

# Unconventional Monetary Policy and Income Inequality

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## Abstract

This paper evaluates the distributional effect of unconventional monetary policy for the USA. This paper assesses the impact of unconventional monetary policy on income and wage inequality and on different parts of income distribution, applying alternative identification methods of the monetary policy shock. Because of the low frequency data on income inequality, the interpolation and the mixed frequency methods are used for them. The results show that expansionary unconventional monetary policy raises income inequality. It also increases income inequality in the upper and the lower parts of income distribution. At the same time, expansionary unconventional monetary policy reduces wage inequality. The evaluation of the impact of monetary policy on inequality through its distribution channels shows that the stronger positive effect of unconventional monetary policy on financial income than on labor earnings leads to the overall increase in income inequality. In addition, the variance decomposition analysis reveals that unconventional monetary policy significantly affects the variation in income and wage inequality.

**JEL classification:** C32, D31, E52

**Keywords:** unconventional monetary policy, identification, inequality

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## **1. Introduction**

To respond to the global financial crisis, central banks have generally taken unconventional monetary policy measures to ease financial conditions by providing external funding. While there are already available studies on the macroeconomic and the financial market impact of unconventional monetary policy (e.g., Baumeister and Benati, 2013; Chen et al., 2012; Gambacorta et al., 2014; Joyce et al., 2011), its distributive effect has not been widely explored yet (Saiki and Frost, 2014). The objective of this paper is to fill the gap by evaluating the distributive impact of unconventional monetary policy.

In response to the global financial crisis, many central banks have substantially lowered their policy rates. To improve deteriorated economic conditions, they have also resorted to unconventional monetary policy instruments when their policy rates have hit the effective zero lower bound. In particular, as unconventional monetary policy measures, the large scale asset purchases have been implemented by the Federal Reserve since the financial crisis (Baumeister and Benati, 2013). These operations have changed the relative supply of short term and long term bonds, and other assets, consequently affecting their prices and the flow of funds in the economy. This can benefit high-income households who hold these bonds and assets.

The main objective of unconventional monetary policy measures is to lower long term interest rates in order to support private borrowing of households and businesses, thereby fostering aggregate demand and real economic activity. This can be beneficial for households who mainly rely on labor income, which might be adversely affected during the crisis. Labor earnings are the primary source of income for the most of households, and these earnings are mostly exposed to recessions (Coibion et al., 2017).

Thus, the implementation of unconventional monetary policy can facilitate to overcome the recent financial crisis. At the same time, it might also affect income distribution. On the one hand, unconventional monetary policy might increase the financial and the businesses income of high-income households. On the other hand, it could restore labor earnings for low-income households too. As a result, unconventional monetary policy might affect income inequality but

its impact is ambiguous because of the opposite effects. The paper assesses the overall distributional impact of unconventional monetary policy.

The distributional effect of unconventional monetary policy is evaluated in the case of the USA. It is assessed for the overall impact on income distribution. This paper also evaluates the impact of unconventional monetary policy on the lower and the upper parts of income distribution as well as on wage inequality. This paper applies alternative identification methods of the monetary policy shock, and it uses the interpolation and the mixed frequency methods because of the low frequency data on income inequality. The results indicate that expansionary unconventional monetary policy raises income inequality. Unconventional monetary policy significantly affects the upper and the lower parts of income distribution. At the same time, it decreases wage inequality. The impact of monetary policy on income inequality is also explored through the examination of its distribution channels. In addition, the variance decomposition analysis reveals that unconventional monetary policy accounts for the high share of the variation in income and wage inequality.

The rest of the paper is organized as follows. Section 2 discusses the distribution channels of monetary policy. Section 3 presents the empirical methodology while Section 4 describes the data. Section 5 provides the obtained results and Section 6 includes the concluding remarks.

## **2. Distribution Channels of Monetary Policy**

The overall distributional effect of monetary policy depends on different channels through which monetary policy can have an impact on income inequality. Coibion et al. (2017) specify five such channels. In particular, they define the income composition, the financial segmentation, the portfolio, the savings redistribution, and the earnings heterogeneity channels. The income composition channel is related to the heterogeneity in the primary sources of income (wages, business and financial gains) across households. The financial segmentation channel refers to the reallocation of income towards the agents involved in financial markets. The distribution of income based on the structure of owned assets is expressed by the portfolio channel. The impact of unexpected inflation on nominal contracts is described by the savings distribution channel. The earnings heterogeneity channel represents the tendency that the labor income of the poorest

population is primarily exposed to business cycle fluctuations. In Table 1, this paper provides the data on the composition of income in the USA in 2007 (just before the global financial crisis). It can be observed that labor earnings are the primary source of income for the poor while financial income is gained by mostly the rich.

Monetary policy could have different distributional effects through the channels. Supposedly, through the first three channels, expansionary monetary policy increases income inequality and reduces it via the last two channels. Nevertheless, the channels can operate with different intensity with conventional and unconventional monetary policies. That is, conventional and unconventional monetary policies could have disproportionate effects on the channels. Moreover, the magnitude of their impact through the channels might be different too, and, consequently, they can have different overall distributive effects. The objective of this paper is to evaluate the overall effect of all the channels in the case of unconventional monetary policy.

Monetary policy affects prices and real economic activity. In particular, the mandate of the Federal Reserve involves maintaining price stability and promoting maximum employment. Talking this into account, Nakajima (2015) classifies two general distribution channels of monetary policy: the inflation and the income channels. They include the channels specified by Coibion et al. (2012). The inflation channel incorporates the financial segmentation, the portfolio composition, and the savings redistribution channels. The income channel contains the income composition and the earnings heterogeneity channels. To evaluate the distributive impact of monetary policy, this paper considers these aggregate channels. It uses prices and real output as the aggregate distribution channels of monetary policy. Federal Reserve assets are used as an unconventional monetary policy instrument. An income inequality measure is also considered in order to assess the overall distributive impact of unconventional monetary policy.

Although the distributional effect of monetary policy is not extensively studied, there are still some related papers. They consider the impact of conventional and unconventional monetary policies as contractionary and expansionary, respectively. Coibion et al. (2017) provide evidence for the USA that conventional monetary policy increases economic inequality. In the case of Mexico, Villarreal (2014) shows that conventional monetary policy reduces income inequality. Mumtaz and Theophilopoulou (2016) find that (contractionary) conventional and (expansionary)

unconventional monetary policies raise economic inequality in the UK. The report by the Bank of England (2012) asserts that its unconventional monetary policy measures might increase income inequality. Saiki and Frost (2014) find that unconventional monetary policy raises income inequality in Japan. This literature mainly uses structural vector autoregression (VAR) models to evaluate the distributive effect of monetary policy. While the current paper employs an analogous modeling approach, it has its specific features as well. In particular, it uses the inequality data that are more representative of the whole income distribution and considers alternative identification approaches for a monetary policy shock, complementing the existing literature.

### 3. Empirical Methodology

This paper considers structural VAR models for the analysis of the distributional impact of unconventional monetary policy. These models are commonly used for evaluating the effects of monetary policy in the literature (among others, Gambacorta et al., 2014; Uhlig, 2005). The considered baseline VAR model of order  $p$ , VAR( $p$ ), is the following<sup>1</sup>:

$$y_t = A_0 + A_1 y_{t-1} + \dots + A_p y_{t-p} + u_t, \quad (1)$$

where  $y_t$  is a  $(4 \times 1)$  vector of endogenous variables described below;  $A_0$  is a  $(4 \times 1)$  vector of intercepts terms;  $A_j$ s (*for*  $j = 1, \dots, p$ ) are  $(4 \times 4)$  coefficient matrices; and  $u_t$  is a  $(4 \times 1)$  vector of error terms. The latter is assumed to be a zero-mean independent white noise process with positive definite covariance matrix:  $u_t \sim (0, \Sigma_u)$ .

In general, the vector of endogenous variables  $y_t$  consists of real output, prices, a monetary policy instrument, and an income inequality measure:  $y_t = (Y_t, P_t, S_t, Z_t)'$ . To control for the same main macroeconomic variables, in the baseline case, this paper incorporates real GDP and GDP deflator as well as Federal Reserve assets, as a monetary policy instrument. Gini index is also included, as an income inequality measure.

Reduced form disturbances are generally the linear combinations of underlying structural shocks:

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<sup>1</sup> The notations of the section are generally in line with the representations used by Lütkepohl (2005).

$$u_t = B\varepsilon_t, \quad (2)$$

where  $B$  is a  $(4 \times 4)$  matrix of parameters and  $\varepsilon_t$  is a  $(4 \times 1)$  vector of structural shocks. For the identification of a monetary policy shock, Cholesky decomposition is a standard approach in the literature (Christiano et al., 1996; Sims, 1992). The ordering of the variables in the VAR model is the same as presented above:  $y_t = (Y_t, P_t, S_t, Z_t)'$ . Accordingly, the following contemporaneous restrictions are imposed on the matrix  $B$ :

$$\begin{pmatrix} u_Y \\ u_P \\ u_S \\ u_Z \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 \\ b_{41} & b_{42} & b_{43} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_Y \\ \varepsilon_P \\ \varepsilon_S \\ \varepsilon_Z \end{pmatrix} \quad (3)$$

In the low-triangular matrix of the expression<sup>2</sup>, the zeros provide required restrictions for the identification of the monetary policy shock to assess its distributive impact through the impulse response functions (IRFs). These restrictions imply that the monetary policy instrument has no contemporaneous impact on output and prices. However, it is assumed that the policy instrument contemporaneously reacts to the changes in output and prices. All the assumptions and, consequently, the ordering of the corresponding variables are common in this identification framework (Christiano et al., 1996; Peersman and Smets, 2001). In addition, it is also assumed that income inequality does not contemporaneously affect monetary policy instruments and the other variables whereas all of them have contemporaneous impact on it. For the plausibility of the assumptions, their application requires the usage of high frequency data. Therefore, the paper interpolates some of the data used in order to apply this recursive identification scheme.

