wealth of individual households using a series of figures with 'micro' impulse responses implied by the micro-simulation described in section 2.2. The impulse responses are grouped in terms of quintiles of the income and wealth distributions.

3.2.1 Effects on Household Income—The Earnings Heterogeneity and the Income Composition Channels

In the baseline setup, the effects of QE on income arise via two channels: (i) the earnings heterogeneity—the increase in income as people become employed (also defined as the extensive margin) and (ii) the income composition channel—the increase in labor income (for all employed people) due to higher wages (also defined as the intensive margin).

Let us first investigate the earnings heterogeneity channel in isolation. Figure 4 shows the impulse responses of the unemployment rate by (country-level) income quintiles. The first noteworthy result is that the stimulative effects on employment are strongly skewed toward low-income households. This finding is not straightforward because there are two countervailing factors that can affect the response of unemployment across income quintiles. On the one hand, higher income individuals have generally more favourable demographics (for example, an higher level of education) and, hence, also

[13] Notice that the long-term interest rate coincides with the term spread—given that the short-term interest rate is assumed not to change on impact to the QE shock, and that its response is zeroed out over the rest of the horizon by means of standard monetary policy shocks.

an higher estimated probability to become employed.[14] On the other hand, and this is the key factor to explain the result, the bottom right panel of Figure 4 shows that the number of unemployed is heavily skewed toward the bottom income quintile across all four countries.

Figure 4 also shows a relevant heterogeneity in the micro impulse responses across countries, both regarding the level and the dispersion of responses across income quintiles. One factor to explain the differences, in particular for the levels, is the cross-country difference in macro responses. For example, the overall reduction in unemployment is larger in Spain than in the other three countries. The dispersion of micro impulse responses across income quintiles is instead importantly affected by the distribution of the unemployed across quintiles which is very different across countries. Indeed, a substantial mass of unemployed people in Spain has income in higher quintiles, so that the differences in impulse responses across quintiles in Spain are smaller (see, again, the bottom right panel in Figure 4). In contrast, the number of the unemployed in Germany and Italy is more strongly skewed toward the lowest income quintile, which causes unemployment in the lowest income quintile to drop more (relative to other quintiles) in these two countries. A final, although less relevant factor, that can explain the differences in the dispersion of micro responses is that the employment probabilities in the the probit models (1) are country-specific.

Figure 5 shows the micro responses of mean income by income quintile, due to both the earnings heterogeneity and the income composition channels. These responses are primarily driven by the transitions into employment and by differences in replacement rates (as estimated by the Heckman model). The replacement rates are in general more generous in Germany and France than in Spain and, in particular, Italy.[15] As a result, the magnitude and dispersion of income responses in Italy and Spain is larger. For example, the large positive response in mean income of the lowest quintile in Italy arises thanks to both the substantial decline in unemployment rate highlighted in Figure 4 and the substantial increase in (labor) income of the newly employed individuals.[16] These findings imply that the earnings heterogeneity channel is the most relevant to explain the changes in income across quintiles. To more precisely show this point, Figure 6 decomposes the overall increase in mean income into the extensive (earnings heterogeneity) and the intensive margins (income composition) for an aggregate of the four countries, one year after the shock. The extensive margin is particularly strong in the bottom income quintile, where wage growth plays a very small role. However, transitions from unemployment to employment make up the bulk of the total effect on income across much of the whole distribution (except for the top income quintile).

To summarize the effects of quantitative easing on income inequality, Table 4 shows

[14] In order to appreciate the quantitative relevance of this heterogeneity in probabilities to become employed, a counterfactual scenario where all individuals have the same probability to be drawn out of unemployment implies a significantly stronger stimulating effects on the lower income quintiles compared to our scenario based on estimated probabilities—as documented in Figure C.2 in Appendix C. Obviously, although significant, this impact does not outweigh the countervailing effect due to over-representation of unemployed people in the lower income quintiles.

[15] See, e.g., data from the OECD: `http://www.oecd.org/els/benefits-and-wages-statistics.htm`.

[16] The results are shown for gross (pre-tax) income. The increase in after-tax income would be somewhat lower, however, not by much, as most newly employed people are not subject to large taxes. As for the effect on inequality of net income, it would be reduced more than inequality of gross income because of progressivity of taxes.

that the Gini coefficient for gross household income declined from 43.07 to 42.86 when we isolate the effects of QE, one year after the shock.

3.2.2 Effects on Household Wealth—The Portfolio Composition Channel

This section analyses how the portfolio composition channel affects household net wealth. Figure 7 shows the micro responses of median net wealth by wealth quintile.[17] These responses arise from a combination of the response of house prices, stock prices and bond prices, and holdings of wealth across the distribution (and countries). Broadly, the responses of wealth in quintiles 2–5 increase by around 1.5% in France, Spain and Italy, and are rather flat in Germany. There is little evidence that the median wealth among the top wealth quintile households would increase more strongly, though this does happen above percentile 90, where the holdings of stocks are prevalent (though only within 4 quarters after the APP shock). Overall, Table 4 documents that the Gini coefficient on net wealth was only modestly affected by QE. An important takeaway from this exercise is the key role of including house prices in the analysis, since most households own large holdings of housing wealth in contrast to stocks and bonds, which are very disproportionately in the top tail of the distribution.[18]

3.2.3 Robustness Checks

This section explores whether some plausible perturbations of our baseline specification affect the main results. For these robustness checks, we rely on alternative macroeconomic data sources as, for example, the data on the flow-of-funds of the four countries under analysis. In order to derive the effects of the QE scenario on these variables, we employ the local linear projection method of Jordà (2005).[19]

Focusing first on income, a possible concern could be that the baseline analysis of the income composition channel underestimates how quantitative easing stimulates income in the top tail via its effects on financial income. If quantitative easing increases financial income,[20] e.g., via stimulating corporate profits, this effect may to some extent work counter to the employment effect and widen income inequality.[21] To address this concern, we use the local linear projection method to investigate how two alternative (aggregate) measures of financial income respond to quantitative easing: (i) profits (available for the euro area) and (ii) net property income (available for the four country under analysis). As for profits, Figure C.3 in Appendix C shows that they increase by roughly up to about 5% (despite substantial estimation uncertainty), one year after the shock. For

[17] The growth rate for the lowest quintile is not shown because its level is close to EUR 0.

[18] This finding is in line with Adam and Tzamourani (2016); see, e.g., their Figure 4. See also Kuhn et al. (2017), Figure 17 for historical evidence from the US.

[19] See Appendix B for more information on the alternative data sources we use in the robustness checks and for the description of the local linear projection method.

[20] Financial income includes income in the form of interest or dividends on sight deposits, time and saving deposits, certificates of deposit, managed accounts, bonds, publicly traded stock shares or mutual funds. More broadly, we also include income from renting real estate and income from private business other than self-employment.

[21] Existing evidence, e.g., Guvenen et al. (2014), points to slight, rather than strong, pro-cyclicality in the unconditional dynamics of earnings and financial income among top earners.

net property income, Figure C.4 shows a relevant heterogeneity across country, one year after the shock, with the smallest increase in Germany (about 4%) and the largest in Italy (about 20%). Figure 8 considers the implications for the income distribution: (i) assuming that financial income behaves similarly to profits (i.e., also increasing by 5 % in all countries), top panel; (ii) assuming that financial income responds as estimated by linear projections for aggregate data on net property income, bottom panel. As expected, the scenarios do increase income in particular among the top income quintile of households. However, the overall impact on total income is quite limited and, as shown in Table 4, the Gini coefficients for the two scenarios only marginally change with respect to our baseline assessment.

Turning to wealth inequality, first we relax our assumption of no portfolio rebalancing. To get an idea of a plausible amount of rebalancing, we rely on country-level flow-of-funds data on the holdings of different asset categories by households. As a caveat to this analysis, notice that the data refer to the value of holdings and, hence, they also reflect asset valuations which, as we have seen, are affected by QE. This could be a source of mis-measurement for the impact of QE on the volume of asset holdings and, hence, these results should be only taken as suggestive. As for the analysis on income, we estimate how quantitative easing affects holdings of wealth components by using local linear projections, and we find that QE affects mostly the value of stock holdings. In fact, despite substantial estimation uncertainty, Figure C.5 in Appendix C suggests quite large increases (in the median responses) in the holdings of shares. Figure 9 takes these estimates to micro data, showing a scenario in which households buy 15% of their holdings of stocks in response to quantitative easing. However, we find that stock trading affects the distribution of net wealth only very little: in particular, Table 4 documents that the Gini coefficient on wealth under this alternative scenario falls to 68.08 one year after the shocks rather than to the value of 68.04 which we had found in our baseline scenario. This is explained by the fact that the share of stocks in the portfolios of European households lies below 5%.

