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The Effects of Monetary Shocks on Job Polarization

Master's thesis

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Name and signature of supervisor………………………………………………….

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I have written this master's thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

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Abstract

This paper analyzes the effects of monetary policy on job polarization using an instrumental variable structural vector autoregressive model and high frequency data for identification of monetary innovation. The paper finds that after expansionary monetary shock middle skill employment share drops by 0.05% during the period from 1983 until 2012 in the USA. The composition of employment changes towards increasing share of low skilled relative to middle skilled. Innovations in monetary policy explain up to 11.5% of forecast error variance in different skill groups. This study also shows that employment variables have asymmetrical reaction to expansionary and contractionary monetary policy shocks.

JEL Classification: E24, J21, J24

Keywords: monetary policy, job polarization, composition of employment, SVAR

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Introduction

Developed economies have experienced a great deal of job polarization for example see Autor and Dorn (2013), Goos et al. (2014), Bredemeier et al. (2017) as recent examples that focus on labor market dynamics. Job polarization is characterized by increasing employment of low and high skilled employees compared to middle skilled. It is accompanied by wage growth polarization, which means faster simultaneous growth of lower and upper tail of wage distribution than in the middle as shown by Acemoglu and Autor (2011). Two most common explanations of such trends are routine biased technological change and increasing offshoring. Deep understanding of job and wage polarization is crucial because it creates grounds for welfare differences in society through greater earnings inequality.

Recently Furceri et al. (2016), Coibion et al. (2017) have focused on the effect of monetary policy on inequality. Based on different substitutability between capital and labor in different occupations, monetary policy can also play a big role in labor market polarization. As middle skilled workers usually perform routine tasks and can be replaced by capital (for example, computer software), expansionary monetary policy would decrease price of capital and can lead to reduction of middle skill employment.

Bredemeier et al. (2017) have developed a model, which explains how fiscal shocks influence employment dynamics in different occupational groups. Following their logic, an expansionary monetary shock leads to increased demand and firms seek for more inputs. At the same time, relative input prices shift, so that it is more cost-effective to engage capital instead of labor. As a result, demand for labor increases less than proportionally to output. A rise in capital usage leads to a drop in marginal productivity of middle skilled labor compared to the low skilled or high skilled. Considering this, firms increase demand for low and high skilled labor more than demand for middle skilled.

The topic of labor market polarization has been discussed in details for more than 20 years, see Bluestone and Harrison (1988), Katz and Murphy (1992) or Levy and Murnane (1992) for early examples. Labor market polarization has been documented in many countries, there is evidence of it in the USA, the United Kingdom (Goos and Manning, 2007), developed European countries like Austria, Italy, Norway, Portugal etc. (Goos et al., 2009) and developing countries (Acemoglu, 2002; Sanchez-Paramo and Schady, 2003; Medina and Posso, 2010). However, to the best of my knowledge there are no papers that try to find out how monetary policy and polarization are connected.

The aim of the paper is to analyze the effect of monetary policy shocks on employment of different labor market groups, in particular on the low, middle and high skilled groups. The paper studies following questions. Do monetary policy shocks influence job polarization? If yes, does a contractionary policy shock increase or decrease polarization? Is there asymmetry in responses to positive and negative monetary shocks? Is effect of monetary policy economically important? I expect that monetary policy shock has influence on labor market polarization. After negative monetary shock the share of middle skilled employees decreases, while there is an increase or no change in shares of low and high skill employment. The effect of monetary tightening shock is stronger than monetary expansion shock.

In order to achieve aim and answer questions, I employ a proxy structural vector autoregressive (SVAR) methodology and high frequency information for exogenous monetary shock identification. I use unexpected movements in futures rate to detect impact of monetary policy shock on market interest rates and then use it as instrumental variable. Using external instrument, covariance restrictions are obtained and the structural shocks are identified. The approach follows the recent literature of identifying shocks in a VAR framework with external instruments as in Gertler and Karadi (2015), Mertens and Ravn (2013) and Stock and Watson (2012). I use monthly occupational data from the USA and divide occupations into middle, low and high skill occupation groups to create a measure of polarization as in Acemoglu and Autor (2011). The dataset covers the period from January 1983 until June 2012.

I show that after expansionary monetary shock there is a decrease in middle skilled employment by 0.05%. I also find evidence that there is a shift from middle skilled group to low skilled. The shift to high skilled group is not so clear, which can be a sign that it is easier for middle skilled to switch to performing low skill task than high skill.

I find that the effect of monetary tightening shock is stronger than monetary expansion shock. Using forecast error variance decomposition I show that contribution of monetary shock has the same magnitude as its contribution to industrial production. Innovations in monetary policy explain up to 11.5% of forecast error variance in different skill groups.

To check robustness I perform series of alternative estimations. Baseline results are robust to using non-detrended employment shares, first differenced employment shares and excluding the crisis of 2008–2009. I also provide responses of employment variables to monetary shock using Cholesky identification. I run proxy SVAR model for 3 periods (January 1983 – December 1992, January 1993 – December 2002, January 2003 – June 2012) and find that the reaction of employment in different groups is not the same which might be connected to change in pace and direction of technological development.

The rest of the paper is organized as follows. Section 1 describes possible linkages between monetary policy and employment polarization and presents reasons that might lead to polarization. Section 2 explains methodology and data used. Section 3 presents the main results and robustness checks. Section 4 concludes.

1. Literature review

In this section I provide reasoning why monetary policy may have effect on employment polarization. I also discuss which factors found in the literature may have influence on labor market polarization.

1.1 The link between monetary policy and job polarization

There are a growing number of studies that focus on the effect of policies on labor market outcomes. I study the effect of monetary policy on job polarization. To the best of my knowledge there is no other papers that focus on the same subject. The topic is closely related to articles that study how monetary policy affects inequality. Coibion et al. (2017) consider different forms of inequality including labor earnings inequality. Using micro-level data for the USA they find that contractionary monetary policy shock deepens inequality in labor earnings by lowering income of low-wage households and increasing income of high-wage households. Same effect of contractionary monetary policy is found by Furceri et al. (2016) using data for 32 developed countries. The authors also find that the effect of monetary policy depends on state of the economy (stage of business cycle), type of monetary policy (expansionary or contractionary) and redistribution policy of the country. Specifically, the effect of shock is stronger during economic expansions than recessions, contractionary monetary shock has stronger effect on inequality than expansionary and countries with limited redistribution policies experience greater effects of monetary policy. Additionally, there are papers, which study the effect of fiscal policy on job and wage polarization. Using American employment data Bredemeier et al. (2017) find that after governmental spending shock employment in pink-collar occupations

(occupations in sales, service and office) rise, while it does not have effect on blue-collar occupations (occupations in routine manual occupations). Mertens and Ravn (2013) show that decrease in income tax increases employment.

In this study, capital plays a role of a substitute or complement to labor. It is a substitute for labor in performing cognitive and manual activities, which we can describe by very accurate rules, for example, calculating or sorting as in Autor et al. (2003). Such activities can be defined as routine tasks and are usually performed by middle-skilled workers. At the same time, it is possible to program a machine to follow certain rules and perform routine tasks instead of workers. Capital can also be complementary to performing non-routine tasks, where an employee has to solve complex problems and use soft skills (for example, driving a car or writing textbooks). In this case, capital makes the work easier and employee can be more productive. Non-routine tasks are performed by either high skilled or low skilled workers.

Taking into account the substitutability between capital and labor, monetary policy can have impact on labor demand. Autor et al. (2003) formalize the connection between capital and labor in their canonical model to explain increasing demand for more skilled workers. In the model, they use only two forms of labor inputs – routine and non-routine. Educated (high skilled) workers have comparative advantage in performing non-routine tasks, while non-educated (low skilled) perform routine tasks. Declining price of high technology is a driving force of changes in skill demand. In the canonical model wage of routine workers is equal to price of capital it can be replaced with. Assuming that the central bank decreases interest rate and capital becomes cheaper, the wage of routine task performers decreases, while the relative wage for non-routine increases. It means that the worker is no longer indifferent between performing routine or non-routine tasks and will switch to the latter one. As a result, there will be a decrease in the number of routine workers and an increase in the number of non-routine ones. Simultaneously, firms will invest in capital more, which will decrease demand for routine workers and increase demand for non-routine workers.

A wider model with three types of labor (high, middle, low skilled workers) and capital, that can replace workers on tasks they used to perform, is present in the study by Acemoglu and Autor (2011). The authors criticize the canonical model for one-to-one connection between skills and tasks (low skilled perform only routine tasks and high skilled only non-routine) and for assuming that output is produced using skills as direct input. Moreover only two types of labor are used in canonical model and as a result it fails to explain job polarization trends found in the data. Differently from the canonical model Acemoglu and Autor (2011) assume that each worker has high, middle or low skills, which can be used to perform tasks. Tasks are units of work needed to produce output. Following Lemma 1 offered by the authors, the set of tasks is divided into three subsets. The first subset of tasks is performed by the high skilled, the second one by the middle skilled and the third one by the low skilled. Importantly, the boundaries of tasks subsets endogenously change in response to changes in technology and the supply of skills. Capital is used in tasks performed by middle skilled workers. The price of capital r is assumed to be fixed. The use of capital instead of middle skill employees implies that middle skilled will have to switch to performing tasks of low skill and high skill workers. The wage of middle skilled relative to both high and low skilled decreases. The change in relative wage of the high and the low skilled depends on how good the middle skilled can substitute the former in performing their tasks. Assuming again that interest rate decreases and there is an increase in product demand, firms require more inputs into production. Price of capital drops and it becomes more profitable to engage capital instead of perfectly substitutable middle skilled labor. Therefore, the firm will increase use of capital more than proportionally to increase in production. Middle skilled labor will have to switch to performing low or high skilled tasks.

Another model developed by Acemoglu and Autor (2011) assumes that development of new technologies depends on the supply of skills in the economy and takes into account possibility of offshoring. In the monopolistically competitive market firms make investments into technologies that are used to create new machines. Final goods producers use these new machines. Technological change is biased towards dominating skill level in economy. If the central bank decides to decrease interest rate, companies will evaluate what is bigger – expected return from investing into new technologies or return on funds placed in the bank. In case first option is more attractive, they will invest into development of technology that can be used to perform middle skill tasks (assuming they are prevailing in the economy). This will lead to a further polarization on labor market.

Jaimovich and Siu (2012) show that employees who perform routine tasks lose their jobs during recessions, while non-routine employment grows or stays the same. Moreover, during economic recovery, those who used to perform routine tasks stay jobless and employment never recovers even in middle or long term. The authors also find that the dynamics of middle skill employment drives dynamics of total employment during and after recession. It is supported by findings of Foote and Ryan (2015) who state that middle-skilled occupations are more cyclical. They explain it by the fact that industries that tend to employ big share of middle-skilled workers are more volatile during the cycle. Technological development and offshoring has reduced prospects of middle-skilled and created a polarization trend. In this case recessions just “speed-up” the unavoidable process of routine employment decline.