Along with the IRFs, the variance decomposition analysis is also implemented for the structural VAR models. In the paper, this analysis is carried out since it is useful for the objective of the paper to evaluate the distributive effect of unconventional monetary policy. The variance decomposition analysis is based on Cholesky decomposition of the covariance matrix as described above. This analysis allows decomposing the total variance of an income inequality measure into the percentages attributable to structural shocks, which are orthogonal and have

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<sup>2</sup> For the simplicity of the representation, the time indices  $t$  are omitted.

unit variances. The VAR model can be expressed through structural shocks using a vector moving average representation:

$$y_t = A_0 + F(L)\varepsilon_t, \quad (4)$$

where  $F(l)$  is a polynomial in lag operators. The variance of  $Z_t$  is given by

$$\text{Var}(Z_t) = \sum_{k=1}^4 \sum_{j=0}^{\infty} F_{ik}^{j^2} \text{Var}(\varepsilon_{kt}) = \sum_{k=1}^4 \sum_{j=0}^{\infty} F_{ik}^{j^2}, \quad (5)$$

where  $\sum_{j=0}^{\infty} F_{ik}^{j^2}$  is the variance of  $Z_t$  generated by the  $k$ th structural shock  $\varepsilon_{kt}$ . This implies that

$$\frac{\sum_{j=0}^{\infty} F_{ik}^{j^2}}{\sum_{k=1}^4 \sum_{j=0}^{\infty} F_{ik}^{j^2}} \quad (6)$$

is the percentage of the variance of  $Z_t$  explained by  $\varepsilon_{kt}$ . It is also possible to study the variance of an income inequality measure explained by a structural shock at a given horizon. The percentage of the variance of  $Z_t$  due to  $\varepsilon_{kt}$  at horizon  $h$  is given by

$$\frac{\sum_{j=0}^{h-1} F_{ik}^{j^2}}{\sum_{k=1}^4 \sum_{j=0}^{h-1} F_{ik}^{j^2}} \quad (7)$$

A monetary policy shock is one of the structural shocks. Consequently, the variance decomposition analysis enables decomposing the total variance of an income inequality measure into the percentages attributable to a monetary policy shock.

#### 4. Description of the Dataset

The empirical analysis is implemented for the USA. The estimation sample is from 2009 to 2015. The first year of the sample is determined by the fact that the federal funds rate has reached the zero lower bound since 2009. The sample runs until 2015 because the data on income inequality are only available until this year. Following Gambacorta et al (2014), the data on the monthly frequency are used.

In the baseline model, Gini index is used as an income inequality measure. The data source is the OECD, which provides consistently measured series for income inequality. Gini index is measured for total population and it is expressed in percent. It is for disposable income, i.e., after taxes and transfers. Gini index for disposable income is used in order to control for the distributional effects of fiscal policy. This paper also uses Gini index for wages. It is computed using the CEPR datasets, which are based on the data from Current Population Survey.

Federal Reserve Economic Database, FRED, is the data source for the macroeconomic variables. In the baseline case, this paper uses the following macroeconomic variables: real GDP (based on the prices of 2009), GDP deflator (with the base year of 2009), and Federal Reserve total assets. As an alternative instrument for unconventional monetary policy, the total monetary base is also included in the empirical analysis. Figure 1 shows that the dynamics Federal Reserve total assets and the monetary base are very similar. All the variables are seasonally adjusted.

As another unconventional monetary policy measure, the shadow federal funds rate proposed by Wu and Xia (2016) is also used. The shadow rate is analogous to the federal funds rate when the latter is at the zero lower bound. Therefore, Wu and Xia (2016) suggest using the shadow rate to assess the effects of unconventional monetary policy. Since the shadow rate is a proposed indicator, it can get negative values. Figure 2 reports the graphs of the federal funds rate and its shadow rate.

The data for the considered variables are generally available on a high frequency. The exception is the data for income inequality measures. The time series for them are only available on an annual frequency. Therefore, in order to apply the contemporaneous identification scheme in the empirical analysis, income inequality measures are interpolated into a higher frequency<sup>3</sup>. The disaggregation of the data for income inequality measures is justifiable since their time series have low variation.

Gini index of income inequality is disaggregated by the index type. That is, the interpolation is implemented in such a way that, for each reference period, the average of the disaggregated series equals to the corresponding aggregate value. The disaggregation of the series for Gini

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<sup>3</sup> In the paper, all the interpolations are implemented by the specialized ECOTRIM software created by Eurostat.



index is carried out by the mathematical method proposed by Boot et al. (1967). The disaggregation of the series by this method is implemented using the first difference approach. By applying this disaggregation procedure, the series for Gini index is interpolated from the yearly frequency to the quarterly and the monthly series. Figure 3 provides the disaggregated series together with the “real” data on Gini index for wages. Their dynamics are generally similar until 2014 when they start to diverge.

As another measures of income inequality, the paper also employs percentile ratios. They are calculated using the percentiles provided in the report by DeNavas-Walt and Proctor (2015). In particular, the paper considers the ratio between the 90<sup>th</sup> and the 50<sup>th</sup> percentiles (the 90-50 ratio), and the ratio between the 50<sup>th</sup> and the 10<sup>th</sup> percentiles (the 50-10 ratio). The percentiles provided in the report are based on the data from the Current Population Survey of the U.S. Census Bureau. The percentiles are based on income before taxes and it does not include noncash benefits (DeNavas-Walt and Proctor, 2015). However, it is still informative to use this available data to compute the new measures to evaluate the impact of monetary policy on the upper and the lower parts of income distribution. For the usage in the empirical analysis, the yearly percentile ratios are interpolated into the quarterly and the monthly series. The interpolation is performed in the same way as it is implemented for the interpolation of the series for Gini index.

The series for real GDP and GDP deflator are interpolated as well. The time series for real GDP is disaggregated by the flow type. For each reference period, the sum of the disaggregated series equals to the corresponding aggregate value. The series for GDP deflator is interpolated by the index type as it is described earlier. The interpolation of the series for real GDP and GDP deflator is implemented by the statistical method suggested by Fernandez (1981). For the interpolation by this method, two reference indicators are used for each series. Following Gambacorta et al. (2014), as reference indicators for real GDP, the paper uses the series for industrial production index, and real retail and food services sales. As reference indicators for GDP deflator, in line with Uhlig (2005), the paper employs the consumer price index and the producer price index. By implementing these interpolation procedures, the data for real GDP and GDP deflator are disaggregated from the quarterly frequency to the monthly series.

To address the issue of low frequency data on income inequality, this paper adopts a mixed frequency method alongside with the interpolation approach. By applying a mixed frequency method, this paper uses annual inequality data with high frequency macroeconomic variables. In line with Foroni and Marcellino (2016), this paper treats the lower frequency inequality variable as a high frequency variable with missing observations, which are latter estimated. This approach requires to represent the VAR model in a state space form and, using Kalman filter, to estimate it with the maximum likelihood method. Nevertheless, this modeling approach is comparable with the baseline VAR model and so it is straightforward to use the same identification method of the monetary policy shock<sup>4</sup>.

## 5. Empirical Analysis

As discussed in Section 3, the baseline VAR model includes the variables with the following ordering: real GDP (GDP09L)<sup>5</sup>, GDP deflator (GDPDX09L), Federal Reserve total assets (TAL), and Gini index (GINI). The variables are used in levels in the empirical analysis. The implementation of the analysis in levels allows for implicit cointegration relations among them (Peersman and Smets, 2001; Sims et al., 1990).

Since the estimation sample is relatively short and the objective is to have a parsimonious VAR model, Schwarz criterion is used to determine the lag order of the model (Lütkepohl, 2005). The application of this criterion indicates the order of two for the VAR model. Besides, Gambacorta et al. (2014) use the same order for their VAR model, which is also estimated with monthly data and applied within the framework of unconventional monetary policy. The estimation of the VAR models is implemented by ordinary least squares.

The dynamic interactions among the variables are explored through the IRFs of the VAR models. They are identified by imposing the contemporaneous restrictions discussed in Section 3. This identification scheme is common in the literature (among others, Christiano et al. 1996; Peersman and Smets, 2001; Sims, 1992) for the evaluation of the impact of conventional

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<sup>4</sup> To keep the text compact, this paper provides the results in the case of interpolation but, on request, they are also available in the case of the mixed frequency method.

<sup>5</sup> In the parentheses, the abbreviations of the variables are stated as they are used in the empirical analysis. The last letter L in the abbreviations indicates the performed natural logarithmic transformation.

monetary policy. For the identification of an unconventional monetary policy shock, this recursive identification method is also applied in the literature (Chen et al., 2015; Jannsen et al., 2015; Meinusch and Tillmann, 2014). In particular, Jannsen et al. (2015) find that their results obtained with the contemporaneous identification are very similar to the IRFs identified through the sign restrictions proposed by Uhlig (2005).