Another important aspect that our baseline scenario could be disregarding, considering the relevance of housing for the wealth distribution in Europe, is the potential heterogeneity in the responses of house prices across regions (arising, e.g., due to differences in elasticity of housing supply). To investigate the relevance of such scenario, Figure C.6 shows the dispersion in responses of house prices across provinces in Spain,[22] confirming some, though not overwhelming heterogeneity: a 68% confidence range around the aggregate response after 4 quarters spans between increases between 0 and 6% in local house prices. Interestingly, Figure C.7 documents that the percentage increase in house prices tends to be larger in provinces with higher levels of house prices (measured in EUR per square meter), so that more expensive houses respond more strongly to monetary policy. To assess how this heterogeneity in responses of house prices to monetary policy affects our baseline results on the portfolio composition channel, we undertake the following simulation. The HFCS dataset collects information both on the price and on the area of the household main residence (in square meters). Within each of the 4

[22]Spain is the only country in our sample for which quarterly data on regional house prices are available since 1999.

countries, we sort households into 5 quintiles by the price per square meter. In line with the scatter plot in Figure C.7, we then assume that quantitative easing increases the prices of more expensive houses (in terms of the price per square meter) more strongly.[23] Figure 10 quantifies how our baseline compares to the simulation in which the increase in house prices depends on the level of house prices. Because poorer households tend to own less expensive houses, the alternative assumption reduces the differences in changes in wealth across quintiles: For the lowest net wealth quintile, median wealth grows by 1.8% (compared to 2.4% for the baseline)—still quite a bit above the change for the other quintiles (which remains around 1%). Table 4 shows that under this scenario the Gini coefficient on net wealth remains essentially unchanged at 68.09 and, hence, our conclusion about the negligible effect of quantitative easing on wealth inequality remains unaffected.

4 Conclusions

We quantify how the recent quantitative easing measures in the euro area affect income and wealth of individual households via the income composition, the portfolio composition and the earnings heterogeneity channels. Using a combination of a four-country VAR with aggregate data and a simulation on household-level data from the Household Finance and Consumption Survey, we find that nonstandard monetary policy has only negligible effects on wealth inequality. In contrast, monetary policy compresses the income distribution since many households with lower incomes become employed. Specifically, a year after the shock the Gini coefficient for income falls from 43.1 to 42.9, while the reduction of the Gini coefficient for net wealth is an order of magnitude smaller.

These changes are relatively small in comparison with the well-known (unconditional) increases in income inequality, which occurred in many advanced countries over the last couple of decades and amounted roughly to 2–3 percentage points (or more). However, while monetary policy is not a key driver of inequality in the long run (for which other factors, such as globalization or progressivity of the tax system are more important), also due to the likely temporary nature of its effects, quantitative easing substantially contributed to support vulnerable households.

Our results are informative about the strength and nature of the transmission of monetary policy to consumption. An extensive literature has recently documented that constrained households—e.g., those with low incomes or little liquid assets—have high marginal propensities to consume. We find such households also particularly benefit from a monetary stimulus, which boosts their employment and income. In combination, these two facts imply that the stimulating effect of quantitative easing on aggregate consumption is substantially magnified both because it mostly boosts incomes

[23] Specifically, we calibrate that across the quintiles, the responses of the price of the household main residence and its other real estate after 4 quarters range between 0–4% for Spain, between 0–3% for France and Italy and between 0–1% for Germany. This calibration thus preserves the aggregate response of house prices to quantitative easing estimated in the VAR, upper right-hand panel in Figure 3, and adds to it a positive relationship between the level of house prices and their sensitivity to monetary policy.

in the lower part of the distribution and because this impulse has a stronger effect on consumption via the larger MPC of the constrained households.[24]

[24]See Ampudia et al. (2018) for quantitative results about the channels of monetary transmission to consumption and their heterogeneity across households.

Appendix A: Macroeconomic Database, Prior Distribution and Identification Assumptions

Table 5 describes our aggregate time series and sign restrictions we use to identify the effects of quantitative easing in our VAR.

The prior distributions in our Bayesian VAR are specified in the following way. For the prior on the covariance matrix of the errors, we set the degrees of freedom of the Inverse-Wishart distribution equal to $N+2$, the minimum value that guarantees the existence of the prior mean, and we assume a diagonal scaling matrix Ψ. We treat Ψ as a hyperparameter.

The baseline prior on the model coefficients is a version of the so-called Minnesota prior (see Litterman (1979)). This prior is centered on the assumption that each variable follows an independent random walk process, possibly with drift. The prior first and second moments for the VAR coefficients are as follows:

$$\begin{aligned}
\mathbf{E}\big((B_s)_{ij}|\Sigma\big) &= \begin{cases} 1 & \text{if } i=j \text{ and } s=1 \\ 0 & \text{otherwise} \end{cases}, \\
\operatorname{cov}\big((B_s)_{ij},(B_r)_{hm}|\Sigma\big) &= \begin{cases} \lambda^2 \frac{1}{s^2} \frac{\Sigma_{ih}}{\psi_j/(d-n-1)} & \text{if } m=j \text{ and } r=s \\ 0 & \text{otherwise} \end{cases}.
\end{aligned}$$

Notice that the variance of this prior is lower for the coefficients associated with more distant lags, and that coefficients associated with the same variable and lag in different equations are allowed to be correlated. Finally, the key hyperparameter is λ—which controls the scale of all variances and covariances, and effectively determines the overall tightness of this prior. The terms Σ_{ih}/Ψ_j account for the relative scale of the variables. The prior for the intercept C is non-informative.

The Minnesota prior is complemented with two priors on the sum of the VAR coefficients, introduced as refinements of the Minnesota prior to further "favor unit roots and cointegration, which fits the beliefs reflected in the practices of many applied macroeconomists" (see Sims and Zha (1998), p. 958). These additional priors tend to reduce the importance of the deterministic component implied by VARs estimated conditioning on the initial observations (see Sims (1996) and Giannone et al. (2015)). The first of these two priors is known as no-cointegration (or, simply, sum-of-coefficients) prior. To understand what this prior entails, we rewrite the VAR equation in an error correction form:

$$\Delta y_t = C + (B_1 + \cdots + B_p - I_N) y_{t-p} + A_1 \Delta y_{t-1} + \cdots + A_p \Delta y_{t-p} + \epsilon_t,$$

where $A_s = -B_{s+1} - \cdots - B_p$.

A VAR in first differences implies the restriction $\Pi = (B_1 + \cdots + B_p - I_N) = 0$. Doan et al. (1984) introduced the no-cointegration prior which centered at 1 the sum of coefficients on own lags for each variable, and at 0 for the sum of coefficients on other variables' lags. This prior also introduces correlation among the coefficients on each variable in each equation. The tightness of this additional prior is controlled by the

hyperparameter μ. As μ goes to infinity the prior becomes diffuse, while as it goes to 0, it implies the presence of a unit root in each equation.

The fact that, in the limit, the prior just discussed is not consistent with cointegration motivates the use of an additional prior on the sum of coefficients that was introduced by Sims (1996) and is known as dummy-initial-observation prior. This prior states that a no-change forecast for all variables is a good forecast at the beginning of the sample. The hyperparameter δ controls the tightness of this prior. As δ tends to 0, the prior becomes more dogmatic and all the variables of the VAR are forced to be at their unconditional mean, or the system is characterized by the presence of an unspecified number of unit roots without drift. As such, the dummy-initial observation prior is consistent with cointegration.

The setting of the prior distributions depends on the hyperparameters λ, μ, δ and Ψ, which describe the informativeness of the prior distributions for the model coefficients. In setting these parameters, we follow the theoretically grounded approach proposed by Giannone et al. (2015), who suggest to treat the hyperparameters as additional parameters, in the spirit of hierarchical modelling. As hyper-priors (i.e., prior distributions for the hyperparameters), we use proper but almost flat distributions.

Appendix B: Additional Macroeconomic Data and Local Linear Projection

In our robustness exercises, we exploit some additional data source, available at the quarterly frequency in the sample 1999Q1–2016Q4. First, we look at quarterly data on profits for the euro area. Precisely, this variable captures gross operating surplus (total economy, nominal, seasonally adjusted data) and is available from the Main National Accounts collection in the ECB Statistical Data Warehouse (SDW). The data on net property income and stock holdings of the four countries under analysis come from the euro area sectoral accounts. Finally, the data on regional house prices in Spain are available from the website of the Spanish government, Ministerio de Fomento.[25]

As for the estimation technique, our robustness exercises adopt the local linear projection to derive the response of various variables to the shocks we estimate in the VAR. In the following, we briefly describe our application of the method developed in Jordà (2005). Assume that X_t is a variable from the additional database. We transform the variables as for the VAR, i.e., we compute annualized log-levels unless the variables is already expressed in terms of rates. Define as x_t the transformed variable.

Denoting u_t the time-series of the QE structural shock derived from our multi-country VAR, we evaluate the impulse response β^h of x_t to such shock at a horizon h by regressing x_{t+h} on the shock and the lags of x_t, i.e., we estimate the following regression:

$$x_{t+h} = \alpha + \beta^h u_t + \gamma(L)x_t + \varepsilon_t.$$

[25] We use the series "valor tasado medio de vivienda libre" (the aggregate house price, total national, and the house prices of the 17 regions for which the quarterly data are available, i.e., we exclude the autonomous cities Ceuta and Melilla): http://www.fomento.gob.es/BE2/?nivel=2&orden=35000000.