Using New Keynesian business-cycle model framework Bredemeier et al. (2017) show how fiscal shocks influence pink and blue collar employment. In the context of my research, pink collar group incudes routine cognitive and non-routine manual occupations and blue collar group includes routine manual occupations. The authors assume that it is easier to substitute blue collar workers with capital than pink collar workers. Bredemeier et al. (2017) include households, firms and a government that conducts monetary and fiscal policy into the model and show that fiscal expansion leads to rise in pink collar employment relatively to blue collar employment.

Making an analogy with mechanism of fiscal policy transmission described in the paper, expansionary monetary shock leads to increased demand for output and firms require more inputs. As supply of labor is more inelastic than supply of capital, relative input prices shift, so that it is more cost-effective to engage capital instead of labor. It leads to a rise in demand for capital more than proportionally to output. A rise in capital usage leads to a drop in marginal productivity of labor that can be substituted with capital relative to the other type of labor. Considering this, firms increase demand for low and high skilled labor more than demand for middle skilled. They substitute middle skilled labor with capital. Following studies made by Jaimovich and Siu (2012) and Foote and Ryan (2015), middle skilled, who have lost jobs during recession are not likely to get their jobs back after recession as their tasks are already performed by capital (machines).

1.2 Other reasons of labor market polarization

Even though monetary policy can influence process of polarization it is not the primary reason of it. In the literature, one of the dominating hypotheses is based on routine-biased technological change. Baumol's (1967) model of unbalanced expansion has created a ground for this hypothesis. This is a two sector model (technologically progressive and non-progressive) in which more labor will be concentrated in non-progressive sector after some time even though the output does not change. The relative costs of output in non-progressive sector will increase. In turn, the routine-biased technological change hypothesis states that changes in technologies (like computerization, automation) happen in such a way that technologies can replace labor in routine tasks and change demand for human skills (Autor et al., 2006; Acemoglu and Autor, 2011). Autor and Dorn (2013) find that changes in employment structure of local labor markets are predetermined by strength of specialization in routine activities. The higher is routine specialization, the faster computer technologies are adopted and the faster routine employment drops. Another hypothesis is skill-biased technological change, which explains a rise in demand for more educated workers. For example, Michaels et al. (2014) shows that countries and industries with rapid increase of ICT (information and communications technology) have higher demand for employees with higher education and no changes in demand for least educated employees. However, skill-biased technological change does not explain job polarization, while routine-biased technological change does (Goos et al. 2014).

Some economists consider offshoring to be another reason of U-shaped skill distribution of employed. Grosmann and Rossi-Hansberg (2008) point out that international trade nowadays is characterized not by trade in goods, but trade in tasks and that routine tasks are perfect for offshoring since it is easy to control them even being abroad. Decreasing costs of transportation has created favorable conditions for offshoring. Unlike routine-biased technological change hypothesis, for which economists find strong empirical support, the offshoring hypothesis does not have such clear evidence. On the one hand, Foster-McGregor (2013) find that offshoring has negative effect on employment with all skill levels, but the impact is particularly stronger for middle skilled. The negative effect of offshoring on wages for routine occupations is evident in paper by Ebenstein et al. (2014). On the other hand, Goos et al. (2014) show, using data of 16 European countries, that technological change has more influence on change in employment structure, than offshoring. The result is further supported by Autor and Dorn (2013) using data for the United States and Michaels et al. (2014) where offshoring sometimes has significant relationship with employment variables and sometimes has not.

Another explanation of polarization present in the literature is increase in immigration. On the example of the USA, Wright and Dwyer (2003) show that during 90's increase in lower skill occupations employment happened because of increasing number of Hispanic immigrants. Immigration also had influence on rise of high-skill employment but in a lower degree. Mandelman and Zlate (2016) state that while routine tasks are offshored, non-routine manual tasks are almost impossible to offshore and as a result they are performed by immigrants. Boom in immigration during recent decades has led to increasing number of low skill employees and lowering of their earnings. Similar results are found by Ottaviano et al. (2013). They state that rise in immigration has increased number of manual tasks performed in a country, instead of offshoring. Furthermore, lower costs of offshoring and immigration has shifted native employees to performing abstract non-routine tasks.

Labor market institutions are also regarded as potential reasons of polarization, but very small number of authors study its effect. For example, Autor (2010) states that wage floors, labor unions and unemployment benefits have impact on trend in employment shares, but this impact is not supreme. Albertini et al. (2015) based on their model find that higher minimal wages and unemployment benefits make the process of transition from middle to low skill employment slower and that higher dismissal cost decelerate employment shrinkage.

2. Data and econometric method

This section describes methodology of estimating the effects of monetary shock on employment. It also provides details on the data and construction of skill-based employment measure.

2.1 Econometric Method

As the main goal of current analysis is to explore the effect of monetary policy shock on job polarization, it is important to ensure that shock is exogenous. Since the central bank's decision about interest rate is influenced, for example, by state of country's economy and at the same time the interest rate affects the future path of the economy, the right identification strategy should be used.

I conduct the estimation using proxy structural vector auto regression model. I define a monetary shock in two steps. As a first step, I use high frequency data to detect impact of monetary policy shock on market interest rates and then use it as instrumental variable. In particular, I follow the approach offered by Gertler and Karadi (2015) who use surprises in federal funds futures rate after Federal Open Market Committee (FOMC) announcements measured as:

$$(E_t i_{t+j})^u = f_{t+j} - f_{t+j-1}, \qquad (1)$$

where:

$(E_t i_{t+j})^u$ – Surprise in price for interest rate futures that expire in month t+j;

f_{t+j} – Settlement price for interest rate futures on FOMC meeting day in month t for futures that expire in month t+j;

f_{t+j-1} – Settlement price for interest rate futures on the day before FOMC meeting in month t for futures that expire in month t+j;

Federal funds futures are a good measure of investors' expectation about decisions of monetary policymakers. Such futures allow financial market participants to hedge against unpredicted changes in interest rates. Federal funds futures rate can be used to separate expected and unexpected changes in federal funds rate since any deviation from anticipated rate will lead to change in futures rate (Kuttner, 2001). To make sure that unexpected movements in futures rate are due to FOMC decisions and not because of other events, changes are taken into account only if they happen within 30-minute interval after FOMC meeting. These unexpected changes in futures rate are noisy measures of monetary shock.

As a second step, I use proxy SVAR methodology, which was developed by Mertens and Ravn (2013), Stock and Watson (2012) and used to identify monetary shocks by Gertler and Karadi (2015). The structural VAR model in general can be described by the following equation:

$$\boldsymbol{BY}_t = \sum_{j=1}^{p} \boldsymbol{\Gamma}_j \boldsymbol{Y}_{t-j} + \varepsilon_t, \qquad (2)$$

where:

B - *n x n* non-singular matrix of coefficients;

$\boldsymbol{Y}_t$ – Matrix with endogenous variables;

$\boldsymbol{\Gamma}_j$ – $n \times n$ coefficient matrices (j=1,…,p);

p – Number of lags in the model;

ε_t – Structural shock with mean zero, which can be partitioned into vectors ε_t^{mp} and ε_t^{q};

Vector ε_t^{mp} has shocks that happen due to monetary policy and ε_t^{q} has all the other shocks (except the monetary policy one). Multiplying equation (2) by B^{-1} transforms it into reduced form VAR:

$$\boldsymbol{Y}_t = \sum_{j=1}^{p} \mathbf{A}_j \, \boldsymbol{Y}_{t-j} + \boldsymbol{u_t}, \qquad (3)$$

where:

$\boldsymbol{u}_t$ – Reduced form shock vector that is related to structural shock by $\boldsymbol{u}_t = \boldsymbol{B^{-1}}\varepsilon_t$ and can be partitioned into vectors u_t^{mp}(contains shocks that happen due to monetary policy) and $\boldsymbol{u}_t^{q}$ (contains all the other shocks except for monetary);

$\boldsymbol{A_j}$ – Coefficient matrices, $\boldsymbol{A_j} = \boldsymbol{B^{-1}}\boldsymbol{\Gamma}_j$;

Covariance matrix of $\boldsymbol{u_t}$ is Σ ,as I define in equation (4), where $\mathbf{S} = \boldsymbol{B^{-1}}$**.**

$$\mathrm{E}[\boldsymbol{u_t u_t'}] = \mathrm{E}[\boldsymbol{SS'}] = \Sigma. \qquad (4)$$

The covariance matrix (Σ) provides identifying restrictions, but these restrictions are not enough to identify **S** uniquely. Proxy VAR model uses covariance between residuals of VAR and instrument variable to identify ε_t.

I assume that there is a *k x 1* vector of proxy variables $\mathbf{Z}_t$ with zero mean. In order for it to be a valid instrument $\mathbf{Z}_t$ must correlate with structural shock of interest, which in our case is ε_t^{mp} and uncorrelated with all other structural shocks ε_t^{q}. The condition specified above can be summarized by:

$$E\left[\mathbf{Z}_t \varepsilon_t^{mp'}\right] = \phi, \phi \neq 0, \qquad (5)$$

$$E[\mathbf{Z}_t \varepsilon_t^{q'}] = 0.$$

We need to estimate equation (6) to calculate impulse response functions to a monetary shock.

$$\boldsymbol{Y_t} = \sum_{j=1}^{p} \boldsymbol{A_J}\, \boldsymbol{Y_{t-j}} + \boldsymbol{s\varepsilon_t^p}, \qquad (6)$$

where:

s – Column in **S,** that shows impact of $\boldsymbol{\varepsilon_t^p}$ on each element of reduced form residuals $\boldsymbol{u_t}$.

$$u_t{}^{mp} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} \boldsymbol{Z}_t + \epsilon_t. \qquad (7)$$

To get **s-**column Gertler and Karadi (2015) run simple VAR (equation (3)) to find reduced form residuals of monetary policy indicator (u_t^{mp}). Assuming that $\boldsymbol{s}^q$ is the response of $\boldsymbol{u}_t^q$ to an increase in ε_t^{mp} and $s^{mp}$is response of u_t^{mp} to an increase in ε_t^{mp}, it is possible to get ratio of $\boldsymbol{s}^q/s^{mp}$. In order to find the ratio, we should run equation (7) and get fitted value of $\widehat{u_t}^{mp}$. This step ensures that variation in reduced form residual of monetary policy indicator happens only because of structural monetary policy shock. To get estimate of ratio of $\boldsymbol{s}^q/s^{mp}$ Gertler and Karadi (2015) run regression described in equation (8) and then using reduced form covariance matrix from equation (4) identify s^{mp}. After that it is also possible to identify $\boldsymbol{s}^q$.

$$\boldsymbol{u}_t^q = (\boldsymbol{s}^q/s^{mp})\widehat{u_t}^{mp} + \boldsymbol{\xi_t}. \qquad (8)$$

To sum up, using external instrument covariance restrictions are obtained and the structural shocks are identified. These shocks are used to obtain impulse response functions of interest. Same approach was used by Hanson and Stein (2015), Gilchrist et al. (2015) and Passari and Rey (2015).