The IRFs are for the responses of the variables to one standard deviation increase in a monetary policy shock. Since Federal Reserve total assets are used as a monetary policy instrument, a monetary policy shock is expansionary. For the IRFs, Hall's (1992) 95% confidence bands based on 1500 bootstrap replications are provided. They are presented in dotted lines while the IRFs are depicted in solid lines. In line with Gambacorta et al. (2014), the IRFs are presented for 24 periods (2 years).

### **5.1. Baseline Model**

First of all, the empirical analysis is implemented in the baseline case. The estimation results serve as a basis point for the further empirical analysis. Then, the baseline specification of the VAR model is modified and extended in different dimensions, implementing various robustness checks in the paper.

For the baseline VAR model of unconventional monetary policy, the estimated IRFs are provided in Figure 4. It can be observed from the figure that an expansionary unconventional monetary policy shock raises real GDP with the peak effect of 0.25 percent. The unconventional monetary policy shock also leads to a peak increase in GDP deflator by nearly 0.15 percent. These real and nominal effects of the exogenous expansion of the Federal Reserve balance sheet are generally in line with the analogous results in the related literature (Chen et al., 2015; Gambacorta et al., 2014; Jannsen et al. 2015). From Figure 4, it can also be seen that the expansionary unconventional monetary policy shock significantly increases Gini index of income inequality up to approximately 0.07 percentage points. The period of the biggest distributive impact of monetary policy is during the second year after the shock.

As an alternative method for the identification of a monetary policy shock, sign restrictions are also imposed in the case of the baseline specification. Following Uhlig (2005), this paper imposes sign restrictions for the first half a year after the shock<sup>6</sup>. An expansionary unconventional monetary policy shock is specified as the one that increases Federal Reserve total assets, and raises real output and prices<sup>7</sup>. No sign restrictions are imposed for the impact of a monetary policy shock on income inequality since it is the research question of the paper.

The results obtained with the application of the sign restrictions are presented in Figures 5, which includes the median responses with 16th and 84th percentiles as their confidence bands. As can be seen from the figure, an expansionary unconventional monetary policy shock significantly raises real output and prices in line with the corresponding results obtained with the recursive identification. Similarly, the shock also significantly increases income inequality up to 0.06 percentage points. Thus, unconventional monetary policy has significant distributive effect.

## **5.2. Modifications and Extensions of the Baseline Model**

As an alternative variable for monetary policy stance, the monetary base is used instead of Federal Reserve total assets in the VAR model. As another quantitative policy instrument, the monetary base (MBL) is employed in the literature (Gambacorta et al., 2014; Saiki and Frost, 2014) for the evaluation of the effect of unconventional monetary policy. The corresponding IRFs are depicted in Figure 6. As can be observed from the figure, all the obtained results are very similar to the respective IRFs from the case when Federal Reserve assets are considered as a monetary policy instrument. In particular, an unconventional monetary policy shock also significantly raises Gini index of income inequality, and its biggest impact is around 0.08 percentage points. Analogously, Saiki and Frost (2014) find that unconventional monetary policy increases income inequality in Japan.

The other considered indicator of unconventional monetary policy is the shadow rate (SR). Figure 7 reports the corresponding results. Since the shock is contractionary in this case, it leads

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<sup>6</sup> There are some concerns regarding the set identification by sign restrictions. Therefore, the Median-Target (MT) method proposed Fry and Pagan (2011) is also used to verify the validity of the IRFs obtained with the sign restrictions. The IRFs match well the MT responses testifying the validity of the IRFs analyzed in this paper.

<sup>7</sup> This paper also considers the cases when no sign restrictions are imposed on the effect of monetary policy on real output. The obtained results available on request are in line with the corresponding IRFs provided in this paper.

to the decreases in real output and prices. The responses are significant and in line with the previous results. The shock also significantly reduces Gini index of income inequality up to 0.08 percentage points. That is, this result is analogous to the previous responses of Gini index of income inequality.

To assess the robustness of the results with respect to the interpolation of the macroeconomic variables, another modification of the model is implemented. As mentioned earlier, the interpolated data on real GDP and GDP deflator are used for the estimation of the baseline model to evaluate the distributive effect of unconventional monetary policy. Nevertheless, the data on the monthly frequency are available for industrial production index, IPI, and consumer price index<sup>8</sup>, CPI, which are closely related to real GDP and GDP deflator, respectively. To check the robustness of the previously obtained results, the baseline model is modified by replacing real GDP and GDP deflator with the IPI (IPI09L) and the CPI (CPI09L), respectively. The resulting IRFs are presented in Figure 8. It can be observed that the IRFs are very similar to the corresponding results of the baseline case. They only differ by the larger response of real output in this case. In comparison with real GDP, the higher responsiveness of the IPI to an unconventional monetary policy shock is also found by Gambacorta et al. (2014).

For the identification of an unconventional monetary policy shock, implied stock market volatility index<sup>9</sup> (VIX) is included into VAR models by some of the related literature (Gambacorta et al. 2014; Janssen et al., 2015; Meinus and Tillmann, 2014). It serves as a proxy for financial risk and uncertainty. According to Gambacorta et al. (2014), the inclusion of the VIX into a VAR model facilitates to disentangle an exogenous unconventional monetary policy shock from endogenous responses to financial market uncertainty. In this sense, it is analogous to the inclusion of commodity prices into the VAR models of conventional monetary policy. In that case, the commodity price index serves as an indicator for future inflation and it is included into the VAR models for the identification of a conventional monetary policy shock (Christiano et al., 1996; Sims, 1992).

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<sup>8</sup> IPI and CPI are seasonally adjusted and are taken from FRED. The base years of the indices are rescaled to 2009 to be in line with the base year of the other series.

<sup>9</sup> The data source for the VIX is Chicago Board Options Exchange, CBOE.

As a robustness check for the baseline results, the VIX is added to the VAR model. In the ordering of the variables, it is incorporated just before Federal Reserve assets<sup>10</sup>, assuming that innovations to the VIX have instantaneous impact on the balance sheet. Figure 9 includes the estimated IRFs<sup>11</sup>. The results show that the response of the VIX to an unconventional monetary policy shock is not generally significant. The magnitudes of the responses of the other variables are relatively smaller in this case. Nevertheless, these responses are still significant and they display the same dynamics as they have in the baseline case.

One of the assumptions of the recursive identification scheme implemented above is that financial uncertainty has an immediate effect on unconventional monetary policy. Nevertheless, according to Gambacorta et al. (2014), unconventional monetary policy can also have instantaneous impact on financial market uncertainty, mitigating it. Therefore, the paper also applies the sign restrictions used in the baseline case with an additional restriction that unconventional monetary policy reduces financial market uncertainty. Figure 10 contains the results obtained for the VAR model extended with the VIX. While the magnitudes of the responses of the variables are similar to the corresponding results stated above, the impact of an unconventional monetary policy shock on the VIX is significant in this case. At the same time, the shock also significantly raises Gini index, analogously to the previous case.

In order to assess the impact of unconventional monetary policy on the different parts of income distribution, other income inequality measures are also employed in the empirical analysis. In particular, this paper considers the 90-50 and the 50-10 percentile ratios. The VAR model is modified by consecutively including the 90-50 ratio (P9050) and then the 50-10 ratio (P5010) instead of Gini index. The VAR models are then re-estimated, and the corresponding IRFs are identified by the contemporaneous restrictions.

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<sup>10</sup> Jannsen et al. (2015), and Meinus and Tillmann (2014) include the VIX into the VAR models after the monetary policy instrument in the orderings of their considered variables. Accordingly, the VIX is included into the VAR model also just after Federal Reserve assets. The results are not essentially affected by this change of the ordering of the VIX. Therefore, in the paper, the results are provided for only one scheme when the VIX is ordered just before Federal Reserve assets.

<sup>11</sup> The VIX is also added to the other considered VAR models of unconventional monetary policy. The obtained results available on request are in line with the IRFs provided in Figure 5.

As can be observed from Figures 11 and 12, the responses of real output and prices to an unconventional monetary policy shock have similar dynamics with the corresponding results in the case of the usage of Gini index. The responses of the 90-50 and the 50-10 ratios are also similar to the IRF of Gini index in the baseline case. In particular, the unconventional monetary policy shock significantly increases the 90-50 and the 50-10 ratios by around 0.003 and 0.002 units, respectively. In comparison, the result for Gini index is more significant. This is especially the case with the response of the 50-10 ratio. Nevertheless, the responses of the 90-50 and the 50-10 ratios are still significant.

This paper assesses the impact of unconventional monetary policy on wage inequality (GINIW). Figure 13 reports the IRFs for this case. As can be seen, the unconventional monetary policy shock reduces the Gini index of wage inequality up to 0.06 percentage points. Thus, the result is in contrast with the response of Gini index of income inequality. That is, expansionary unconventional monetary policy reduces wage inequality but it increases total income inequality.