The regression is estimated by means of Bayesian techniques. We impose a flat prior on α and β^h, while we impose and informative prior on the coefficients on the lags in the equations. The informative prior has the exact same features of the Minnesota prior described in Appendix A. Notably, the shrinkage of the lagged terms grows with the horizon h at which the impulse response is computed.

Also for the local linear projections, we aim to evaluate the effects of the "QE scenario" in which standard monetary policy does not react to stabilize the economy. Hence, as in the VAR analysis, we estimate the response of all the alternative variables by means of linear projections on the VAR standard monetary policy shock. Then, we use these local linear projections to eliminate the effects of the response of the euro area policy interest rate from the local linear projection to the QE shock, using the same series of standard monetary policy shocks used in the VAR analysis.

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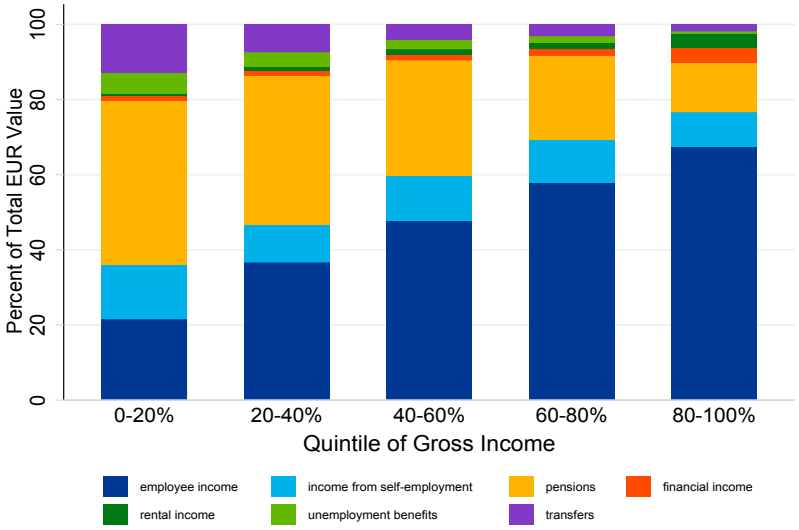
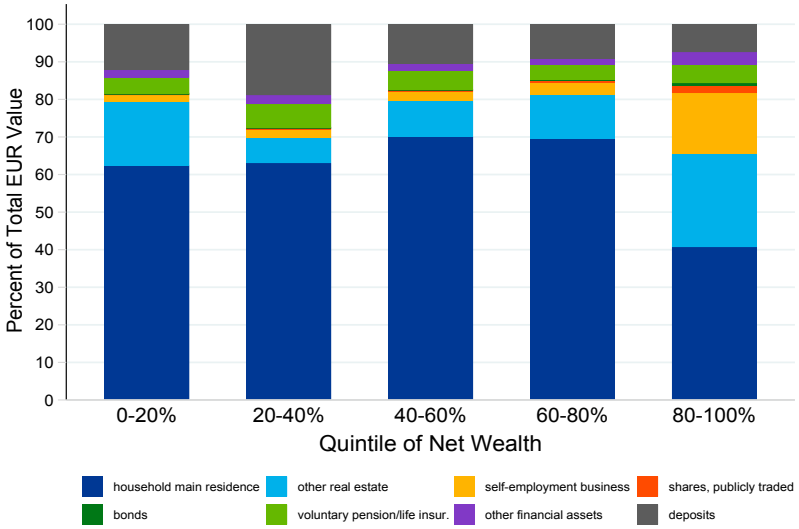
Tables and Figures in the Main Text

Figure 1 Composition of Income



Source: Household Finance and Consumption Survey
Note: The chart shows how the share of income components in total gross income varies across quintiles of gross income. Unemployment benefits and transfers include regular social transfers (except pensions) and private transfers. The chart covers the euro area countries and includes the 17 countries included in wave 2 of the HFCS.

Figure 2 Composition of Total Assets

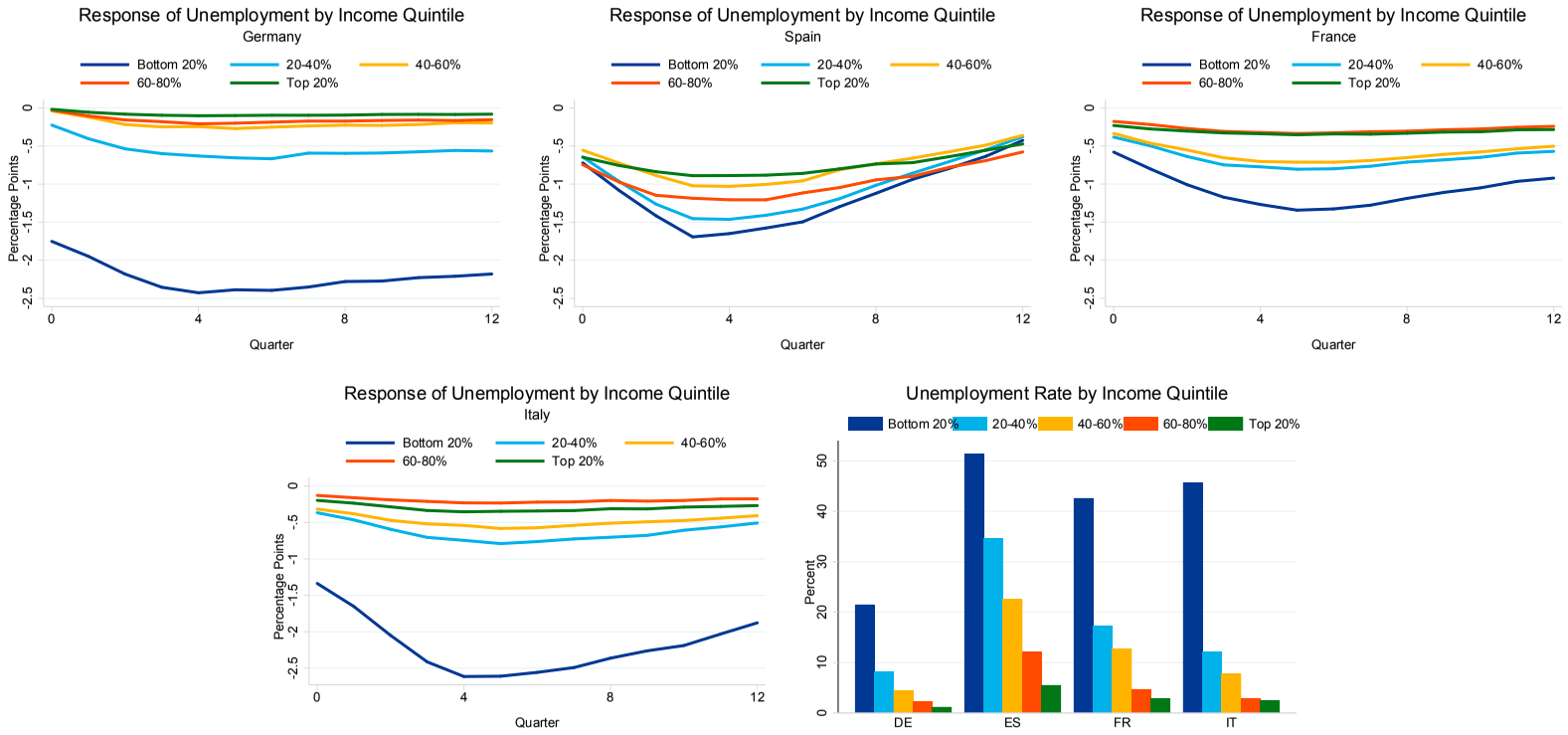


Source: Household Finance and Consumption Survey
Note: The chart shows how the share of components in total assets varies across quintiles of net wealth. Other financial assets include managed accounts, mutual funds and money owed to households. The chart covers the euro area countries and includes the 17 countries included in wave 2 of the HFCS.