The methodology described above is used for identification of symmetrical monetary shock. This study also checks the effect of non-symmetrical shock because there is evidence in the literature that the effect might be asymmetrical. For example, Furceri et al. (2016) found that monetary tightening shock has a significant effect on inequality, while the effect of expansionary shock is not statistically significant. Garibaldi (1997) has presented an evidence that there is an asymmetric effect of monetary shock on job creation and destruction with positive shock being significant in jobs destruction and negative shock being ineffective in job creation. Barnichon and Matthes (2014) found that non-linear effect of contractionary monetary policy has negative effect on output, while expansionary policy does not have significant impact on output. These findings create grounds for checking if monetary shock has asymmetric effects on heterogeneous employment dynamics.

To estimate the effect of positive and negative shock I rewrite equation (6) turning it into:

$$u_t{}^{mp} = \boldsymbol{\beta_0} + (1 - \boldsymbol{D}_t)\boldsymbol{\beta}_1^{(-)}\boldsymbol{Z}_t + \boldsymbol{D}_t\boldsymbol{\beta}_1^{(+)}\boldsymbol{Z}_t + \epsilon_t, \tag{9}$$

where:

$\boldsymbol{D_t}$ – dummy variable that takes value 1 for positive shock and 0 for negative;

The approach used by Gertler and Karadi (2015) has a number of advantages compared to other popular identification strategies. Firstly, monetary policy innovation not only takes into account unexpected changes in current interest rate, but also surprises in central bank's messages about future path of the interest rate. Secondly, there is no simultaneity restriction, which means that monetary policy shock can have impact on other variables in the same period when it happens. It is extremely important in the context of this research since financial variables, such as credit costs, usually respond to monetary policy shocks within a period. At the same time, the relative price of capital and labor depends on credit cost. Thirdly, the output or price puzzle is not present, unlike in other monetary shock identification approaches (for example, using Cholesky decomposition).

At the same time, the approach has a couple of weaknesses. Monetary innovation is not zero mean and is serially correlated, as found by Ramey (2016). It means that monetary shock measure also includes predictable and expected changes. Another point noted by Ramey (2016) is that Gertler and Karadi (2015) monetary policy surprise variable can be predicted by variables from Greenbook forecast used by Romer and Romer (2004) for shock identification.

The baseline set of variables necessary for identification consists of industrial production, consumer price index, excess bond premium, one year rate and measures of labor market polarization (for example, middle-skill, low-skill or high-skill employment share), which are rotated in different model specifications. I include industrial production and CPI to identify monetary policy shock since the central bank targets inflation and tries to stabilize output. The reactions of these two indicators are also used to check if monetary shock was identified correctly. Based on economic theory, expansionary monetary shock is expected to increase prices and output. I include excess bond premium as a measure of availability of credit and probability to lend. This measure was developed by Gilchrist and Zakrajšek (2012) by dividing corporate bond credit spread index into two components – predictable component (includes firm level information about expected default) and residual component (excess bond premium), which measures the credit risk attitude of investors. One year government bond rate is a monetary policy measure, which captures effects of shock in current federal funds rate and expected path of the rate, which creates a possibility to measure shocks to forward guidance.

I use data from January 1983 until June 2012 to estimate residuals of reduced form VAR described by equation (3) and choose the lag length. However, the data for vector of proxy variables is available only for the period of January 1991 – June 2012. I choose the number of lags using AIC (Akaike information criterion) over the range 1 to 36 months. Results can be found in Table A.1 of the Appendix 1. Based on Akaike information criterion I use lag length of $p = 3$ for the estimation of proxy SVAR model**.**

I use surprises in three-month ahead monthly federal funds futures as a proxy. It is a strong instrument for one year rate government bond rate based on F-statistics from first stage regression (Table A.2 in Appendix 1) being above 10, which is recommended by Stock et al. (2002) as a threshold value.

2.2 Data

This study focuses on the effect of monetary policy on job polarization in the United States of America because there is an evidence of labor market polarization (Autor et al., 2006; Autor and Dorn, 2013 and Bredemeier et al. 2017) and detailed occupational statistics that covers long time span is available. Official monthly data on employment levels by occupations is provided by Federal Reserve Bank of St. Louis Economic Database. This data is available on a monthly basis and covers 9 broad occupational groups. However, it does not provide any details about industry or socio-demographic characteristics of employed.

I divide occupations into middle, low and high skill occupation groups to create a measure of polarization as in Acemoglu and Autor (2011). Taking into account skills used for performing tasks they distinguish routine or non-routine and cognitive or manual occupations. Cognitive occupations are characterized by prevailing intellectual work, while manual by physical work. To define the difference between routine and non-routine occupations the authors follow the logic offered by Autor et al. (2003). Routine occupations employees have clear and detailed rules of how to perform their tasks. On the other hand, for non-routine workers it is not enough just to follow the pre-defined rules. Their activities involve a wide usage of soft skills (like leadership, communication, creativity and problem-solving skills) and it is much harder to set understandable rules for their tasks. Table 1 provides classification of workers into 4 groups based on characteristics outlined above.

Following Jaimovich and Siu (2012) routine manual and routine cognitive occupations form the group of middle-skill occupations. Non-routine cognitive occupations define high-skill occupations and non-routine manual occupations – low-skill occupations.

Table 1. Classification of occupations

Non-routine cognitive occupations (High-skill occupations) • Management, business, and financial operations occupations; • Professional and related occupations;	**Routine cognitive occupations (Middle-skill occupations)** • Office and administrative support occupations; • Sales and related occupations;
Routine manual occupations (Middle-skill occupations) • Transportation and material moving occupations; • Construction and extraction occupations; • Installation, maintenance, and repair occupations;	**Non-routine manual occupations (Low-skill occupations)** • Service occupations;

Source: Jaimovich and Siu (2012)

Source of data and descriptive statistics are presented in Appendix 1 in Table A.3 and Table A.4 respectively. Skill-based employment shares are constructed by dividing middle, low and high-skill employment levels by the US population, abstracting away from the potential causes of population growth in the country. All the data was seasonally adjusted. Variables that describe employment were also linearly detrended, but robustness analysis is carried out for the case of non-detrended data. The set of control variables used in the calculations is similar to Gertler and Karadi (2015) and includes industrial production, consumer price index, excess bond premium and one year government bond rate.

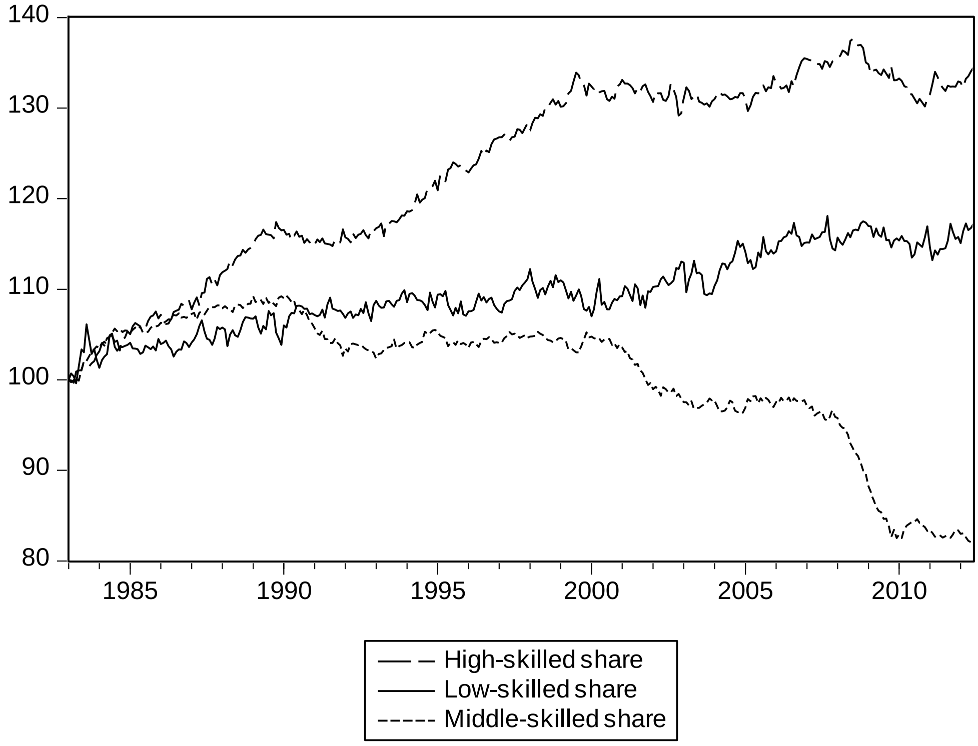

Figure 1. Descriptive development in the shares of high-skilled, low-skilled and middle-skilled employment from total population (January 1983=100)

Notes: Seasonally adjusted high-skilled, low-skilled and middle-skilled employment shares.

Figure 1 shows that different employment groups have different growth rates and volatility. The percentage share of middle-skilled employees starts to decrease in 1990's, while high-skilled and low-skilled groups do not. Another important thing to notice is that during recessions (Early 1990's Recession, Early 2000's Recession and the Great Recession) middle-skilled group has the sharpest decrease compared to two other groups. Moreover, it does not restore to its previous level. At the same time, low-skilled employment share does not seem to have reaction to economic downturns. These observations are supported by findings that middle skill employment decreases during recessions and does not recovers to previous level after recession (Jaimovich and Siu, 2012; Foote and Ryan, 2015).

3. Results

In this section I present main results obtained using high frequency data and proxy SVAR methodology for symmetrical and asymmetrical shocks. I also discuss heterogeneous effects of monetary policy shock, provide results for disaggregated data and robustness checks.

3.1 Baseline results

Using methodology and data described in previous section, it is possible to address the central question of this paper and study how monetary policy surprise affects job polarization. Figure 2 compares the employment effects of monetary shock and shows that there are differences in reactions of groups with different skill levels. In particular, after monetary expansion middle skill employment has a statistically significant drop during first 5 periods by around 0.05 percent. This result is expected and complies with theoretical models described in section 1.1. As expansionary monetary policy reduces the price of capital, companies compare the cost of capital and labor and choose to substitute middle skilled labor with capital. After period 10 the effect becomes positive, which can be explained by increase in demand and start of new economic activities. Such increase requires more inputs from supply side. While part of companies invests in machine capital, other part hires middle skill workers, who are substitutes for capital.