To have a broader picture of the distributive effects of monetary policy through its channels, this paper considers the unemployment rate (UR), as an indicator for labor income and real economic activity, and the S&P 500 Index (SP09L) of stock prices, as a proxy for financial income<sup>12</sup>. The extension of the VAR model with these variables allows to observe the impact of monetary policy on income inequality via its effects on labor and financial income. Figure 14 shows that the monetary policy shock raises wage inequality through the increase in the unemployment rate. Figure 15 indicates that, at the same time, the shock reduces stock prices and income inequality. That is, the impact of monetary policy on stock prices prevails over its effect on the unemployment rate.

### **5.3 Variance Decomposition**

To assess the relative importance of an unconventional monetary policy shock, the variance decomposition analysis is implemented in this paper. It allows decomposing the total variance of Gini index of income and wage inequality into the percentages attributable to an unconventional monetary policy shock identified by the contemporaneous restrictions. It is informative to

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<sup>12</sup> The data source for the unemployment rate and the S&P 500 Index is FRED.

observe the contribution of the shock to the variation in Gini indices. The results are presented for the first two years after the shock in line with the period considered for the IRFs.

In Table 2, this paper provides the results for the variation in Gini indices due to an unconventional monetary policy shock. The obtained results indicate that the unconventional monetary policy shock significantly affects the variation in Gini index of income and wage inequality with the highest impact of 40.71 percent and 12.53 percent, respectively. The shocks of the other variables accounts for the rest of the variation in Gini indices. In particular, it is explained by the shocks of real GDP and GDP deflator as well as by the own shock of Gini indices.

## **6. Conclusion**

This paper evaluates the overall impact of unconventional monetary policy on income inequality in the case of the USA. The results indicate that the expansionary unconventional monetary policy shock raises Gini index up to 0.07 percentage points. At the same time, the shock reduces Gini index of wage inequality up to 0.06 percentage points. This distributional effects of unconventional monetary policy are significant at the 95% confidence level. The results are robust to alternative identification approaches of the unconventional monetary policy shock, and the application of the interpolation and the mixed frequency methods for income inequality data.

The impact of monetary policy on the different parts of income distribution is assessed in this paper. The obtained IRFs reveal that unconventional monetary policy significantly affects the upper and the lower parts of income distribution measured by the 90-50 and the 50-10 percentile ratios, respectively. In particular, expansionary unconventional monetary policy increases these percentile ratios. This paper also evaluates the impact of unconventional monetary policy on income inequality through its distributions channels. The results show that the unconventional monetary policy increases income inequality because its effect on financial income outweighs its impact on labor earnings.

This paper provides the results for the variance decomposition analysis for income and wage inequality attributable to the unconventional monetary policy shock. The results indicate that the



unconventional monetary policy shock has a significant contribution to the variation in Gini index of income and wage inequality. Thus, all these distributional effects of unconventional monetary policy should be considered during its implementation and along with other macroeconomic policies designed to decrease inequality.

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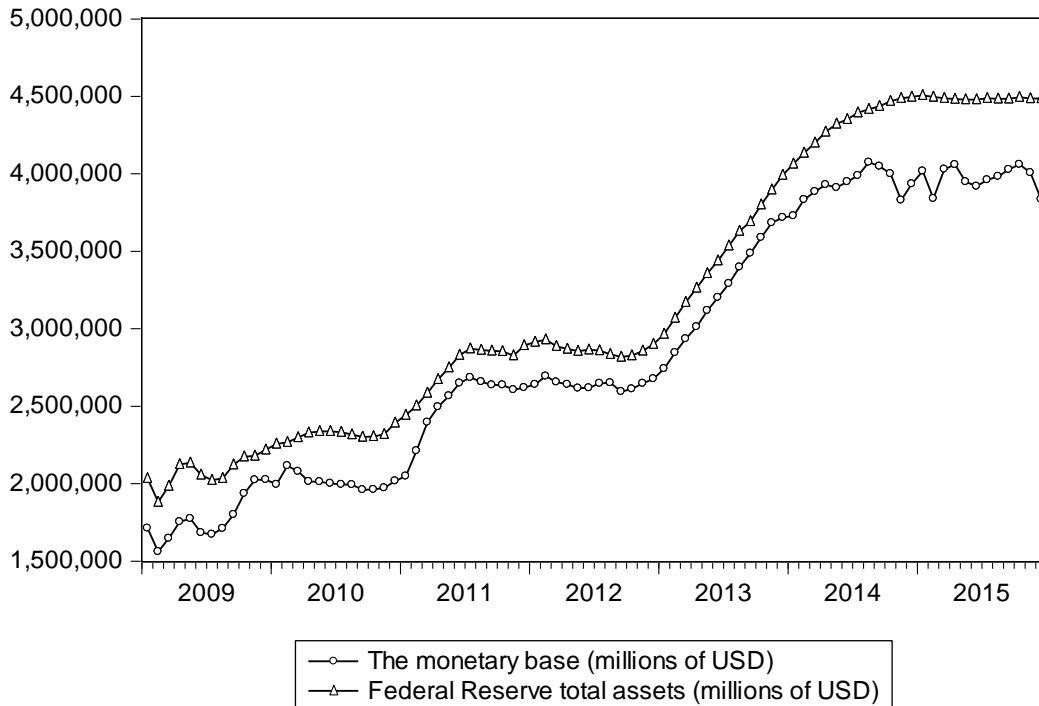
## Appendix

**Table 1: Income Composition**

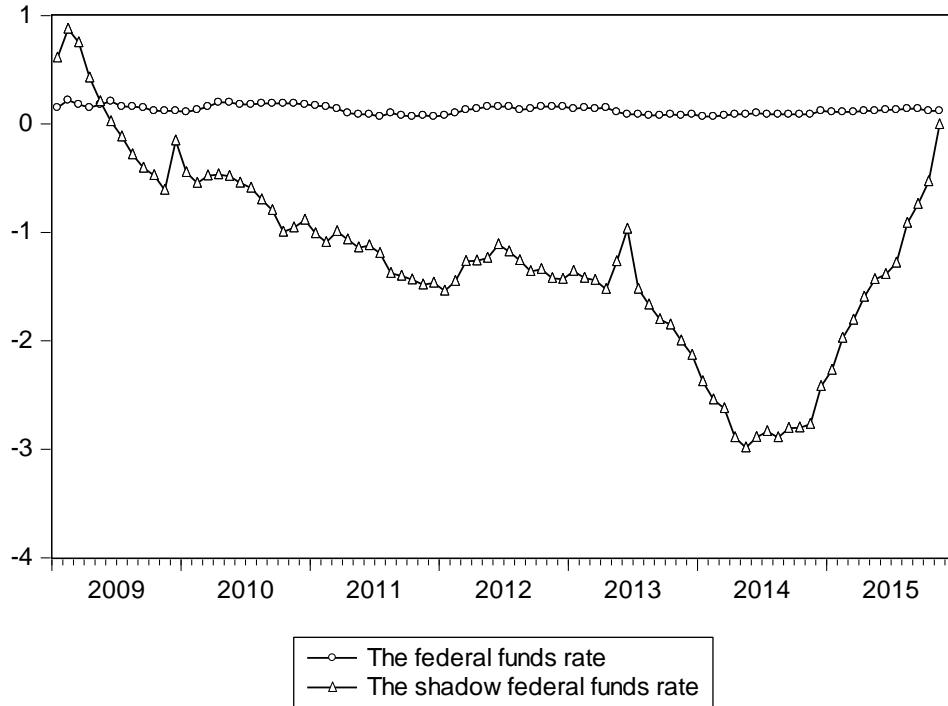
	Wealth quintiles					Top 1%
	1st	2nd	3rd	4th	5th	
Share of total wealth	-0.2%	1.1%	4.5%	11.2%	3.4%	33.6%
Composition of income (in %)						
Labor Income (from wages)	78.9	81.2	78.6	77.1	51.4	30.2
Financial income (from capital and bus. interests)	2.0	4.7	7.2	10.2	39.7	65.7
Transfer income (from government programs)	15.5	12	12.4	12.1	8.2	3.6

Source: 2007 Survey of Consumer Finances, in Diaz-Gimenez, Glover, and Rios-Rull (2011).