Figure 3 Quantitative Easing Scenario: VAR Impulse Responses

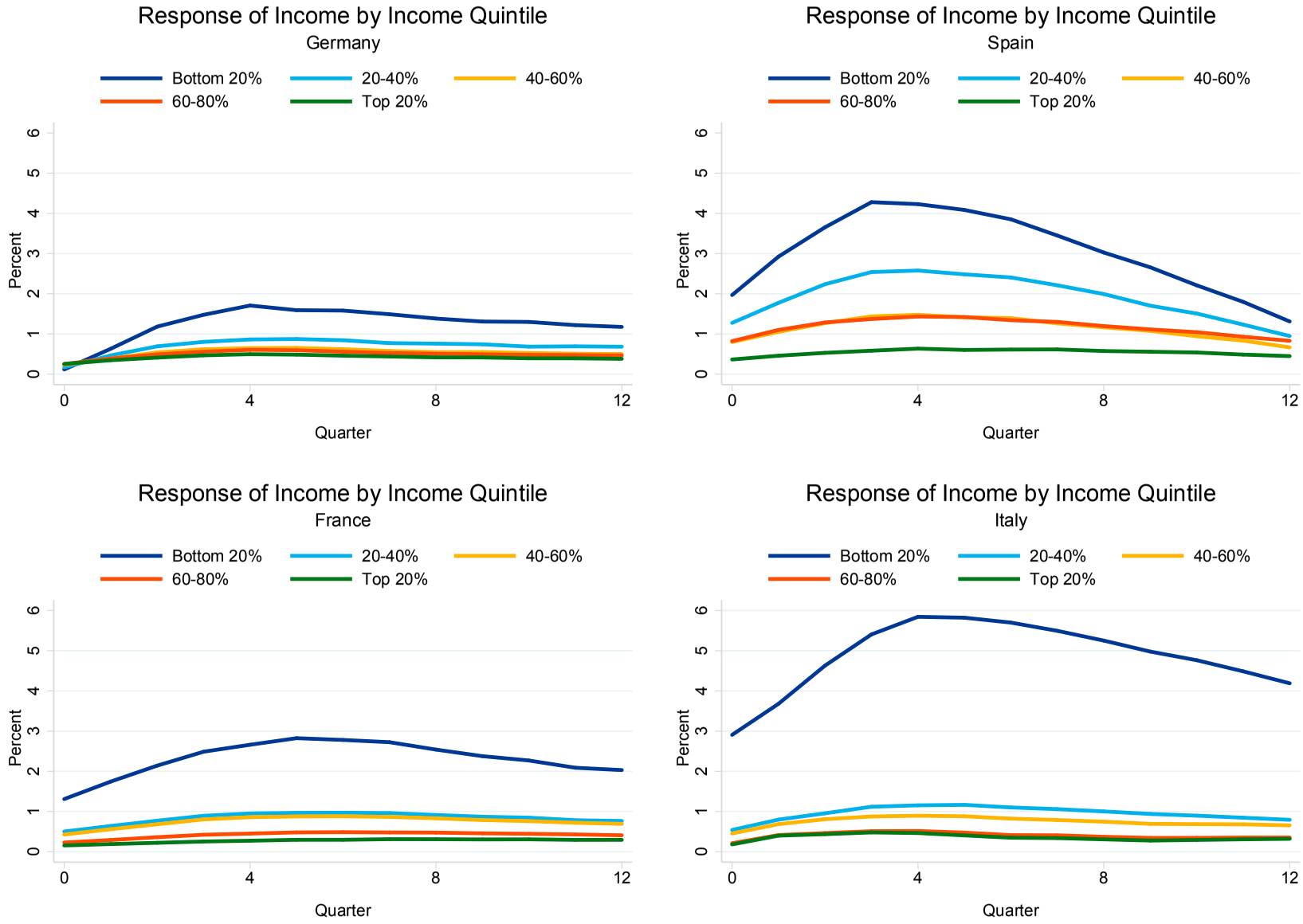
Note: The charts plots median responses to the asset purchase scenario. House prices: percentage deviation from baseline levels; wages: percentage deviation from baseline levels; unemployment rate: deviation from baseline level; stock price: percentage deviation from baseline levels.

Figure 4 Impulse Responses of Unemployment Rate by Country and Income Quintile



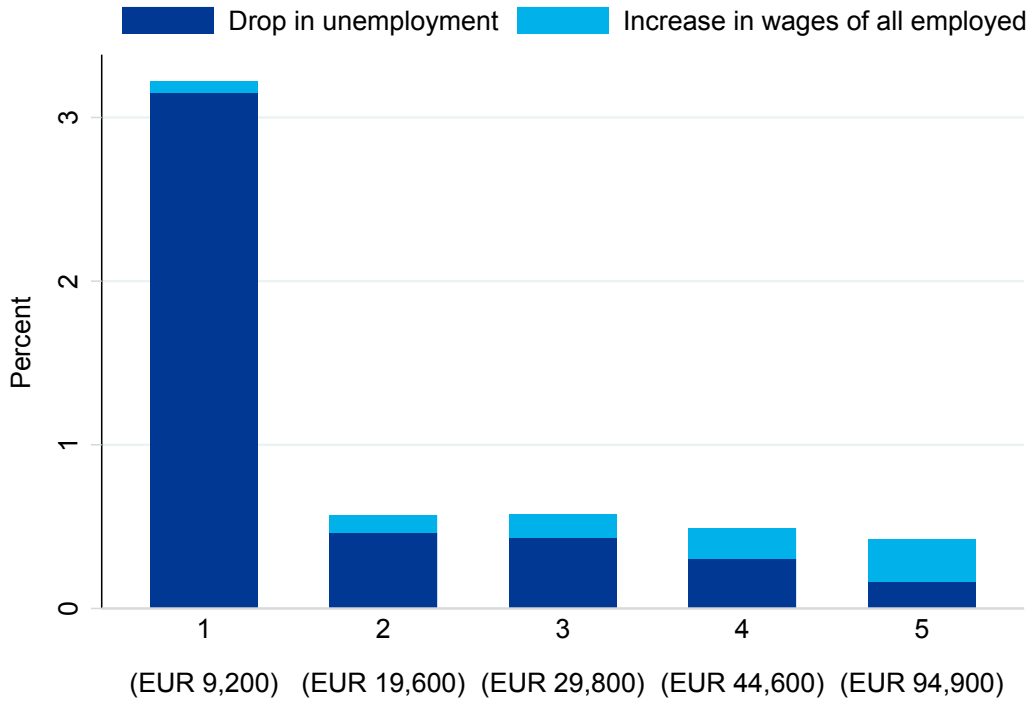
Source: Household Finance and Consumption Survey
Note: The charts show impulse responses of unemployment by income quintile.

Figure 5 Impulse Responses of Mean Income by Country and Income Quintile



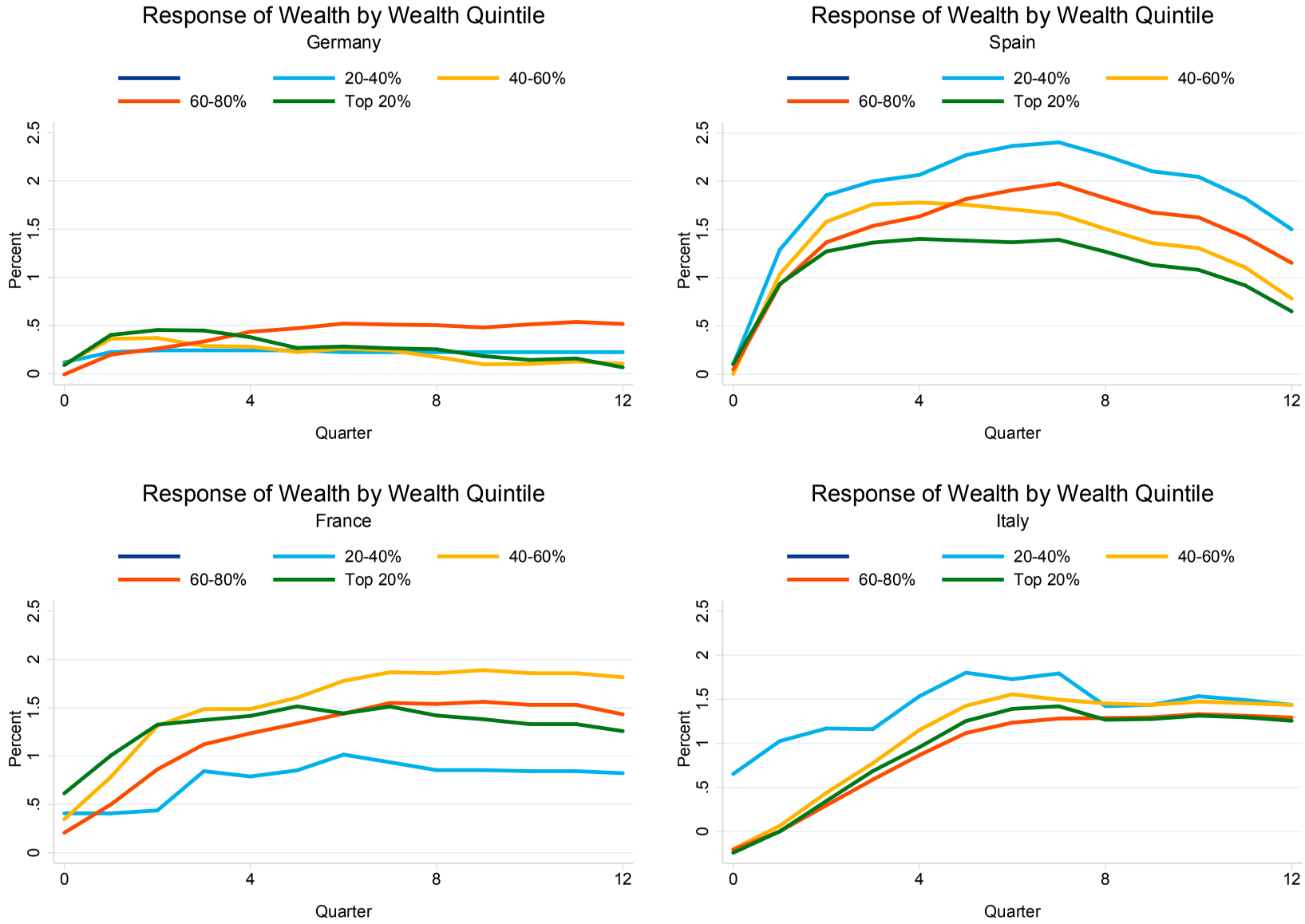
Source: Household Finance and Consumption Survey
Note: The charts show impulse responses of mean income by income quintile.