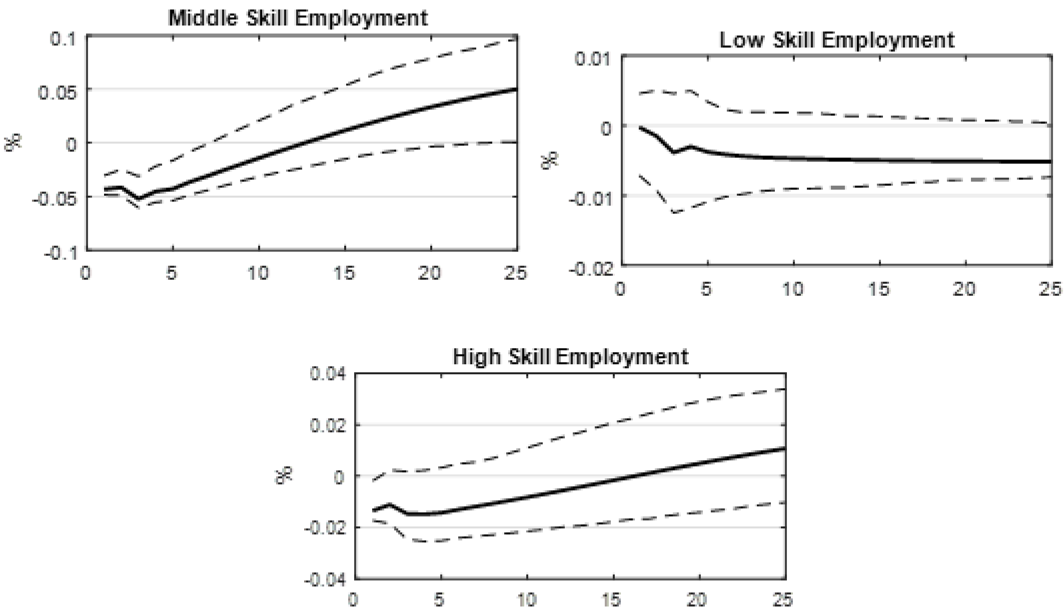

Figure 2. Impulse response functions of different employment groups to expansionary monetary policy shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. The horizontal axes are in months.

The share of low skill employment decreases during all 25 periods, but the drop is only marginally significant after the 20th period and accounts for roughly 0.006 percent. It means that monetary policy does not have significant impact on low skilled employment and supports my hypothesis. The shape of the impulse response function of high skill group is similar to middle skill one. However, the magnitude of drop and increase is approximately 2-3 times smaller and the result is significant only in the first month after the shock. The impact of monetary policy on high skilled group is contrary to hypothesized impact and the reasons are discussed in subsection 3.3 of this work. Comparing all three graphs, monetary policy has the strongest negative effect on middle skill.

In order to understand the influence of monetary surprise better, it is also important to consider its effects on relative employment shares. Figure 3 presents impulse response functions of high to middle skill and low to middle skill employment ratios. The first panel provides evidence that there is a shift from middle skill employment to low skill until period seven of around 0.02 percent. The response is significant only during the first period. This result supports findings made by Acemoglu and Autor (2011), who state that middle skilled employees have bigger advantage in performing low skill tasks than high skill.

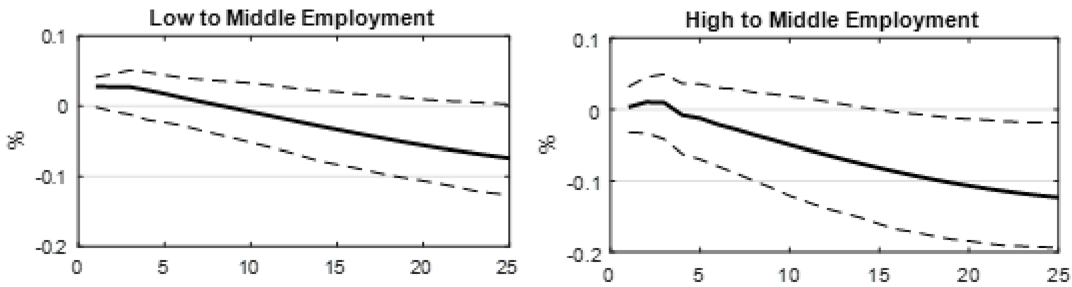

Figure 3. Impulse response functions of employment ratios to expansionary monetary shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. The horizontal axes are in months.

As for the shift to high skill employment, the result is not so straighforward. There is just a slight increase in the ratio during first periods, which is statistically insignificant. The reason behind this could be that it requires more time and additional training for middle skilled workers to switch to high skill job. Foote and Ryan (2015) found that around 85% of high skilled workers have attended college courses, while this figure for middle skilled varies from one third to half. It means that middle skilled group needs more time to move to high skilled group. This idea is supported by model and paper of Jaimovich and Siu (2012), who state that during recessions mainly routine workers lose their jobs and after recession they cannot find manual and cognitive routine jobs, making them switch to other occupation groups (high skill employment group in the paper). This process is slow, since workers have to retrain.

I also show effect of the shock on other macroeconomic variables in order to ensure that the identified shock is a monetary shock. Figure 4 presents impulse response functions of key variables to monetary policy shock. One standard deviation expansionary monetary shock causes a significant increase in industrial production, which varies around 25-50 basis points. There is also a statistically significant rise in consumer price index during first 3 periods after the shock. Both reactions go in line with conventional macroeconomic theory. Negative monetary shock leads to drop in one year government bond rate, as well as of excess bond premium.

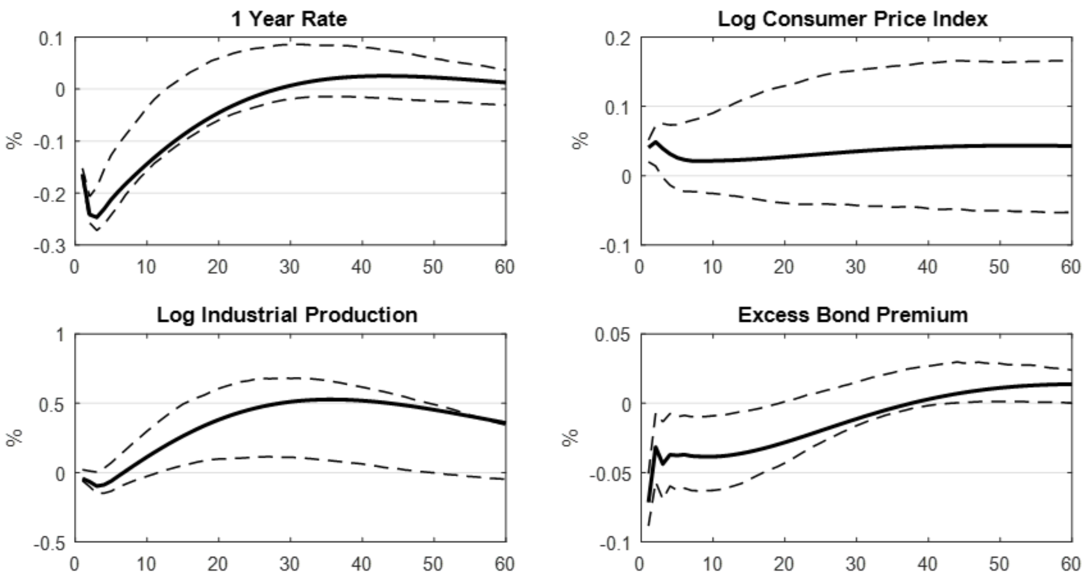

Figure 4. Impulse response functions of selected variables to expansionary monetary policy shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. The horizontal axes are in months.

I perform forecast error variance decomposition to get an indication how important are the results economically and how much of forecast error variance can be explained by monetary policy shock. Table 2 shows forecast error variance decomposition for macroeconomic variables. The contribution of monetary shock to explaining fluctuations in consumer price index is around 5% at 60 month, which is pretty low. The contribution to industrial production and excess bond premium is 11.7% and 5.2% at 60 periods horizon respectively.

Table 2. Forecast error variance decomposition for selected variables due to monetary shock

Months	One year government bond rate, %	Log consumer price index, %	Log industrial production, %	Excess bond premium, %
1	100	0.0	0.6	2.8
12	88.4	4.5	3.7	2.3
24	74.6	5.7	1.9	3.9
36	67.7	5.9	4.4	5.3
48	66.0	5.7	8.4	5.2
60	65.7	5.5	11.7	5.2

Table 3 has forecast error variance decomposition for different employment groups. Monetary policy shock contribution to forecast error is the highest for middle skill employment (11.5%) and low skill employment (10.3%). It is much lower for high skill employment share – 3.4%. Forecast error variance due to monetary shock for ratios of high and low to middle skill employment are of almost same magnitude – 8.7% and 8.3% at 60 periods horizon respectively.

Table 3. Forecast error variance decomposition for employment variables due to monetary shock

Months	Middle skill employment, %	Low skill employment, %	High skill employment, %	High to middle skill employment, %	Low to middle skill employment, %
1	1.4	0.6	0.0	0.2	0.0
12	6.4	4.6	1.0	0.7	0.2
24	3.0	6.6	0.9	0.7	0.3
36	4.1	8.1	0.9	2.7	2.2
48	7.8	9.3	1.9	6.0	5.3
60	11.5	10.3	3.4	8.7	8.3

All in all, the results of variance decomposition suggest that monetary policy shock has economically significant influence on employment variables (except for high skilled employment), especially on middle skill employment.

3.2 Results for positive and negative monetary policy shock

The previous subsection discusses results of symmetrical expansionary monetary policy shock. I run proxy SVAR model using equation (9) instead of (6) to check if there is an asymmetry in reaction to positive and negative monetary shock. Contractionary monetary policy shock is associated with rise in interest rate (positive shock), expansionary – with fall in interest rate (negative shock).

Assymetric effect of monetary shocks can occur, for example, because of credit market imperfections. Following Furceri et al. (2016) increase in interest rates can lead to less liquid companies being cut off from financing when credit market is imperfect. It happens because lending rates increase and the probability that risky borrowers will not pay the loan back increases. Lenders choose to protect themselves and reduce borrowing to risky firms. It means that less liquid firms will cut their investments into capital. In case when capital and middle skilled workers are substitutes and wage is lower than price of capital, firm will choose to hire middle-skilled workers instead of capital. At the same time, decrease in interest rates and more favourable credit market conditions do not necessarily lead to incresing borrowing and investments of a firm. Therefore, I expect that contrationary monetary policy shock will have stronger effect on middle skill employment, than expansionary, and will decrease relative share of high and low to middle skilled employees.

Wage and price rigidities also contribute to asymmetry in responses to monetary shock. Abbritti and Fahr (2013) found that expansionary shock has bigger influence on wages and prices, than contractionary. At the same time, contractionary shock has stronger impact on real variables, like output and employment, than expansionary. When the central bank increases interest rate, investments and consumption fall, demand for output decreases and interest payments increase, which decreases labor demand and makes firm cut wages. However, because of labor market regulations, like minimum wages, or fixed wage employment contracts the firm will not decrease wages. At the same time inflation will fall, which means that real wage will increase and firm will not employ more workers or will even try to reduce the number of existing employees.

Downward wage rigidities have impact on relative employment shares of low to middle skilled. Assuming that low skilled workers receive the lowest wage, they are the most probable “victims” of wage rigidity after contractionary monetary shock and that low skill labor demand will decrease. Taking into account credit market frictions described in previous paragraph, companies will hire middle skilled workers instead of buying capital. I hypothesize that it would lead to increase of middle skill employment compared to low skilled.

The results presented in Figure 5 show that there are some differences in monetary policy transmission for positive and negative shock. The shape of impulse response function for middle skill group is the same for positive and negative shock, but the magnitude of response to contractionary shock is higher (around 0.04 percent in absolute value for expansionary shock compared to 0.07 percent for contractionary). With credit market imperfections present, increase in interest rate will make it harder for less liquid companies to buy capital. Companies will substitute it with middle skilled labor, creating bigger demand for the middle skilled compared to the situation without credit market imperfections.