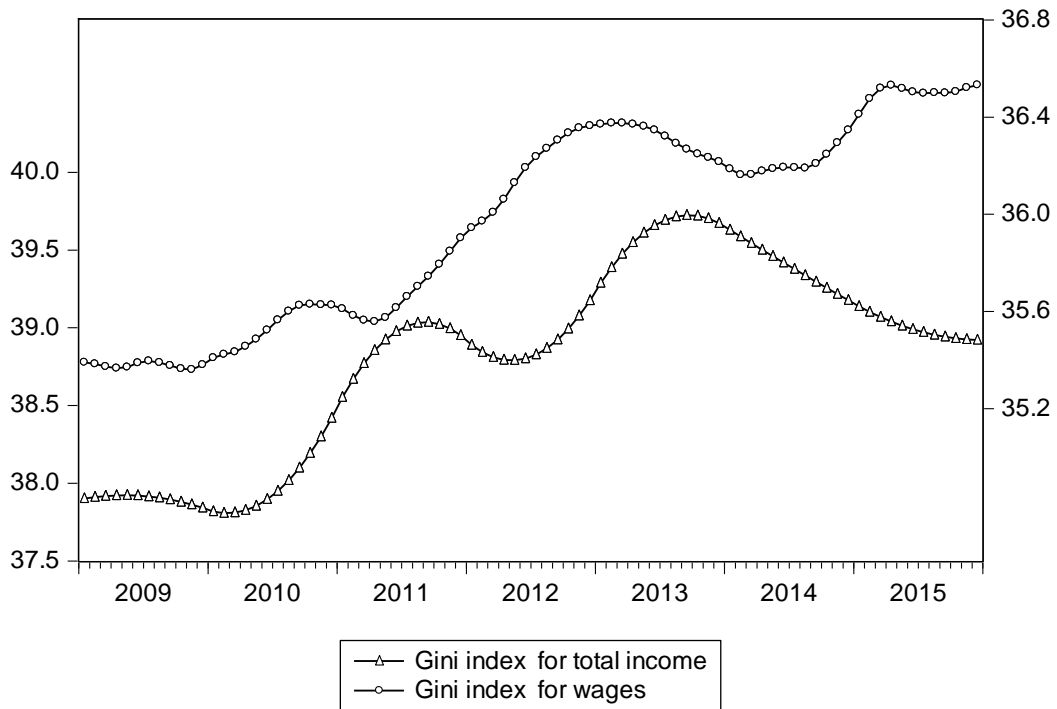
**Figure 1: Federal Reserve Total Assets and the Monetary Base**



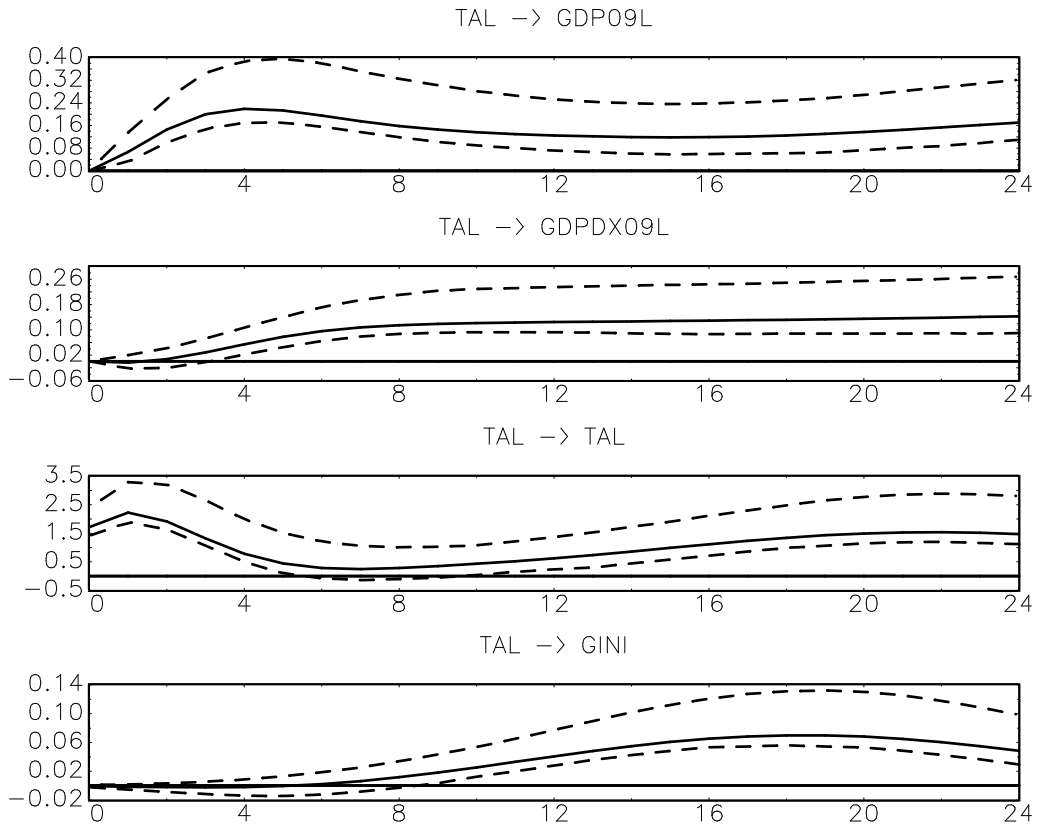
**Figure 2: The Federal Funds Rate and its Shadow Rate**



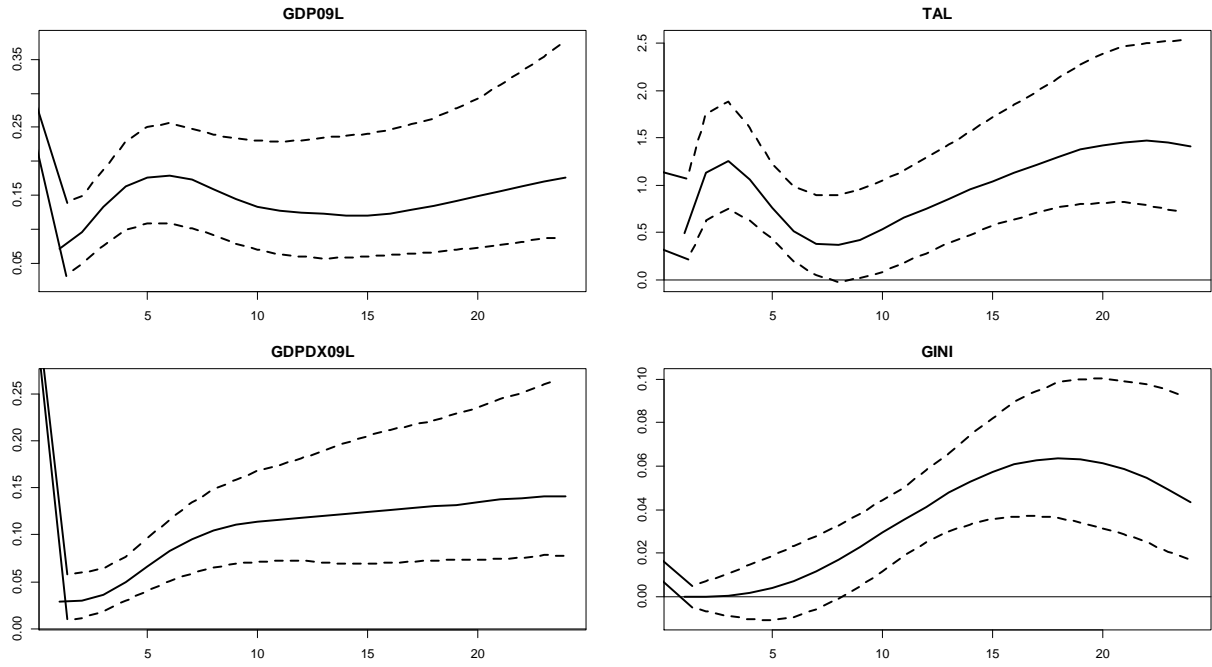
**Figure 3: Gini Index for Wages and Total Income**



**Figure 4: The IRFs to an Unconventional Monetary Policy Shock  
(The Baseline Model)**

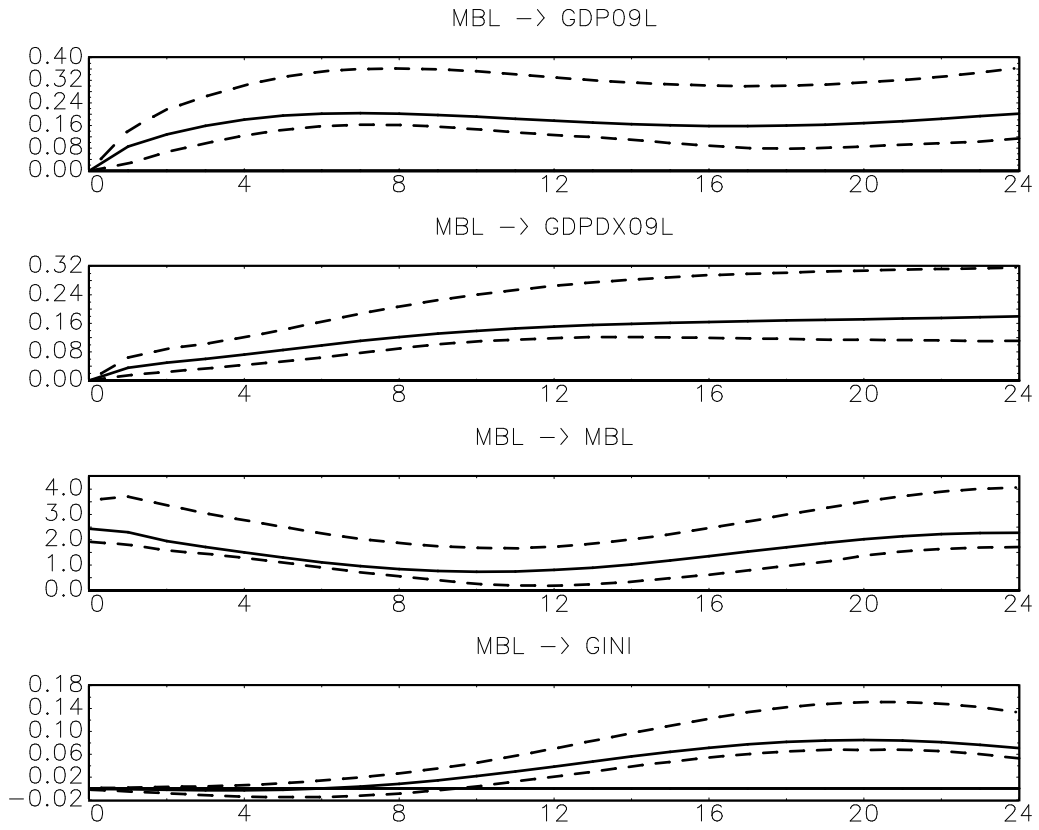


**Figure 5: The IRFs to an Unconventional Monetary Policy Shock  
(Identification of a Monetary Policy Shock with Sign Restrictions)**