Figure 6 Decomposition of the Total Effect on Mean Income into the Extensive and the Intensive Margin



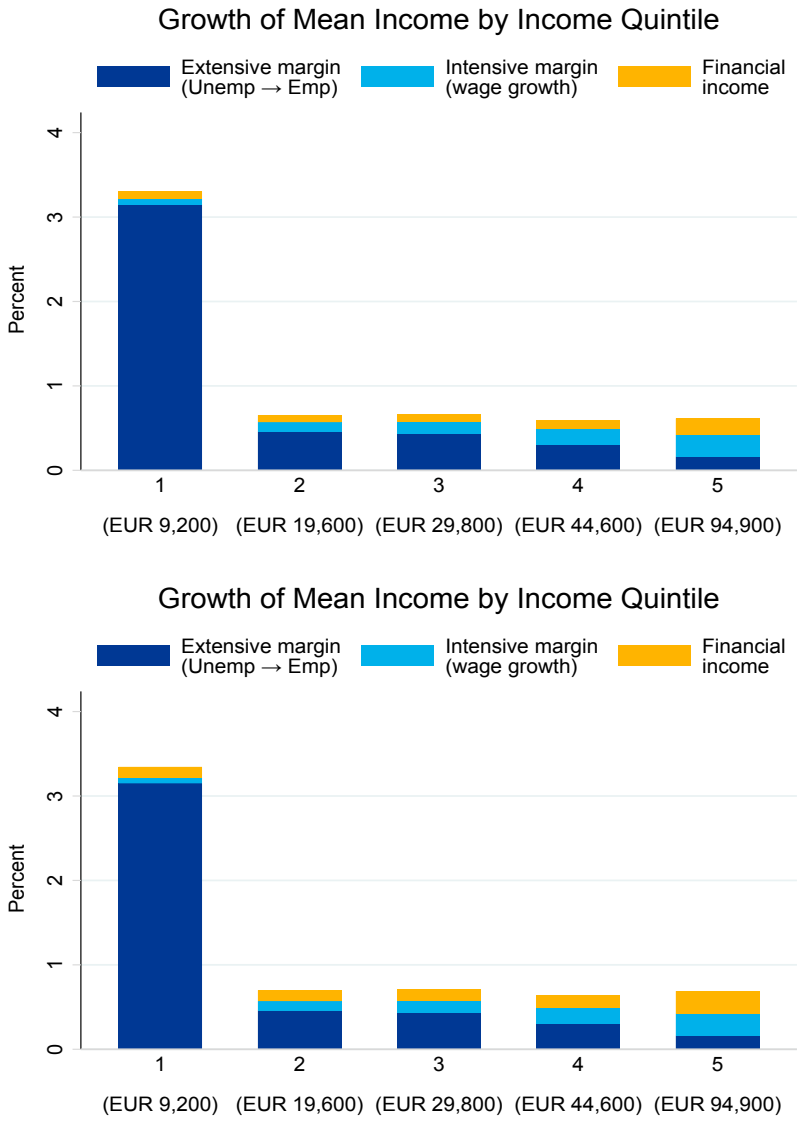
Source: Household Finance and Consumption Survey
Note: The chart shows the percentage change in mean income across income quintiles in the euro area 4 quarters after the impact of the QE shock. It also shows the decomposition of the change into the extensive margin (transition from unemployment to employment) and the intensive margin (increase in wage). The numbers in brackets show the initial levels of mean gross household income. The figure shows an aggregate of Germany, Spain, France and Italy.

Figure 7 Impulse Responses of Median Net Wealth by Country and Net Wealth Quintile



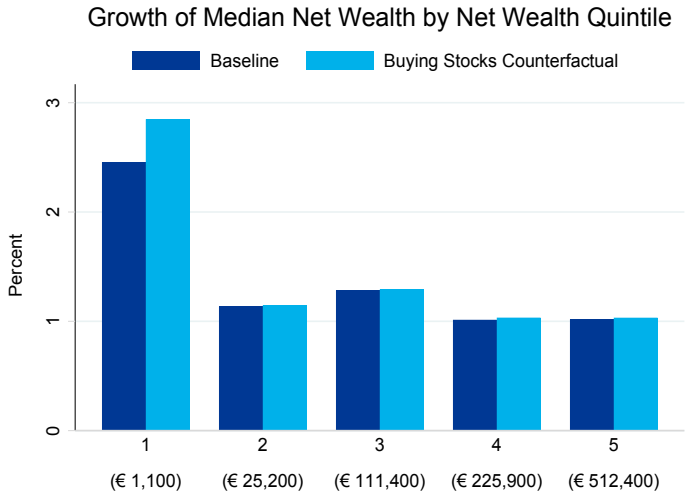
Source: Household Finance and Consumption Survey
Note: The charts show impulse responses of net wealth. The response for the bottom 20% not shown as the value of net wealth in the lowest quintile is close to EUR 0.

Figure 8 Effects of the Scenarios with Financial Income on Distribution of Income



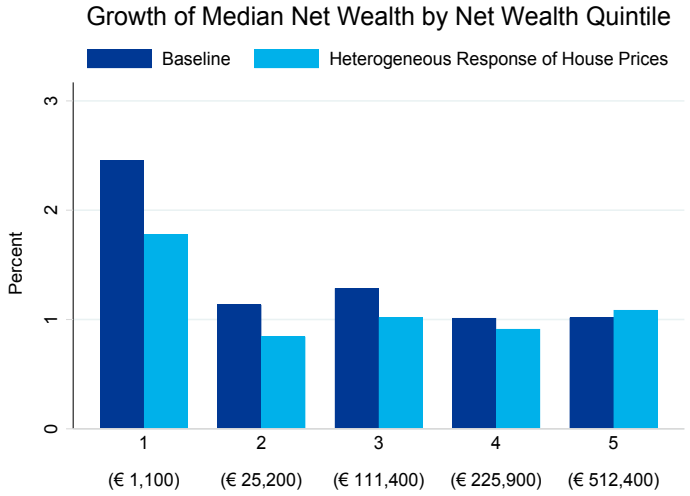
Source: Household Finance and Consumption Survey
Note: The figure shows the implications for gross income of (i) an increase of 5% in financial income (top panel) and (ii) country-specific increase in financial income (France: 6.9%, Germany: 3.6%, Italy: 19.3%, Spain: 8.3%; bottom panel). The bars show the percentage increase in mean income and its components across quintiles of gross household income. The numbers in brackets show the initial levels of mean gross household income. The figure shows an aggregate of Germany, Spain, France and Italy.

Figure 9 Effects of the Scenario with Stock Trading on the Distribution of Net Wealth



Source: Household Finance and Consumption Survey
Note: The figure compares the baseline scenario with the one in which the holding of stocks increases by 5%. The bars show the percentage increase in median net wealth across quintiles of net wealth. The numbers in brackets show the initial levels of median net wealth. The figure shows an aggregate of Germany, Spain, France and Italy.

Figure 10 Effects of the Scenario with Heterogeneity in House Price Responses on the Distribution of Net Wealth



Source: Household Finance and Consumption Survey
Note: The figure compares the baseline scenario with the one in which house prices of more expensive houses (in terms of price per square meter) react more strongly to monetary policy. The bars show the percentage increase in median net wealth across quintiles of net wealth. The numbers in brackets show the initial levels of median net wealth. The figure shows an aggregate of Germany, Spain, France and Italy.