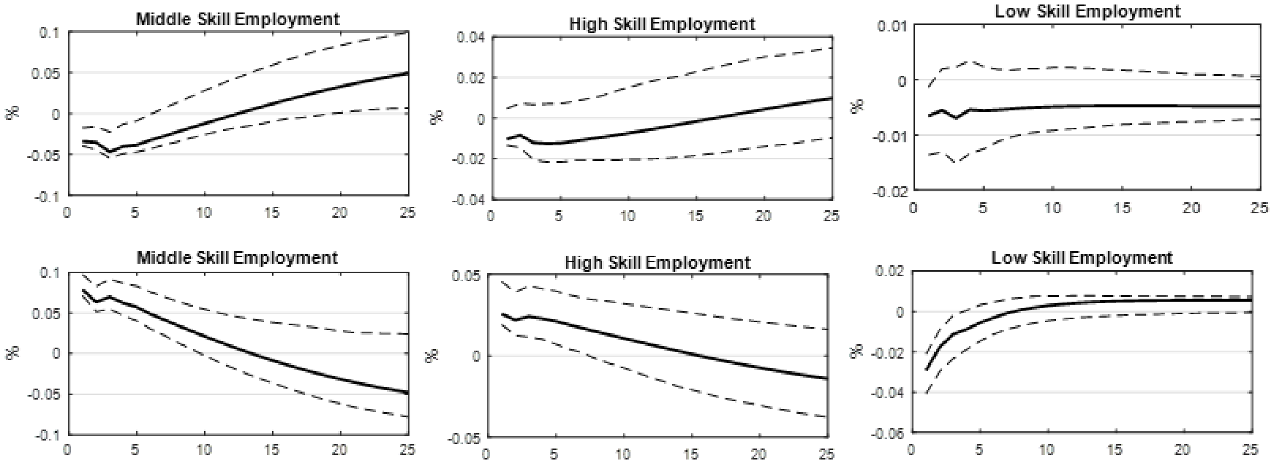

Figure 5. Impulse response functions of different employment groups to positive and negative monetary policy shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. Upper panels indicate responses to negative monetary policy shock, while lower to positive shock. The horizontal axes are in months.

The effect of negative policy shock on high skill employment is not statistically significant, while positive shock is and accounts for roughly 0.025 percent rise. Unlike in the baseline result, where the drop in low skill employment was insignificant, it is significant for both positive and negative monetary policy shocks. However, the effect of both shocks is negative, which does not go in line expectations and needs further insights.

The results in Figure 6 suggest that there are also differences in relative employment shares. Expansionary monetary policy shock has no significant influence on the ratio of high to middle skilled employees. However, monetary tightening shock leads to statistically significant drop in the ratio for around 0,1 percent during first 5 periods. The right panel of the figure shows that negative monetary policy shock also does not have significant influence on low to middle skilled employment ratio, but positive shock leads to significant drop in the ratio by around 0,15 percent. The reason behind this asymmetry could be hidden behind downward wage rigidities. Real wage of low and high skilled grows (due to decrease in inflation), employers can't reduce the wage so they decide either not to change number of low and high skilled employees or to reduce it. At the same time the number of middle skilled employees increases because it is a substitute for more expensive capital.

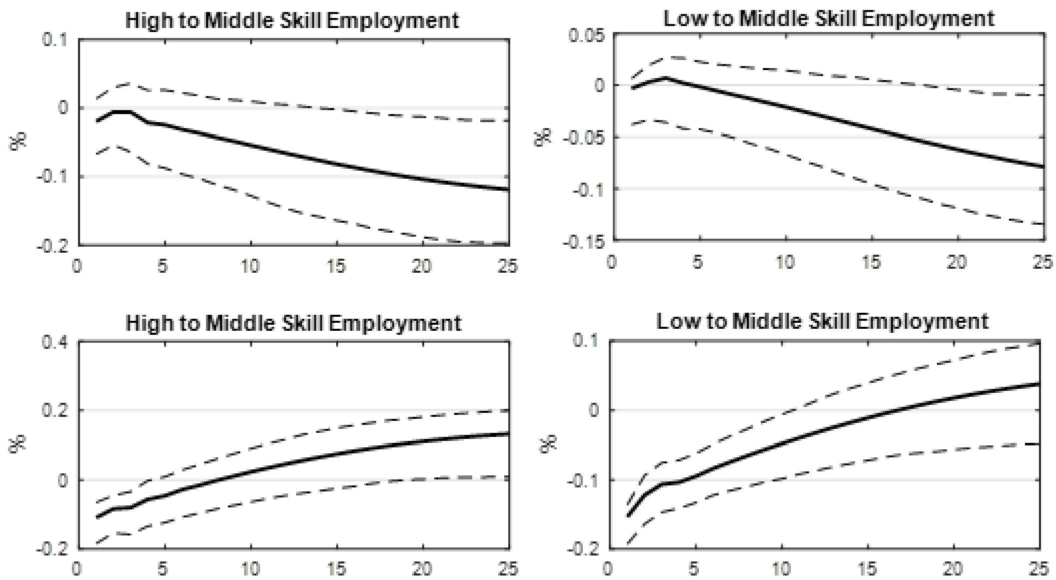

Figure 6. Impulse response functions of relative employment shares to positive and negative monetary policy shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. Upper panels indicate responses to negative monetary policy shock, while lower to positive shock. The horizontal axes are in months.

To sum up, the results go in line with literature, which states that effect of monetary tightening shock is stronger than monetary expansion shock (Furceri et al., 2016; Barnichon and Matthes, 2014). Middle skill employment reaction to both shocks is statistically significant and has the highest magnitude compared to other employment groups.

3.3 Results for disaggregated data and robustness checks

This subsection provides results for 9 disaggregated occupational groups and describes alternative estimations to check if results are robust.

I use employment in 9 occupational groups, presented in Table 1 in subsection 2.2 to check how disaggregated groups respond to monetary shock because it can bring up more details about employment reaction to monetary shock and explain why high skilled employment reacts negatively to monetary surprise. I exclude from the analysis service occupations because they are the only occupation group that form low skilled employment (therefore, the impulse response is the same as on Figure 2 for low skilled**).**

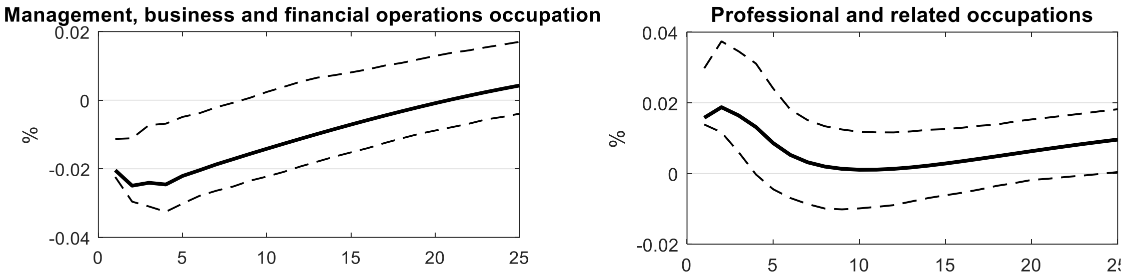

Figure 7. Impulse response functions of disaggregated high skilled employment shares to negative monetary policy shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. Employment shares are seasonally adjusted and detrended linearly. The horizontal axes are in months.

I present results for high skilled group on Figure 7. The impact of monetary shock is significant in both occupational groups. Employment share in management, business and financial occupations reacts negatively, while employment in professional and related occupations positively. The reaction of professional and related occupations is expected. When capital becomes cheaper companies buy it. However, capital does not substitute high skilled employees. It complements their work, which means that with increase in aggregate demand, there will be an increase in high skill employment after expansionary policy. The impulse response function of employment share in management, business and financial occupations contradicts my expectations. One explanation for this contradiction could be that employment in management, business and financial occupations is more volatile and many employees lose their jobs during economic crisis. Another possible reason could be that technological development has reached a point when capital can substitute even part of high skilled employees. For example, growing usage of artificial intelligence and machine learning in finance can leave even high skilled employees without work. These results help to understand why impact of high skilled employment in negative in baseline model (Figure 2 in subsection 3.1).

The impulse response functions for middle skilled disaggregated employment from Figure 8 are in line with expectations. Impact of expansionary monetary shock is significant and negative for all occupation groups except for construction and extraction occupations. Monetary policy shock has the strongest (by magnitude) effect on sales and related occupations.

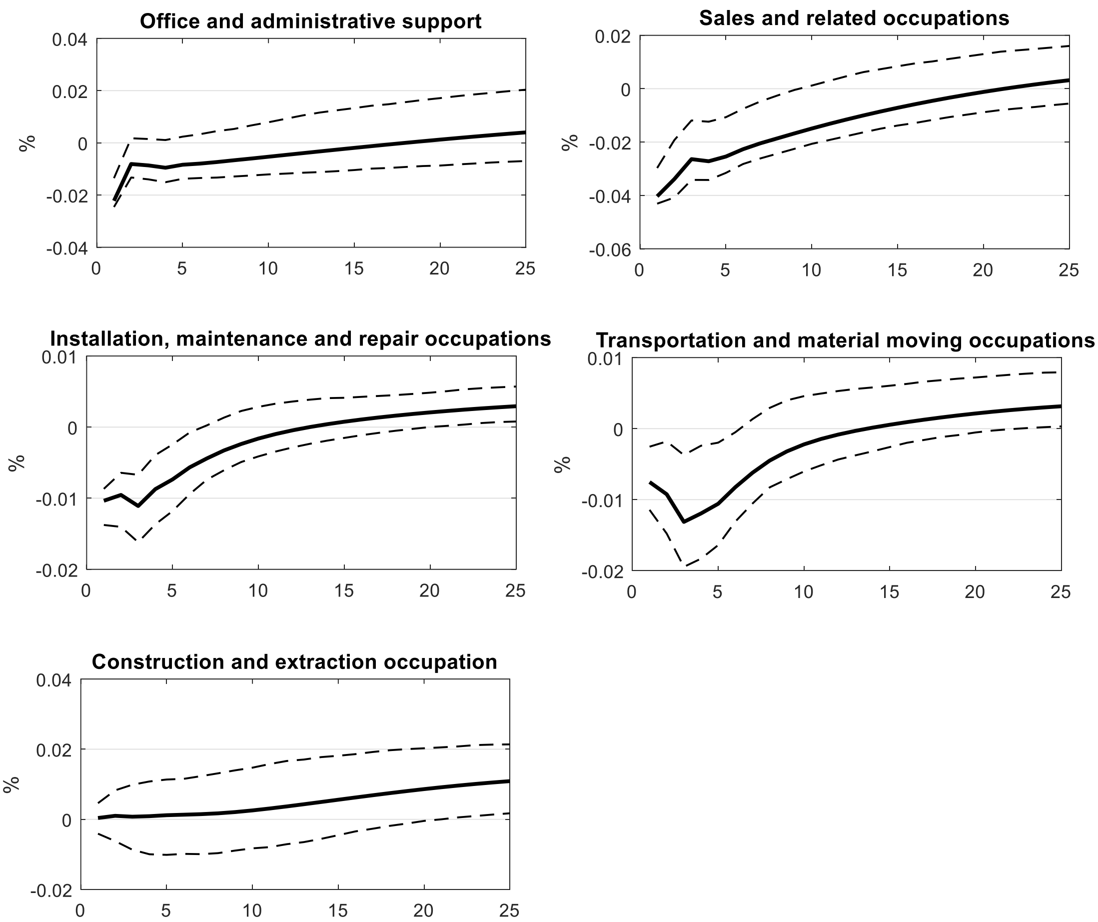

Figure 8. Impulse response functions of disaggregated middle skilled employment shares to negative monetary policy shock

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. Employment shares are seasonally adjusted and detrended linearly. The horizontal axes are in months.