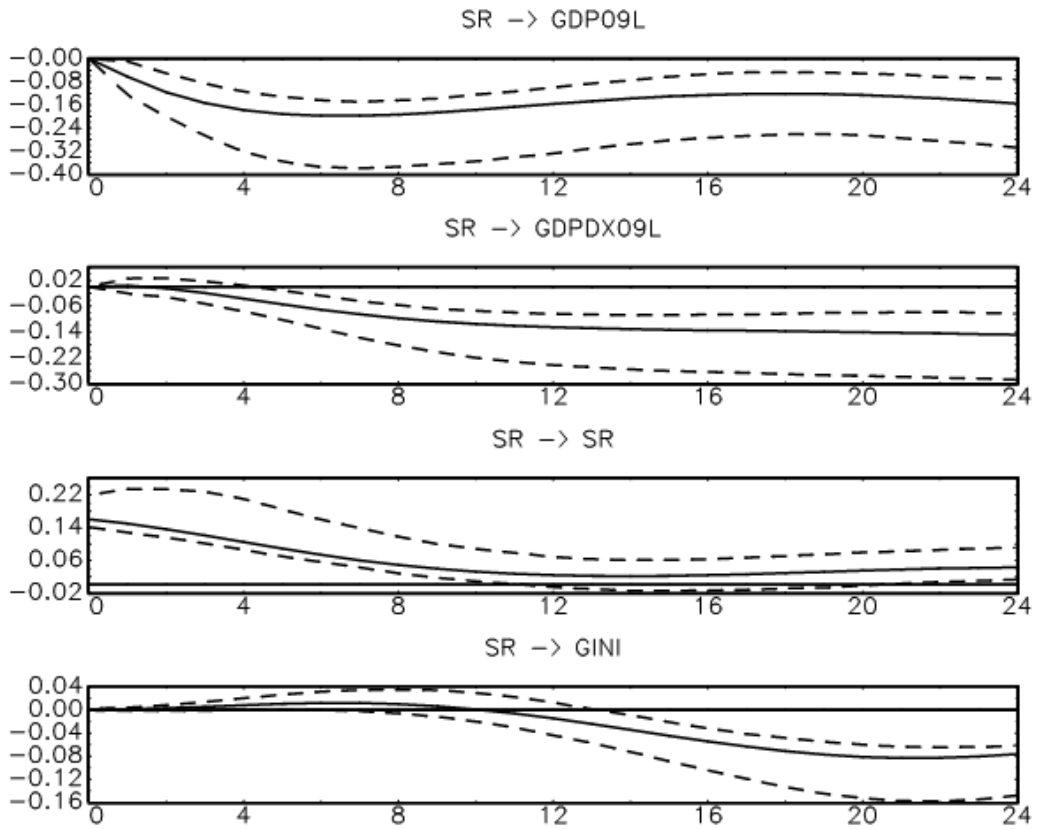




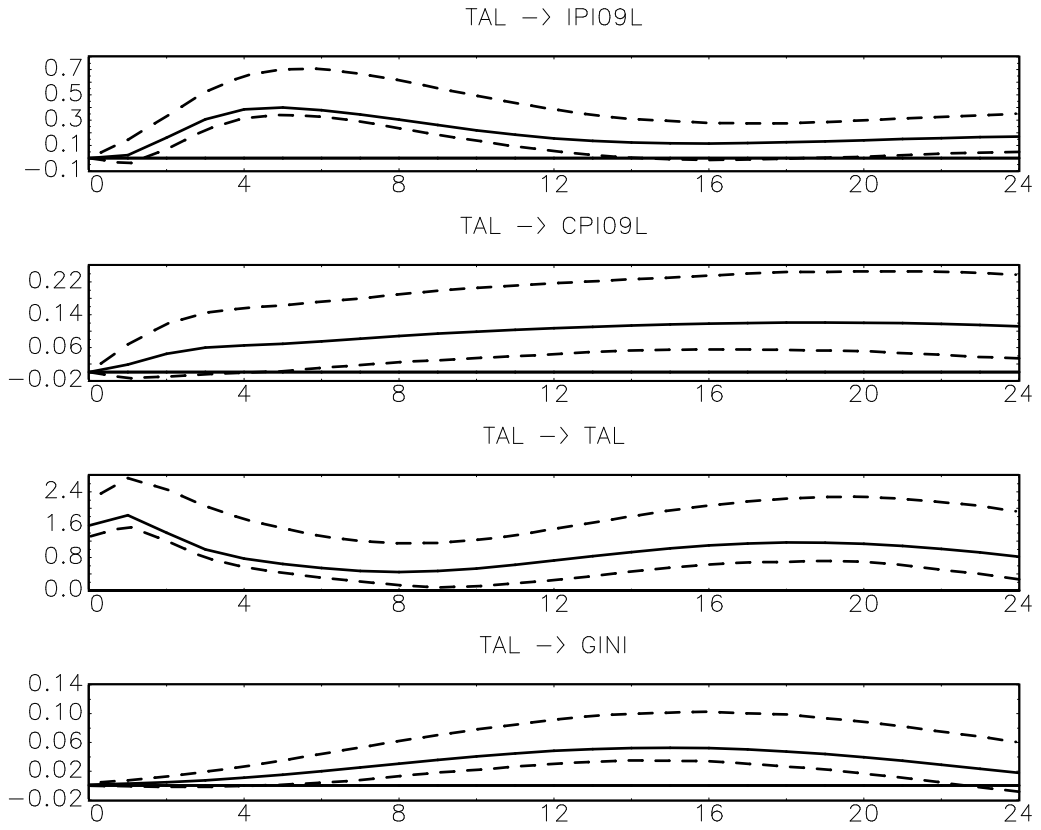
**Figure 6: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with the Monetary Base)**



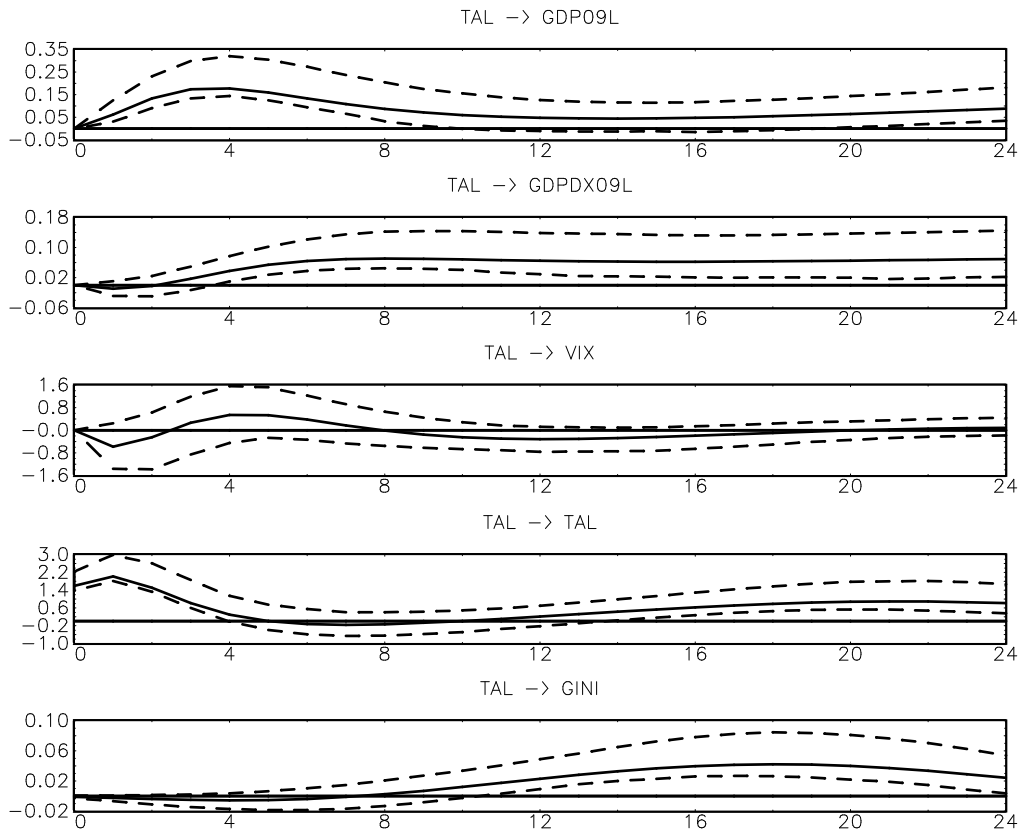
**Figure 7: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with the Shadow Rate)**