Table 1 Modeling of Responses of Wealth and Income Components at Household Level

Wealth / income component	**Modeling procedure**
Real Assets	
Household's main residence	Multiplied with response of house prices (robustness: heterogeneity in house prices)
Other real estate property	Multiplied with response of house prices (robustness: heterogeneity in house prices)
Self-employment businesses	Multiplied with response of stock prices
Financial Assets	
Shares, publicly traded	Multiplied with response of stock prices (in the baseline; robustness: some trading)
Bonds	Multiplied with response of bond prices (based on long-term rate)
Voluntary pension/whole life insurance	No adjustment
Deposits	No adjustment
Other financial assets	No adjustment
Debt	
Total liabilities	No adjustment
Gross Income	
Employee income	Multiplied with response of wages (compensation per employee)
Self-employment income	Multiplied with response of wages (compensation per employee)
Income from pensions	No adjustment
Rental income from real estate property	No adjustment
Income from financial investments	No adjustment (in the baseline; robustness: grows by 5% or country-specific)
Unemployment benefits and transfers	If becomes employed, replace with wage (otherwise no adjustment)

Table 2 Estimates of the Effects of Nonstandard Monetary Policy Using Event Studies

Authors	Country	Type of Event	Typical Impact on 10-Year Rate (p.p.)	Notes
Altavilla et al. (2016)	DE, ES, FR, IT	OMT	0.2 to 1	
Altavilla et al. (2015)	EA, DE, ES, FR, IT	APP	0.3 to 0.5	
Andrade et al. (2016)	EA	APP	0.45	
Joyce and Tong (2012)	UK	APF1	1	
Christensen and Rudebusch (2012)	UK, US	APF1	0.43 to 0.89	
Lam (2011)	JP	CME+	0.24 to 0.27	
Fukunaga et al. (2015)	JP	QQE	0.33 to 0.47	
Gagnon et al. (2011)	US	LSAP1	0.55 to 1.05	
Krishnamurthy and Vissing-Jorgensen (2013)	US	LSAP1, LSAP2, MEP	0.07 to 1.07	
Bauer and Rudebusch (2014)	US	LSAP1	0.89	
Krishnamurthy and Vissing-Jorgensen (2011)	US	LSAP1, LSAP2	0.3 to 1.07	
Cahill et al. (2013)	US	LSAP1, LSAP2, MEP	0.089 to 0.131	for $100bn purchases

Notes: See also Andrade et al. (2016), Appendix B for other studies and details. Abbreviations: OMT—Outright Monetary Transactions (Announcement), APP—Asset Purchases Programmes, APF—Asset Purchase Facility, CME—Comprehensive Monetary Easing, QQE—Quantitative and Qualitative Monetary Easing, LSAP—Large Scale Asset Purchase Program, MEP—Maturity Extension Program.

Table 3 Estimates of the Effects of Nonstandard Monetary Policy Using VARs

Authors	Method (Country)	Type of Event	Effect on Real Economy and Inflation
Altavilla et al. (2016)	VAR (DE, ES, FR, IT)	OMT	Real GDP: 0.34%–2.01%, HICP: 0.28%–1.21%
Baumeister and Benati (2013)	TVP VAR (US, UK)	LSAP	Inflation: trough of −1% to −4% GDP gr: trough −10% to −12%, UR: peak 10.6%
Kapetanios et al. (2012)	TVP VAR (UK)	BoE LSAP	Real GDP: peak effect of 1.42%
Weale and Wieladek (2016)	Bayesian VAR (US, UK)	LSAP	Real GDP: 0.25%–0.58%, CPI: 0.32%–0.62%
Gambacorta et al. (2014)	Panel VAR (EA, non-EA countries)	Various	GDP: −0.25% to 0.25%, CPI: −0.12% to 0.10%
Darracq-Paries and De Santis (2015)	Panel VAR (EA countries)	3-year LTROs	GDP: peak of 0.8%, GDP Defl: peak of 0.35%
Babecka Kucharcukova et al. (2016)	VAR (EA, non-EA countries)	Spillovers from ECB QE	IP: −0.2% to 0.2%, HICP: −0.1% to 0.06%
Bluwstein and Canova (2016)	Bayesian SVAR (EA, EU countries)	Spillovers from ECB QE	IP: −0.1% to 0%, CPI: 0%–0.5%
Hachula et al. (2016)	SVAR (EA, EA countries)	LTROs	GDP: 0.1%–0.65%, CPI: 0%–0.45% UR: −0.21%–0.07%
Behrendt (2017)	SVAR (EA)	ECB QE	IP −0.0032%–0.0023%, HICP −0.0006%–0.0005%
Boeckx et al. (2017)	SVAR (EA, EA countries)	3Y LTRO, CBPP1	GDP: −0.35%–0.6%, HICP: −0.1%–0.3%

Notes: See also Andrade et al. (2016), Appendix B for other studies and details. Abbreviations: LTROs—long-term refinancing operations, CBPP1—Covered Bond Purchases Program.

Table 4 Effects of Quantitative Easing on Income and Wealth Inequality

	Gini Coefficient	
	Income	Net Wealth
Actual Data	43.074	68.093
Baseline Simulation	42.860	68.043
Robustness		
Effects of Financial Income (5% Response)	42.885	
Effects of Financial Income (Country-Specific Response)	42.893	
Stock Trading		68.079
Local House Prices		68.089

The table shows the Gini coefficients for gross household income and net wealth for actual data and 5 scenarios: the baseline and 4 scenarios described in section 3.2.3—2 scenarios accounting for the effects of financial income, a scenario on portfolio rebalancing of stocks (stock trading) and a scenario with heterogeneity in responses of house price to quantitative easing. The scenarios report the Gini coefficients 4 quarters after the impact of the quantitative easing shock.

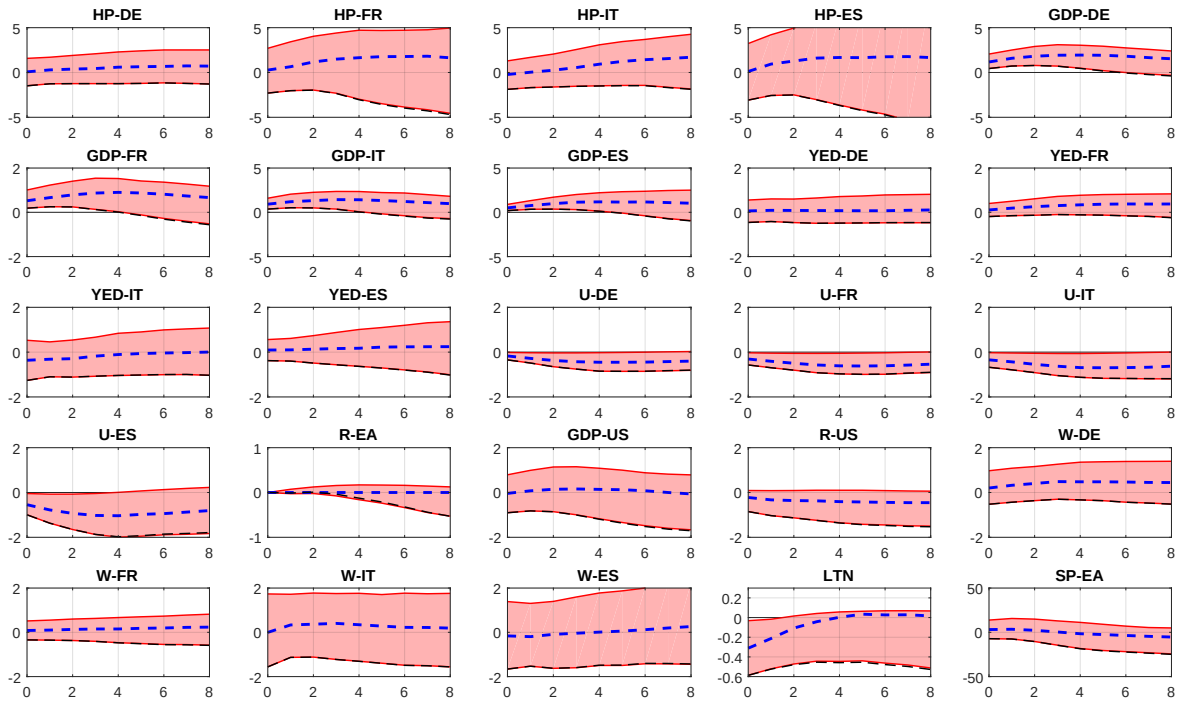
Table 5 Macroeconomic Database and Identification Assumptions

Variables	Transformation	Source	APP shock	MP shock
1 DE GDP	log-levels	Eurostat	+	0
2 DE GDP Deflator	log-levels	Eurostat		0
3 DE Unemployment rate	levels	Eurostat		0
4 DE House prices	log-levels	Eurostat		0
5 DE Compensation per employee	log-levels	Eurostat		0
6 FR GDP	log-levels	Eurostat	+	0
7 FR GDP Deflator	log-levels	Eurostat		0
8 FR Unemployment rate	levels	Eurostat		0
9 FR House prices	log-levels	Eurostat		0
10 FR Compensation per employee	log-levels	Eurostat		0
11 IT GDP	log-levels	Eurostat	+	0
12 IT GDP Deflator	log-levels	Eurostat		0
13 IT Unemployment rate	levels	Eurostat		0
14 IT House prices	log-levels	Eurostat		0
15 IT Compensation per employee	log-levels	Eurostat		0
16 ES GDP	log-levels	Eurostat	+	0
17 ES GDP Deflator	log-levels	Eurostat		0
18 ES Unemployment rate	levels	Eurostat		0
19 ES House prices	log-levels	Eurostat		0
20 ES Compensation per employee	log-levels	Eurostat		0
21 Euro Area Short-term interest rates	levels	AWM database (STN)	0	−
22 Euro Area Long-term interest rates	levels	AWM database (LTN)	−	
23 Euro Area Stock prices	log-levels	ECB SDW		
24 US GDP	log-levels	FRED		0
25 US Short-term interest rates	levels	FRED		0

Note: The database of the Area-Wide Model is available at `https://eabcn.org/page/area-wide-model`.