To check robustness of results I start with estimating proxy SVAR model using non-detrended shares of middle, low, high skilled and their ratios. The results presented in Figure A.1 in Appendix 2 suggest that the employment effects of monetary surprise are not different from the baseline results. It means that monetary policy not only contributes to cyclical fluctuations of middle, low and high skill employment, but also has impact on trends and long-term development.

Second, I calculate first differences of employment variables in order to stabilize the mean and remove the trend. The impulse response functions, which are provided in Figure A.2 in Appendix 2, show that variables react to monetary shock in the same direction as in baseline model. One exception is an impulse response function of high to middle skilled ratio. It is significant and has an increase up to roughly 0,04 percent during first 3 – 4 periods after the shock compared to insignificant and barely noticeable increase in baseline model.

As a third robustness check, I exclude global financial period and re-estimate baseline model using sample from January 1983 until June 2008 to check if results depend on its presence in sample. Figure A.3 in Appendix 2 shows that expansionary monetary shock leads to reactions of employment variables similar to baseline. The magnitude of impulse response functions is slightly stronger for middle skilled (-0.06 percent compared to -0.05 in baseline), high skilled and ratio of low to middle skill employment. High to middle skilled ratio became significant and it increases by around 0.05 during first periods, just like in the previous robustness check.

Next I use Cholesky decomposition for SVAR identification to check if my results depend on identification strategy. I use variables in the following order: CPI, industrial production, employment variable of interest (middle, high, low skill etc.), one year government bond rate, excess bond premium. This way changes in interest rate have instant effect on excess bond premium. In turn, ordering employment variable before interest rate ensures that employment variables are in the information set of the central bank and have influence on central bank’s decisions about interest rate immediately. Same order of variables is used by Gertler and Karadi (2015), but they don’t include employment variable. Results presented in Figure A.4 in Appendix 2 suggest that proxy SVAR methodology offered by Gertler and Karadi (2015) does not create puzzles. Under Cholesky ordering variables also react in line with theory, but the reaction of CPI, industrial production is barely noticeable.

Figure A.5 in Appendix 2 shows that for employment variables Cholesky identification creates puzzles for some variables and results are different from baseline in their magnitudes. Impulse response functions for middle skilled employment are alike in shape under both identification strategies, but magnitude is much stronger for Cholesky ordering (0.15 percent under Cholesky compared to 0.05 using external instrument). The response of low skill employment is significant when I use Cholesky ordering, but it is not using proxy SVAR methodology. Decrease in low skill employment after monetary shock is also much stronger using Cholesky ordering (around -0.07). Same happens with impulse response function of high skill employment, it drops for roughly -0.12 percent (using Cholesky ordering) compared to -0.02 (using external instrument identification). The puzzle appears in the response functions of employment ratios. After expansionary monetary shock, high to middle skill and low to middle skill employment ratios drop, which contradicts the expectation that middle skilled workers will move to either low skilled group or high skilled. The identification method using proxy SVAR does not have this puzzle.

As a final step I analyze the reaction of middle, low, high skilled and their ratios to negative monetary surprise during different time periods. I do so in order to test if there has been any changes in relationship between labor market polarization and monetary policy. Based on the links I describe in Section 1.1, it is possible to make a hypothesis that because of international trade development, offshoring and greater usage of computer technologies, polarization of labor market was not always of the same strength. I estimate same model as in baseline section. The difference is that I divide the data into 3 roughly equal subsamples (January 1983 – December 1992, January 1993 – December 2002, January 2003 – June 2012). During the first period (January 1983 — December 1992), there was a rise in imports from China (Mathai et al. 2016) and 1990 – 1991 recession (as dated by NBER), during which employment in middle and high skill occupations continued to decrease till approximately 1993 (Figure 1**)**. Second period is characterized by adoption of new information technologies. Oliner and Sichel (2000) find that during second half of 90's productivity and output growth is explained by increasing information technology usage. Such technological change can lead to rise in demand for high-skilled employees and computerization can substitute middle skilled employees. There also was a dot-com crisis which started in 2001 (as dated by NBER). During the crisis there was a slowdown in increase of high skilled employment and drop in the share of the middle skilled (Figure 1). The third period includes global financial crisis during which the share of the middle skilled has the sharpest decrease compared to high and low skilled groups (Figure 1).

I present results in Figure A.6 in Appendix 2. Even though it is not possible to make general conclusions for all variables, it is evident that during three periods reaction of job polarization variables is different. One standard deviation expansionary monetary shock decreases employment for middle skilled in all three periods, but it is the sharpest in period from 2003 till 2012 (around -0.1 compared to -0.05 and -0.01 in two other periods). Puzzles are also present in this model. There is a significant increase in high skill employment during January 1983 – December 1992, but in other periods there is a non-significant decrease. Same happens with low skilled group. After monetary shock there there is an increase in low skilled employment during the period of January 1993 – December 2002, but in other two periods there is a decrease. The positive reaction of high to middle and low to middle ratios is also the strongest in the last period (0.25 and 0.11 respectively). To sum up, this exercise shows that during different periods of time labor market polarization is different.

4. Conclusions

This paper investigates the impact of monetary policy shock using proxy SVAR model. One of the main findings is that after an expansionary monetary shock there is a decrease in middle skill employment by around 0.05 percent, which is the biggest in magnitude compared to low skill and high skill. There is a significant decrease of high skill employment by around 0.015 and insignificant drop in low skill group. These results mean that reaction in different skill groups is disproportionate. I also find that middle skilled employees switch to low skill jobs after shock, while the switch to high skill jobs is not so evident. The robustness of these findings is checked using alternative specifications. Results for asymmetric shock show that there is difference in reactions to positive and negative monetary policy shock. The effect of monetary tightening shock is more significant than monetary expansion shock. Reaction of middle skilled group is again the biggest in magnitude.

The results of forecast error variance decomposition suggest that the highest contribution of monetary shock is to middle skill employment (11.5%) and low skill employment (10.3%). It is much lower for high skill employment share – 3.4%. These findings suggest that relationship between monetary policy and different employment measures is economically significant.

There are also certain limitations in my work mostly because of lack of data. For example, due to unavailability of wage data for different occupations for a long time span, I performed my analysis only for job polarization. It is possible to expand the analysis to wage polarization once the wage data is available. It would be also beneficial to analyze the effect of monetary policy on middle, low and high skill employment in different industries because they differ by type of capital they use and its share in production. Another limitation is that I perform analysis only for the USA, but it would be also useful to check similarities and differences of labor market reactions to monetary policy shock in other developed and developing countries.

What are the implications of the results I found for the policy? Even though monetary policy is not the main reason of labor market polarization, it has definitely influenced the speed of this process. One of the objectives for monetary policy in the USA is maximum employment. However, it is evident from my results that stimulating economy by lowering interest rate leads to growing employment polarization and employers who do not want to hire middle skilled workers preferring to engage computer capital instead. Such workers can stay unemployed for a long time, creating a contradiction with the aim of the central bank's policy. The consequences of job polarization include a drop in middle skilled wages and in turn rising income inequality. There is no point in adjusting monetary policy to slow down the polarization, but it is important to take into account that expansionary monetary policy will speed up this process especially during recessions. Policymakers, who develop labor market policy, fiscal policy and education policy, should facilitate the transition of middle skilled to the groups of high skilled or low skilled. For example, by providing free additional training for middle skilled workers, who are still employed or who have lost the job already and by stimulating youth to get university degree. The results I obtained in this work can help policymakers to predict the process of polarization and take necessary measures to minimize negative consequences of it.

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Appendices

Appendix 1. Tables

Table A.1. Akaike Information Criterion (AIC) for lag length selection

Lag	Model with high skill employment	Model with low skill employment	Model with middle skill employment	Model with high to middle skill employment	Model with low to middle skill employment
0	21.808	19.439	22.608	24.965	23.791
1	0.633	-0.059	1.117	3.516	2.510
2	0.178	-0.498	0.641	3.0518	2.063
3	0.139*	-0.524*	0.598*	2.989*	2.047*
4	0.164	-0.502	0.614	3.005	2.085
5	0.199	-0.459	0.643	3.029	2.098
6	0.282	-0.387	0.699	3.099	2.189
7	0.359	-0.306	0.772	3.169	2.255
8	0.399	-0.229	0.842	3.221	2.319
9	0.432	-0.176	0.885	3.266	2.362
10	0.511	-0.108	0.959	3.328	2.449
11	0.557	-0.091	0.979	3.364	2.457
12	0.560	-0.068	1.033	3.369	2.513
13	0.541	-0.033	1.038	3.343	2.516
14	0.603	0.058	1.119	3.402	2.610
15	0.631	0.100	1.102	3.414	2.626
16	0.693	0.155	1.135	3.456	2.699
17	0.703	0.154	1.118	3.451	2.714
18	0.807	0.246	1.177	3.525	2.768
19	0.834	0.281	1.214	3.549	2.801
20	0.879	0.308	1.281	3.611	2.851
21	0.917	0.312	1.319	3.647	2.861
22	0.971	0.375	1.377	3.721	2.924
23	0.988	0.405	1.446	3.762	2.985
24	0.988	0.407	1.471	3.785	2.978
25	1.011	0.396	1.388	3.788	2.948
26	0.963	0.338	1.350	3.739	2.910
27	1.017	0.356	1.405	3.731	2.890
28	1.068	0.382	1.404	3.739	2.918
29	1.070	0.355	1.420	3.743	2.907
30	1.038	0.348	1.408	3.721	2.918
31	0.994	0.243	1.413	3.723	2.846
32	1.062	0.276	1.437	3.784	2.910
33	0.891	0.248	1.393	3.681	2.886
34	0.756	0.199	1.364	3.593	2.850
35	0.717	0.201	1.374	3.603	2.866
36	0.569	0.060	1.295	3.494	2.707

Notes: * indicates lag order selected by the criterion, every model includes industrial production, consumer price index, excess bond premium and one year government bond rate and employment variable specified in the column header.