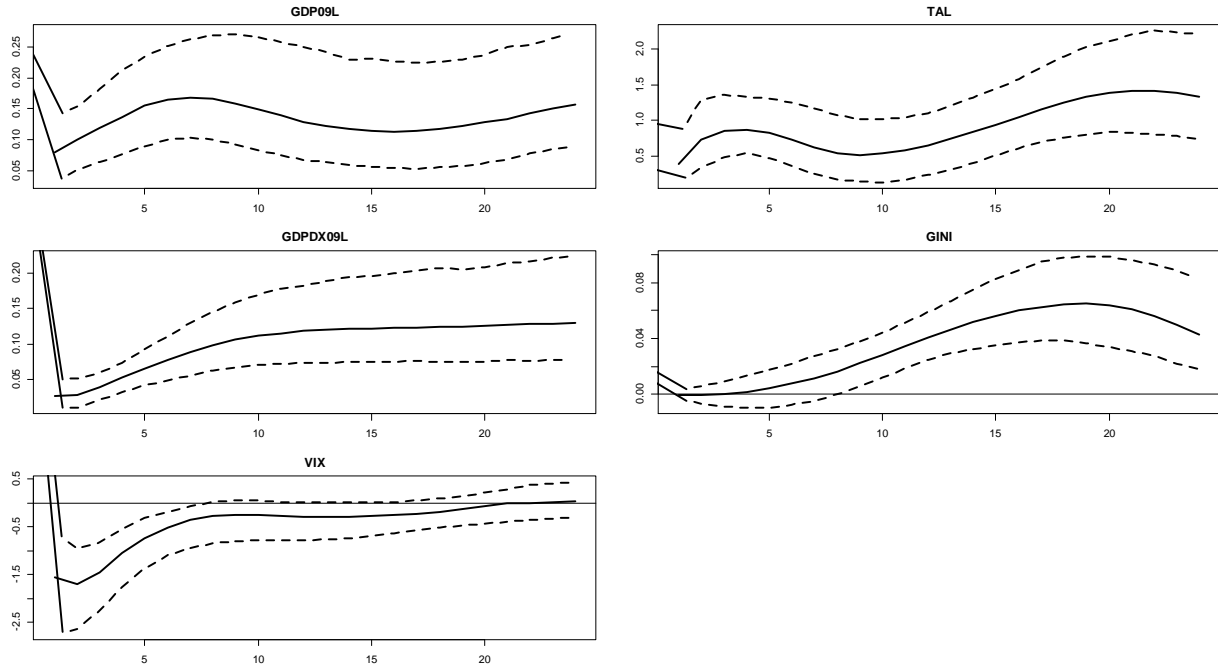
**Figure 8: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with the IPI and the CPI)**



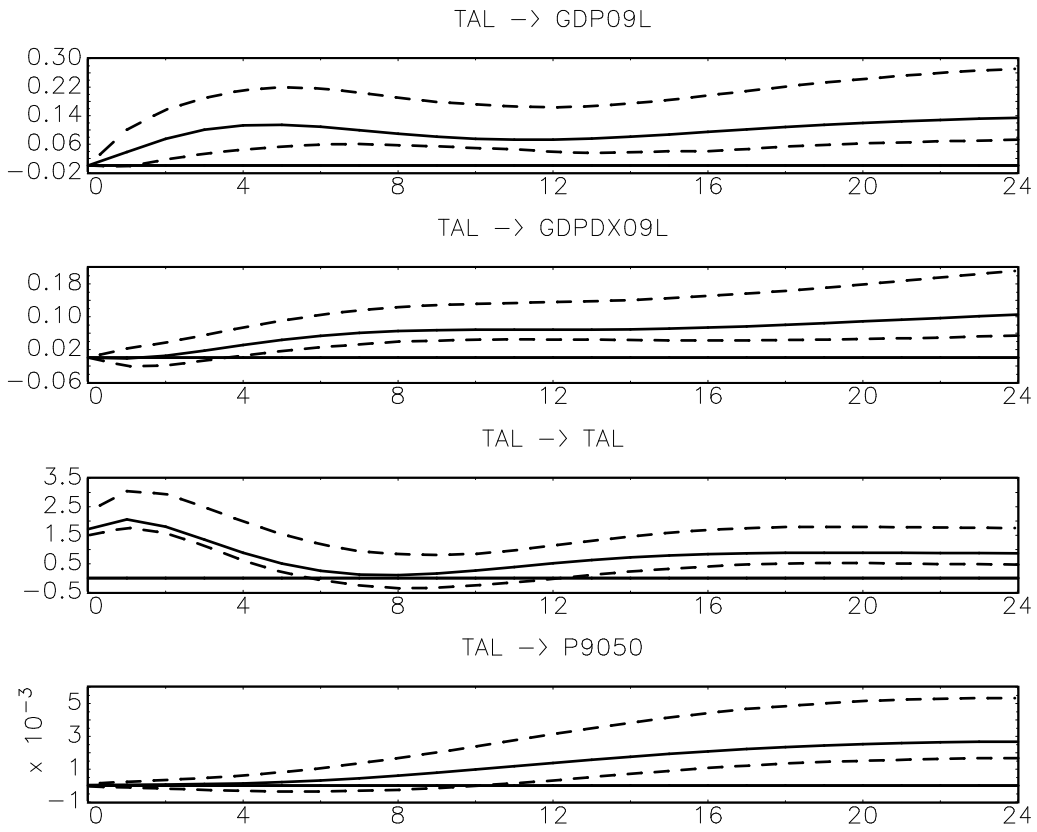
**Figure 9: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with the VIX)**



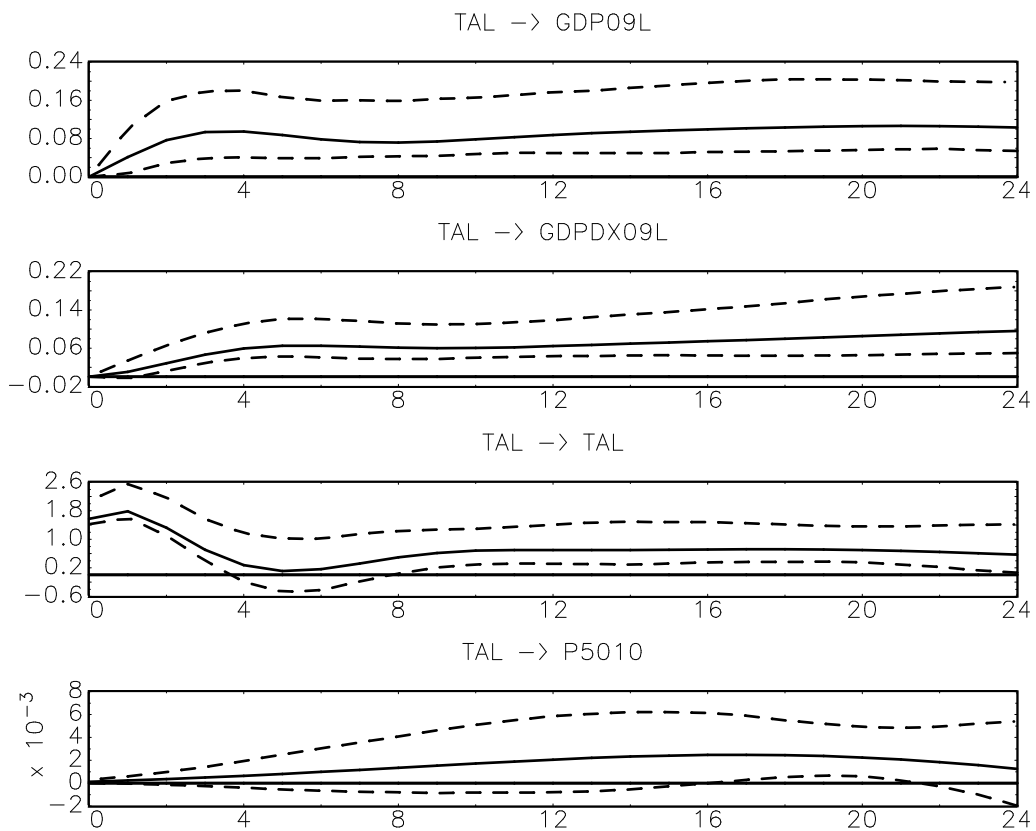
**Figure 10: The IRFs to an Unconventional Monetary Policy Shock  
(Identification of a Monetary Policy Shock with Sign Restrictions)**