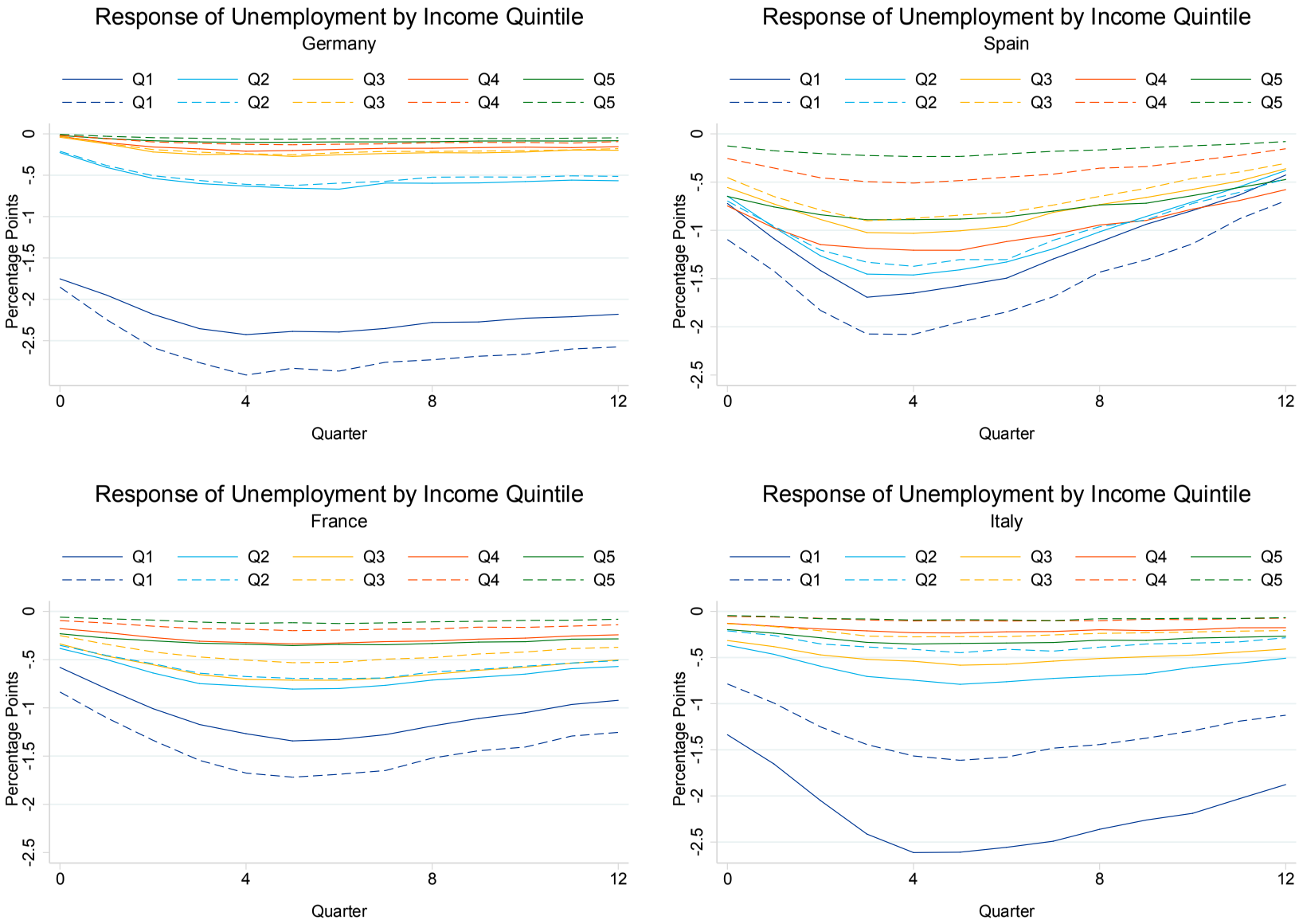
Appendix C: Additional Figures—For Online Appendix

Figure C.1 Impulse Responses to QE Shock



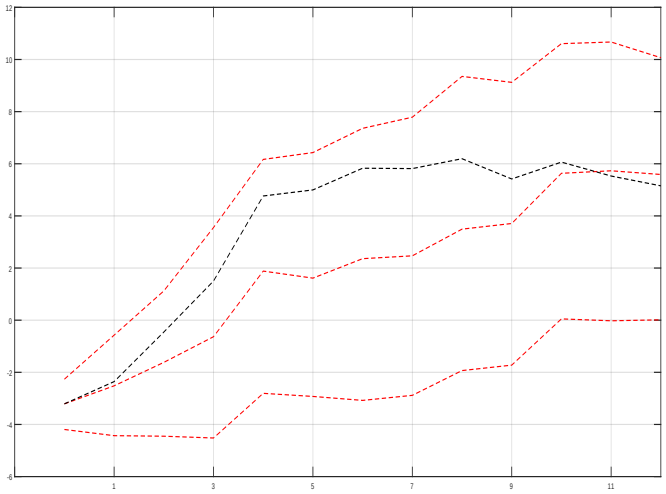
Note: The figure shows the impulse response of all the variables in the model to the QE shock (30 bp drop in the term spread). The red shaded area reflects the 16th–84th percentile range. The black dashed line, instead, is the median impulse response of the variables in the QE scenario in which the reaction of the short-term interest rate is offset by means of standard monetary policy shocks. HP: house prices; GDP: real gross domestic product; YED: GDP deflator; U: unemployment rate; R: nominal short-term interest rate; W: compensation per employee, wage; LTN: nominal long-term interest rate; SP: stock prices. EA: euro area; US: United States; DE: Germany; FR: France; IT: Italy; ES: Spain.

Figure C.2 Impulse Responses of Unemployment—Baseline IRFs (Solid) vs IRFs Generated Under Uniform Probability of Getting Employed (Dashed)



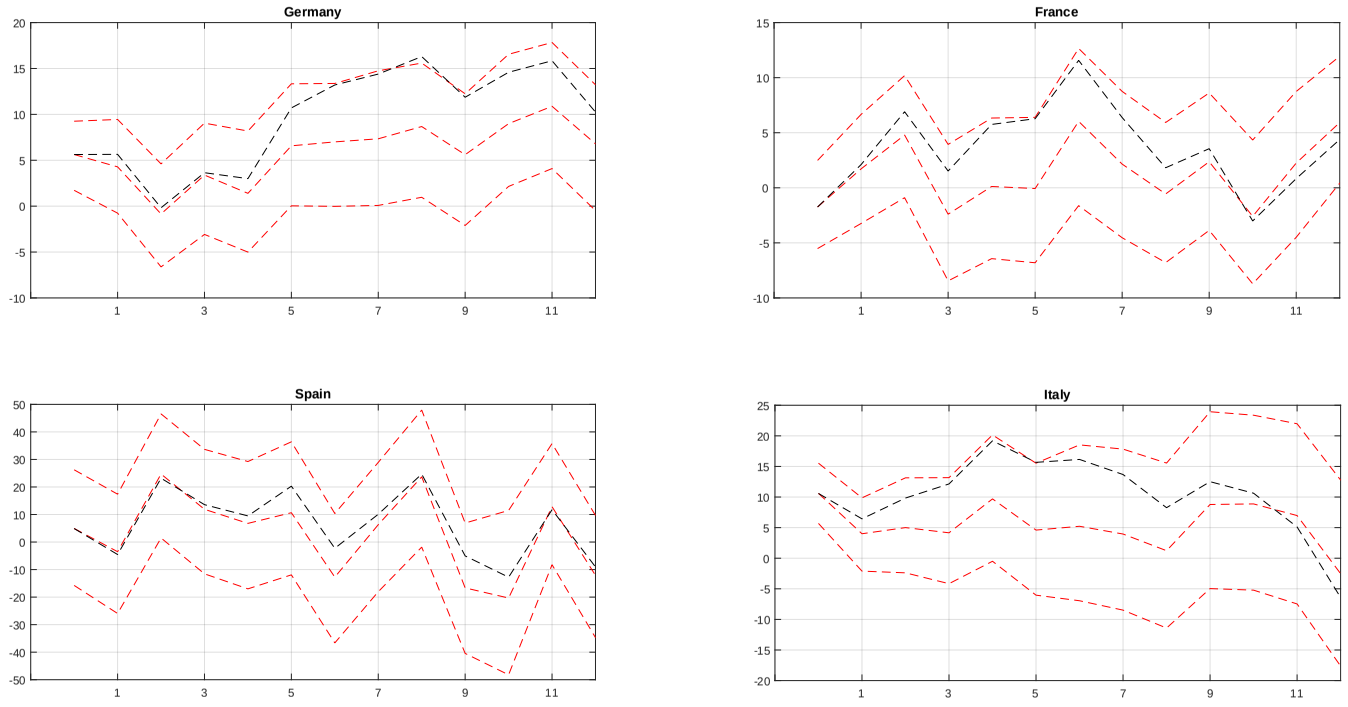
Source: Household Finance and Consumption Survey
Note: The charts show impulse responses of unemployment by income quintile.