Table A.2. F-statistics for regression of one year government bond rate first stage residuals on three-month ahead funds rate future surprise

Employment variable included in VAR	**F-statistic**
Middle Skill Employment	22.53
Low Skill Employment	22.55
High Skill Employment	22.12
Low to Middle Skill Employment	21.78
High to Middle Skill Employment	22.00

Notes: Residuals are taken from reduced form VAR (equation 3), that has following variables: CPI, industrial production, one year government bond rate, excess bond premium and one of the employment variables listed in the table.

Table A.3. Sources of the data

Series Title	Series ID	Source
Employment Level: Management, Professional, and Related Occupations	LNU02032201	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Construction and Extraction Occupations	LNU02032210	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Production Occupations	LNU02032213	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Service Occupations	LNU02032204	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Management, Business, and Financial Operations Occupations	LNU02032202	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Sales and Related Occupations	LNU02032206	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Office and Administrative Support Occupations	LNU02032207	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Installation, Maintenance, and Repair Occupations	LNU02032211	Federal Reserve Bank of St. Louis Economic Database
Employment Level: Production, Transportation and Material Moving Occupations	LNU02032212	Federal Reserve Bank of St. Louis Economic Database
Civilian Noninstitutional Population	CNP16OV	Federal Reserve Bank of St. Louis Economic Database
Excess bond premium	N.A.	Obtained from Gertler and Karadi (2015)
Log industrial production	N.A.	Obtained from Gertler and Karadi (2015)
Log consumer price index	N.A.	Obtained from Gertler and Karadi (2015)
One year government bond rate	N.A.	Obtained from Gertler and Karadi (2015)
Three-month ahead funds rate future surprise	N.A.	Obtained from Gertler and Karadi (2015)

Table A.4. Descriptive statistics

Variable name	Min.	Max	Mean	Standard Deviation
Middle-skill employment share (detrended), %	-4.49	2.51	0.14	1.54
High-skill employment share (detrended), %	-1.50	1.67	0.02	0.67
Low-skill employment share (detrended), %	-0.44	0.32	-0.01	0.15
High-skill to middle-skill ratio (detrended), %	-5.52	5.60	-0.40	2.17
Low-skill to middle-skill ratio (detrended), %	-3.52	4.25	-0.24	1.73
Middle-skill employment share, %	30.45	40.09	36.89	2.60
High-skill employment share, %	19.38	27.09	24.19	2.12
Low-skill employment share, %	10.52	12.73	11.69	0.49
High-skill to middle-skill ratio, %	52.24	87.91	65.05	9.85
Low-skill to middle-skill ratio, %	27.63	41.68	31.95	3.70
Excess bond premium	-1.33	2.97	0.03	0.56
Log industrial production	99.66	461.33	384.15	21.80
Log consumer price index	104.8	543.4	449.7	24.52
One year government bond rate	0.10	12.08	4.83	2.85
Three-month ahead funds rate future surprise	-0.29	0.09	-0.01	0,05

Appendix 2. Figures

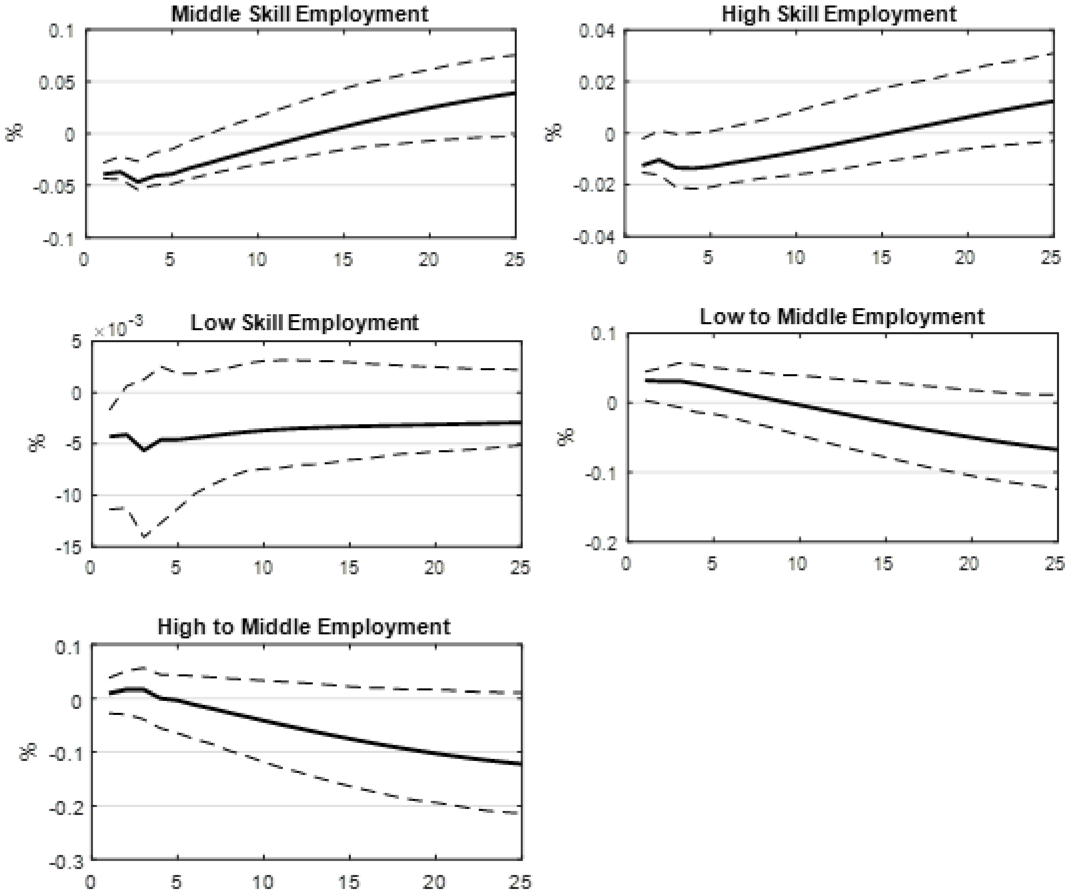

Figure A.1. Impulse response functions for non-detrended data

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. Variables presented are shares of employment in certain skill group to population of the country. The horizontal axes are in months.

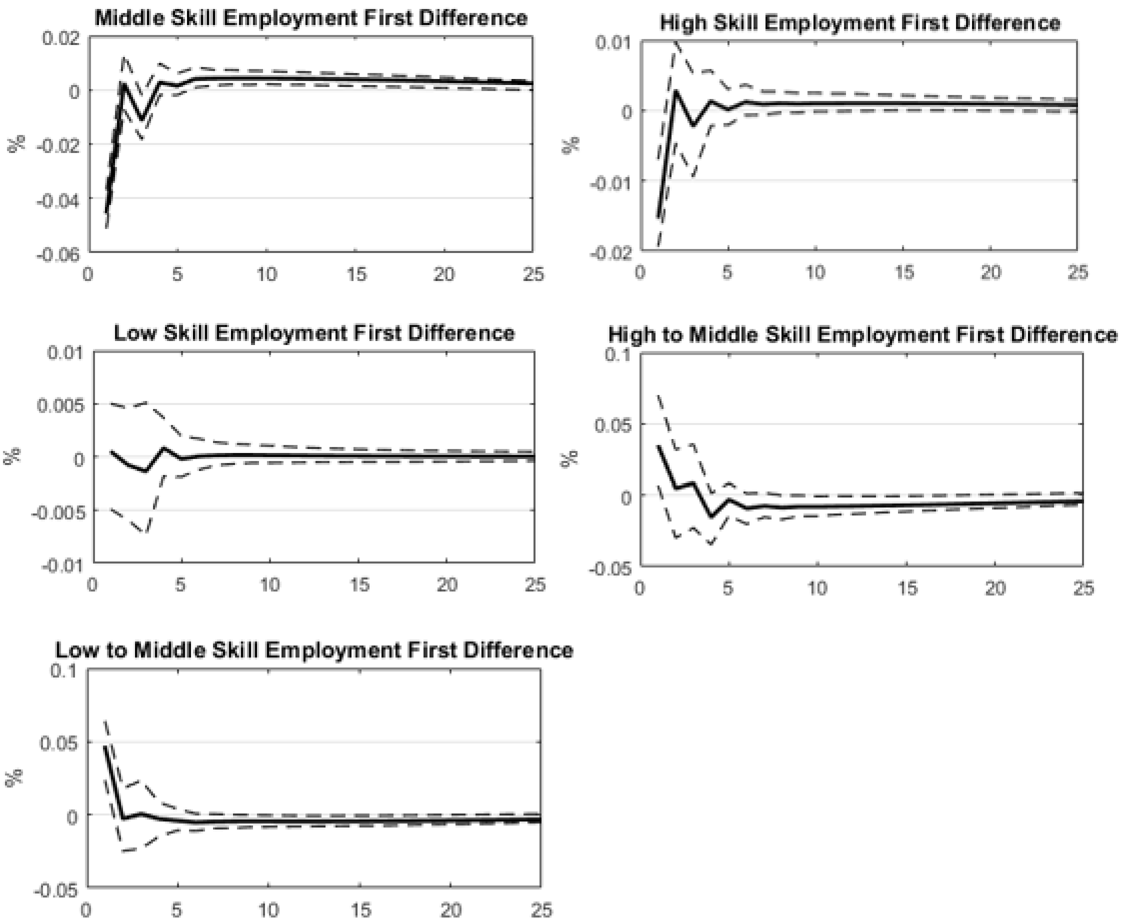

Figure A.2. Impulse response functions for employment variables in first differences

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. Variables presented are first differences of shares of employment in certain skill group to population of the country. The horizontal axes are in months.

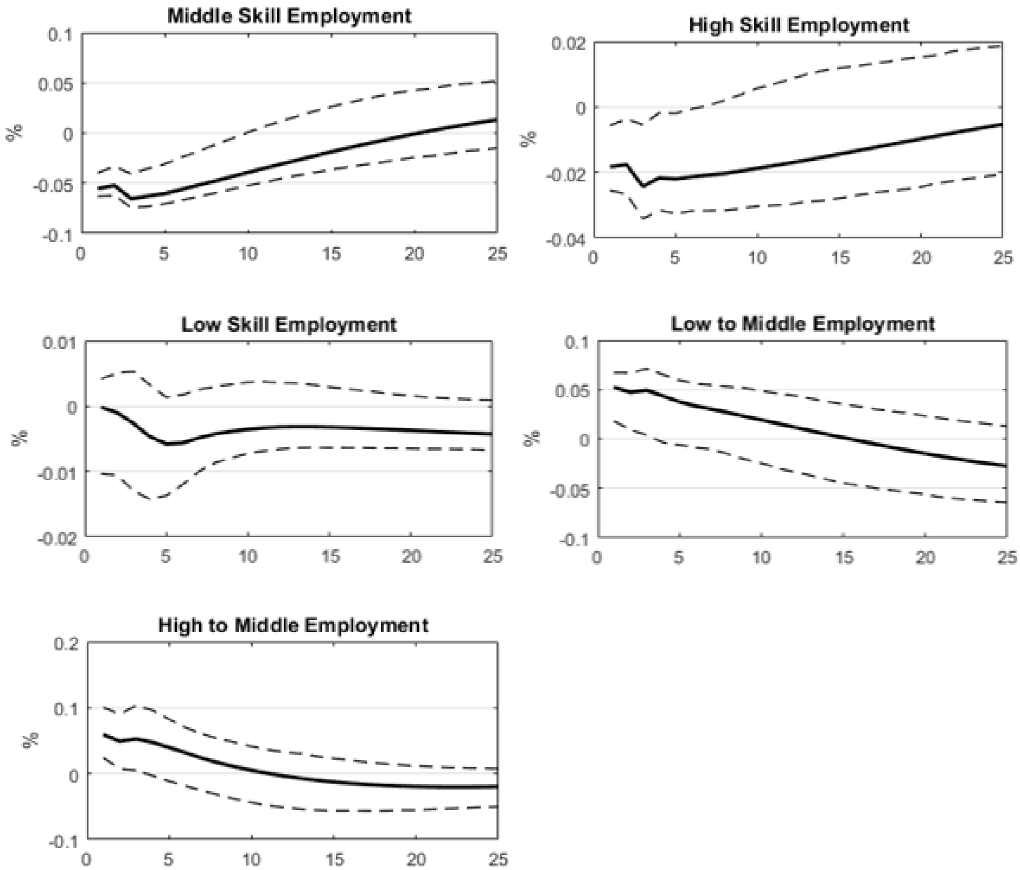

Figure A.3. Impulse response functions for employment variables using January 1983 – June 2008 sample

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. The horizontal axes are in months.