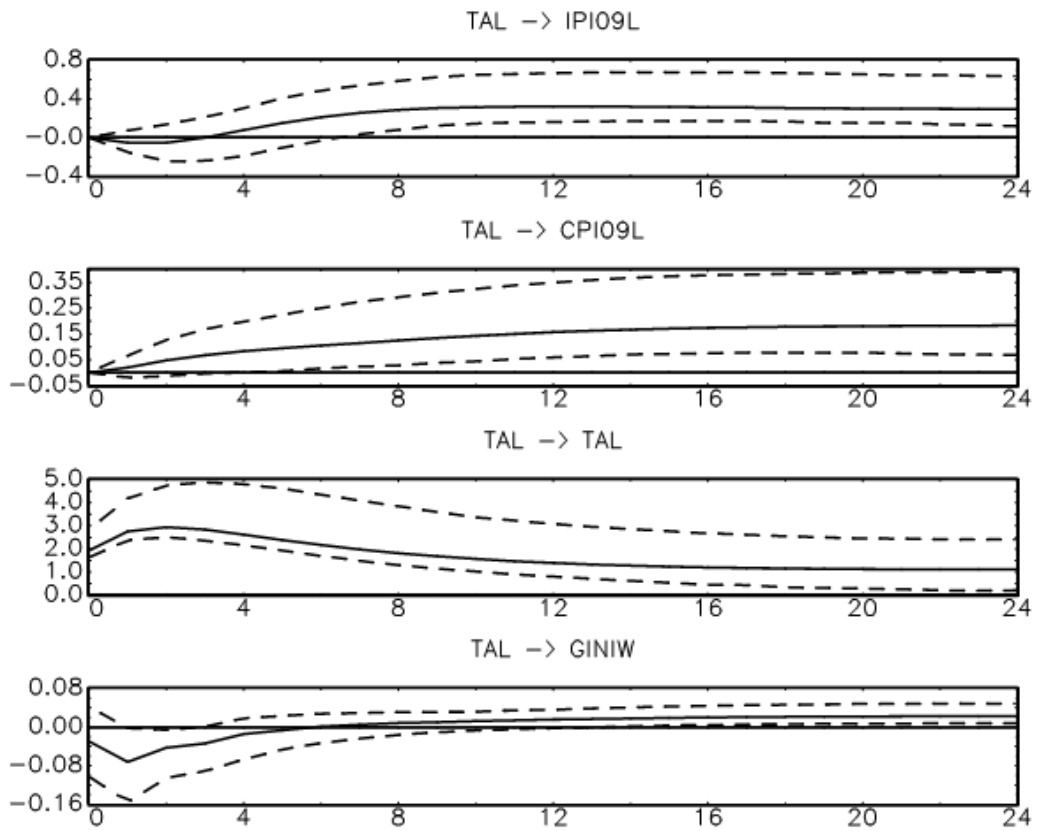
**Figure 11: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with the 90-50 Ratio)**



**Figure 12: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with the 50-10 Ratio)**

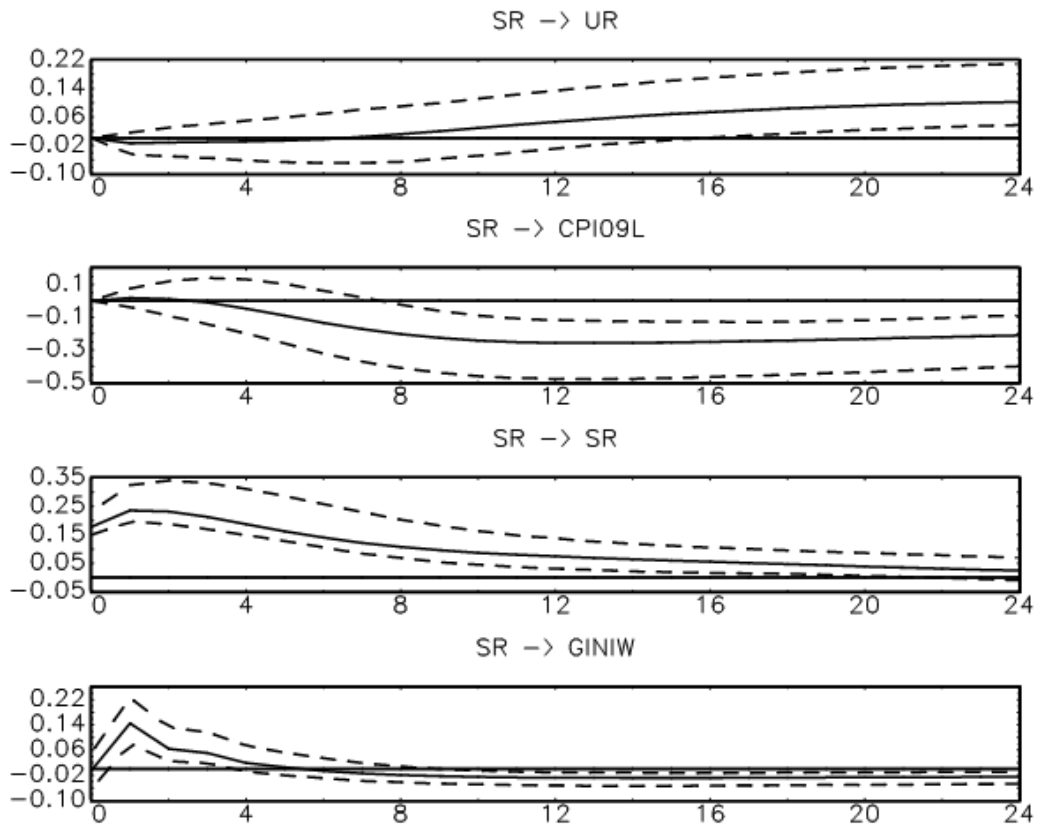


**Figure 13: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with Gini Index for Wages)**

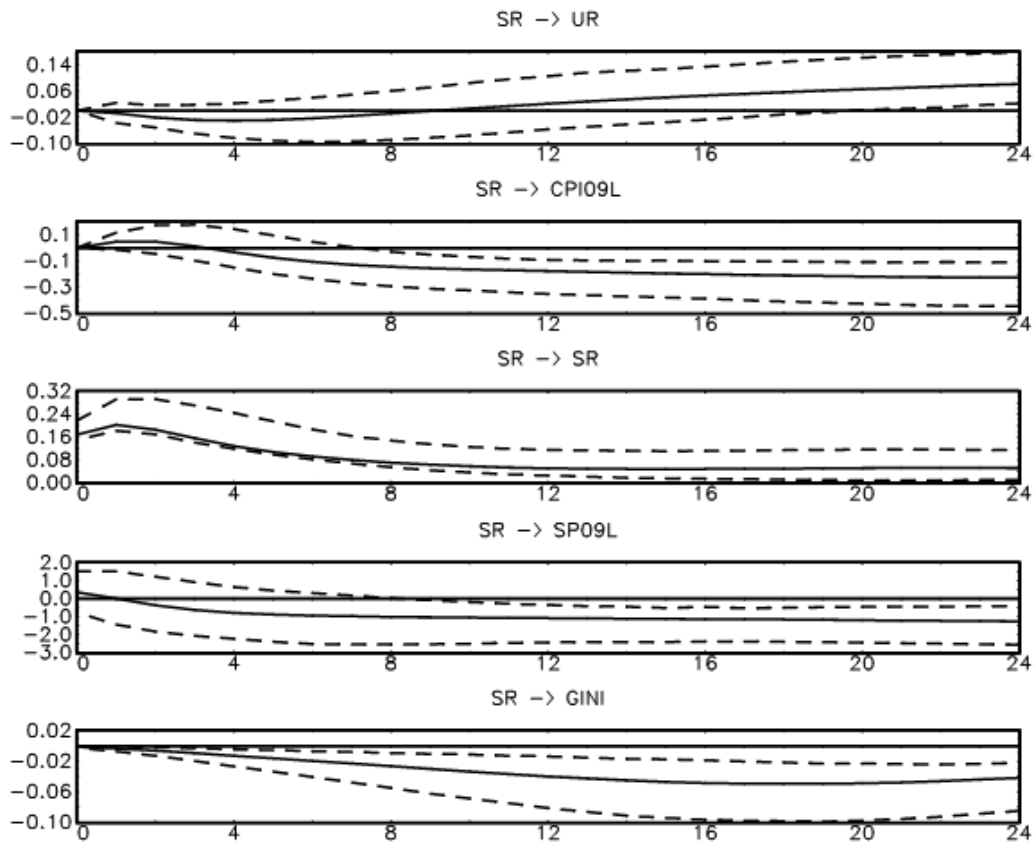




**Figure 14: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with Unemployment Rate and Gini Index for Wages)**



**Figure 15: The IRFs to an Unconventional Monetary Policy Shock  
(The Model with Distributive Channels)**



**Table 2: The Variation in Gini index due to the Unconventional Monetary Policy (UCM) Shock**

Periods (in Months)	GINIW due to UMP Shock	SE	GINI due to UMP Shock	SE
1	2.89%	0.23	0.92%	2.93
2	5.16%	0.33	1.03%	3.26
3	7.50%	0.41	1.07%	3.83
4	9.16%	0.48	0.99%	4.37
5	10.25%	0.53	0.78%	4.8
6	10.85%	0.58	0.53%	5.1
7	11.11%	0.62	0.46%	5.39
8	11.17%	0.66	0.93%	5.86
9	11.12%	0.69	2.26%	6.68
10	11.06%	0.73	4.66%	7.82
11	11.02%	0.76	8.10%	9.08
12	11.03%	0.78	12.26%	10.28
13	11.09%	0.81	16.72%	11.32
14	11.20%	0.84	21.06%	12.18
15	11.35%	0.86	25.00%	12.9
16	11.52%	0.88	28.40%	13.51
17	11.70%	0.90	31.26%	14.05
18	11.87%	0.92	33.60%	14.54
19	12.03%	0.94	35.50%	14.98
20	12.17%	0.96	37.03%	15.37
21	12.29%	0.98	38.27%	15.71
22	12.39%	1.00	39.27%	16.02
23	12.47%	1.02	40.07%	16.28
24	12.53%	1.03	40.71%	16.5

*Notes:* The variation in Gini index is in percent. Standard errors (SE) are provided based on 1500 bootstrap replications.