Figure C.3 Response of Profits to Quantitative Easing Shock



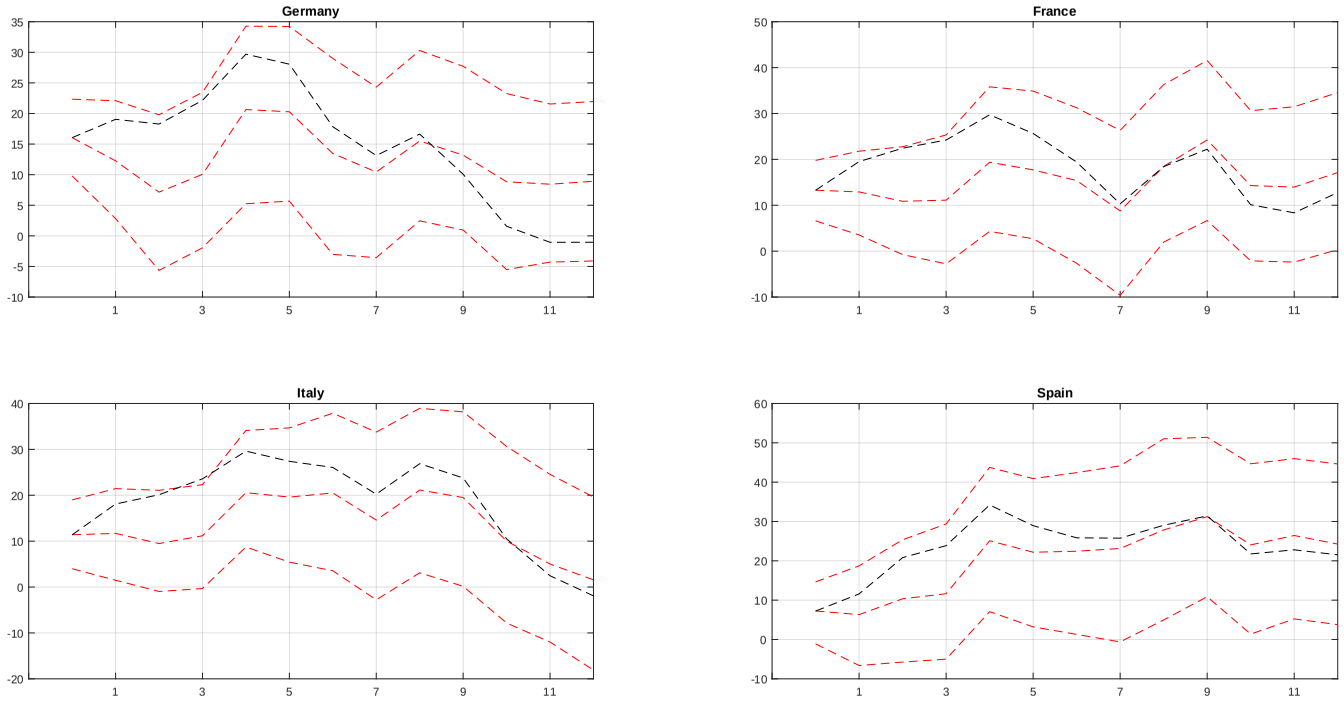
Note: The figure shows the impulse response of aggregate profits the quantitative easing shock. The responses are estimated by means of the local linear projection method of Jordà (2005). Red dashed lines: 16th, 50th and 84th percentiles of the responses to QE shock; black dashed line: median response to QE scenario where standard monetary policy shocks off-set the response of the policy rate to QE shock.

Figure C.4 Response of Net Property Income to Quantitative Easing Shock



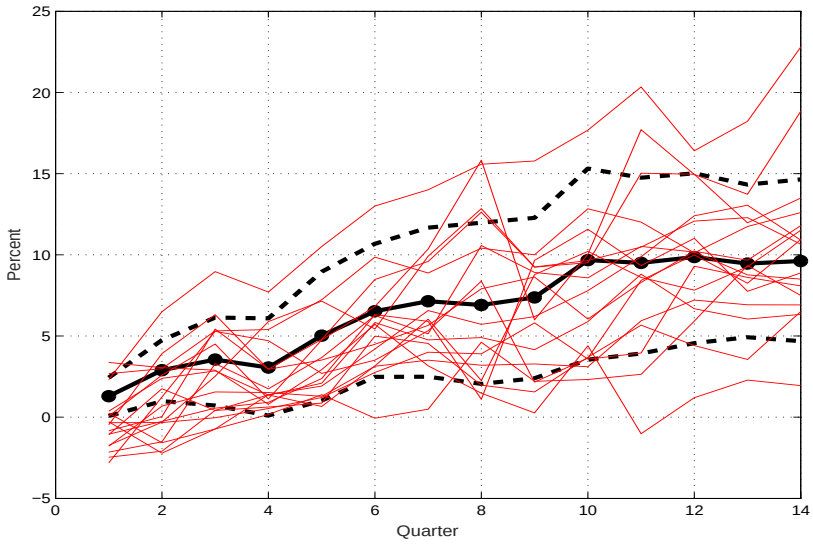
Note: The figure shows the impulse response of net-property income in the four countries to the quantitative easing shock. The responses are estimated by means of the local linear projection method of Jordà (2005). Red dashed lines: 16th, 50th and 84th percentiles of the responses to QE shock; black dashed line: median response to QE scenario where standard monetary policy shocks off-set the response of the policy rate to QE shock.

Figure C.5 Response of the Value of Household Stock Holdings to Quantitative Easing Shock



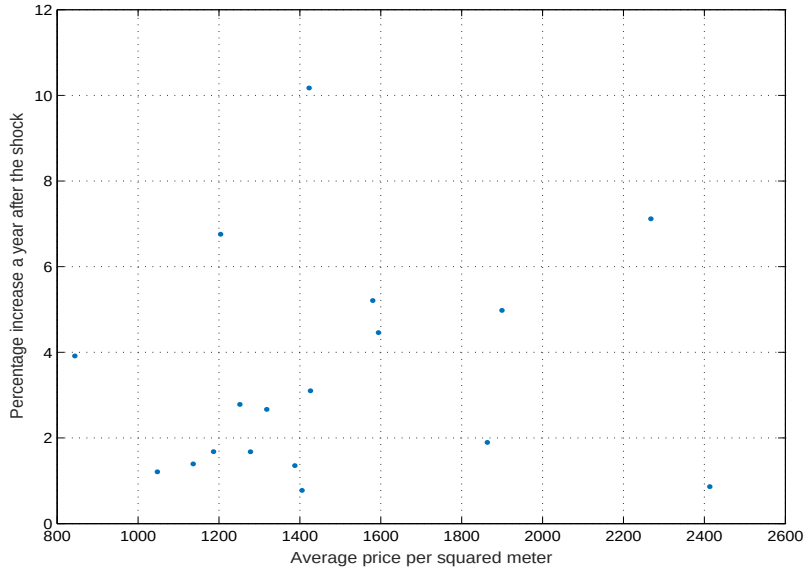
Note: The figure shows the impulse response of the value of the stock holdings of the households in the four countries to the quantitative easing shock. The responses are estimated by means of the local linear projection method of Jordà (2005). Red dashed lines: 16th, 50th and 84th percentiles of the responses to QE shock; black dashed line: median response to QE scenario where standard monetary policy shocks off-set the response of the policy rate to QE shock.

Figure C.6 Effects of Quantitative Easing on Local House Prices in Spain



Source: ENI/Ministerio de Fomento, Spain.
Note: The figure shows the impulse response to the quantitative easing shock of local house prices from Spanish provinces. The black lines refer to the 16th and 84th percentiles (dashed) and median (solid with dots) of the responses of the aggregate (national) house price. The red solid lines refer to the median responses of local house prices. The responses are estimated by means of the local linear projection method of Jordà (2005).

Figure C.7 Level of Local House Prices Across Spanish Regions vs Response to Quantitative Easing Shock after 4 Quarters



Source: ENI/Ministerio de Fomento, Spain.
Note: The figure shows the scatter plot of the responses of local house prices across Spanish provinces 4 quarters after the quantitative easing shock. The responses are plotting against the level of house prices (in EUR per square meter).