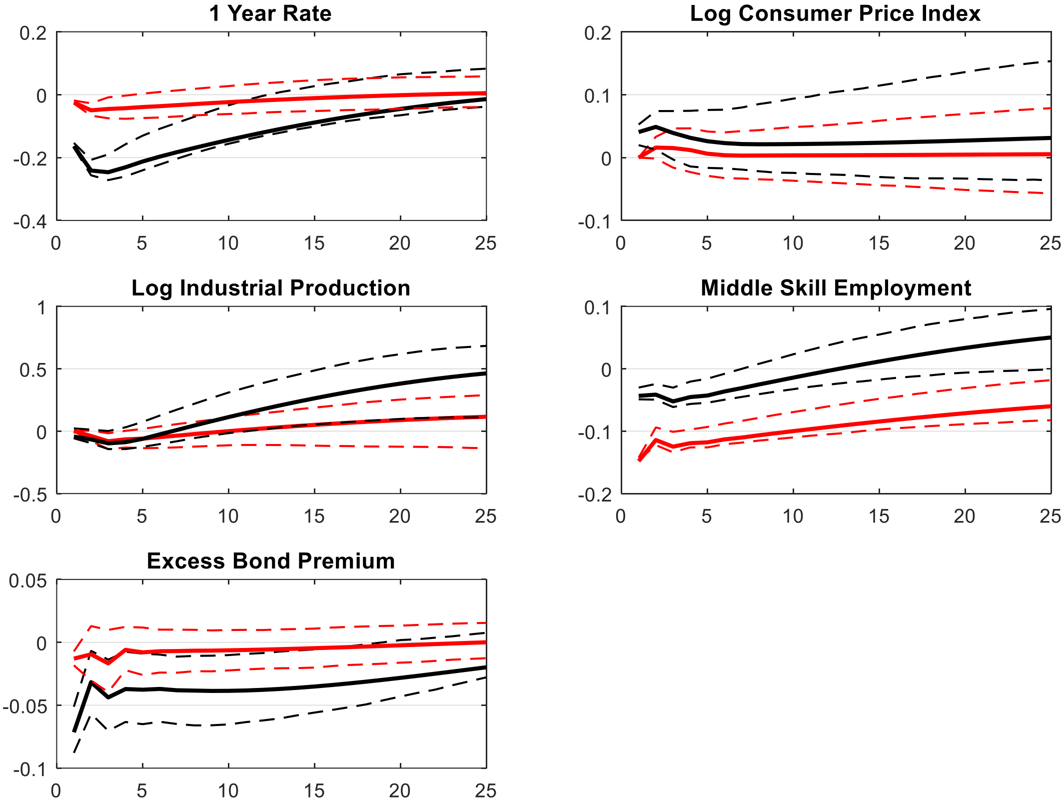

Figure A.4. Impulse response functions using proxy SVAR and Cholesky ordering SVAR identification

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Red lines indicate results for Cholesky decomposition and black ones for external instrument identification. Monetary policy shock is defined using three-month ahead funds rate future surprise. Variables presented are shares of employment in certain skill group to population of the country. The horizontal axes are in months.

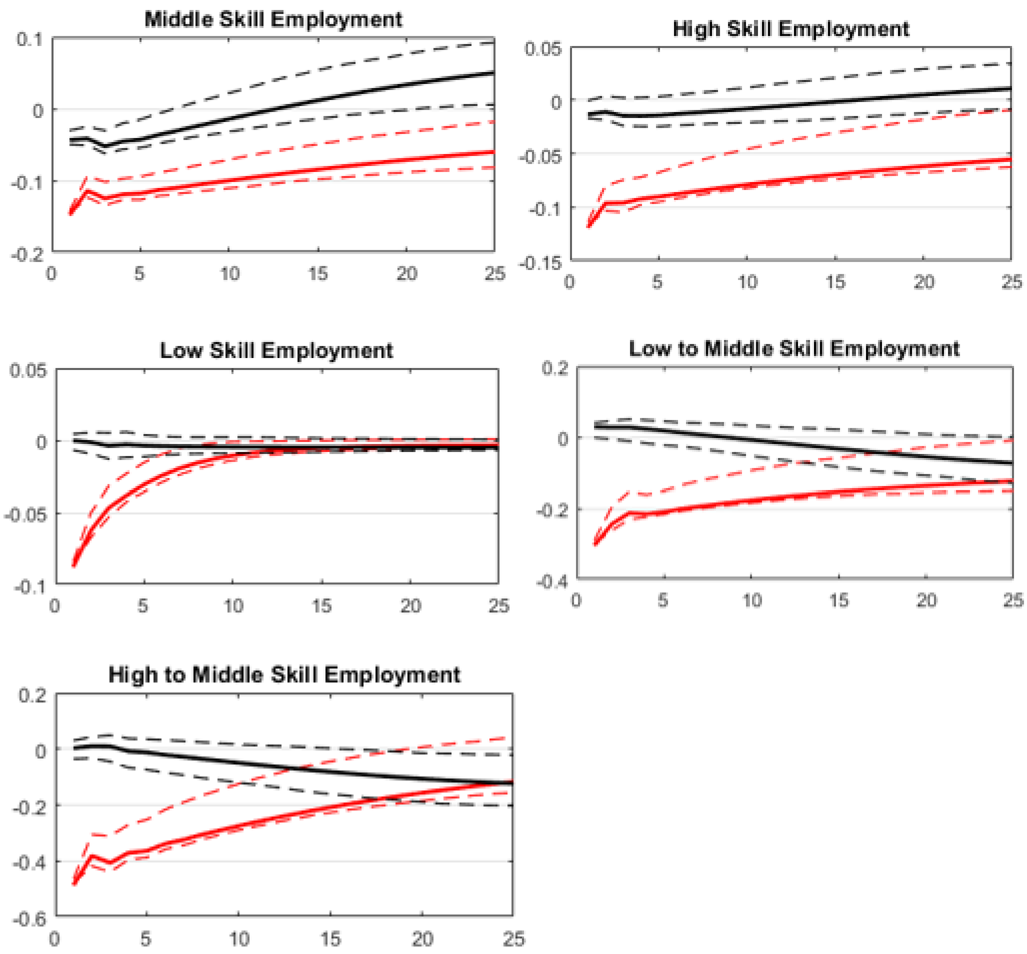

Figure A.5. Selected impulse response functions using proxy SVAR and Cholesky ordering SVAR identification

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Red lines indicate results for Cholesky decomposition and black ones for external instrument identification. Monetary policy shock is defined using three-month ahead funds rate future surprise. Variables presented are shares of employment in certain skill group to population of the country. The horizontal axes are in months.

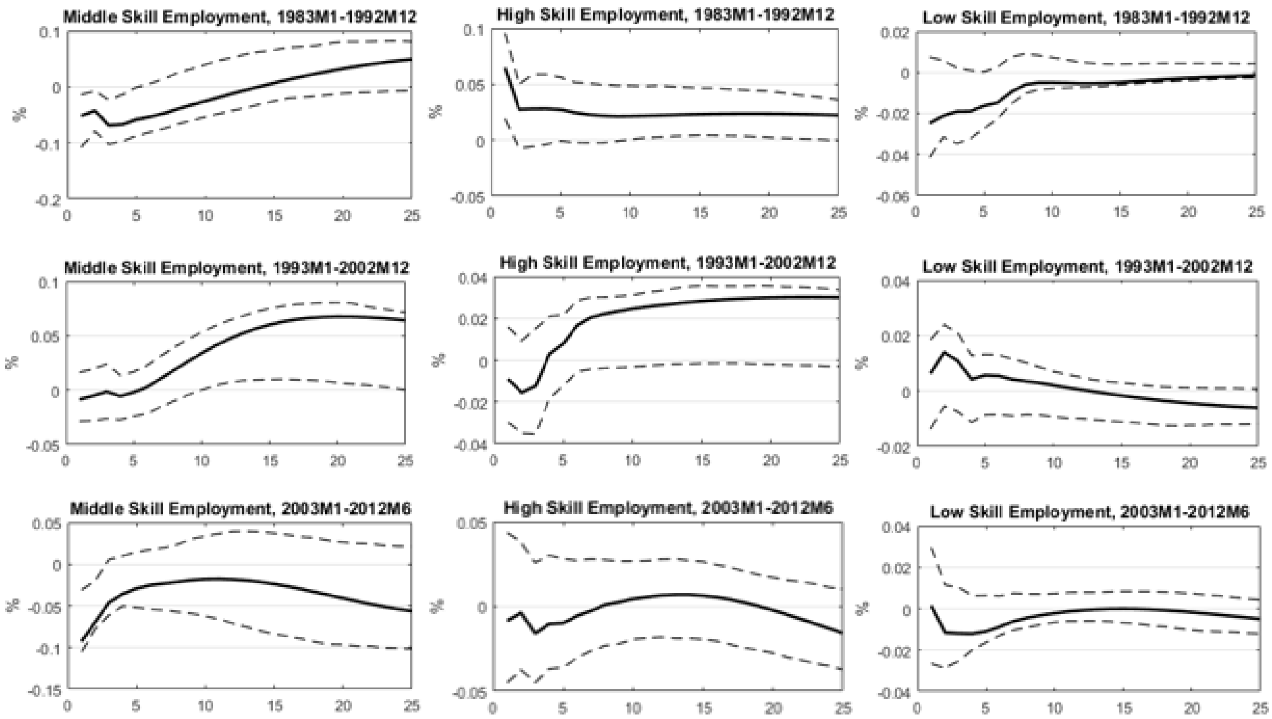

Figure A.6. Impulse response functions for employment variables during different periods

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. The horizontal axes are in months.

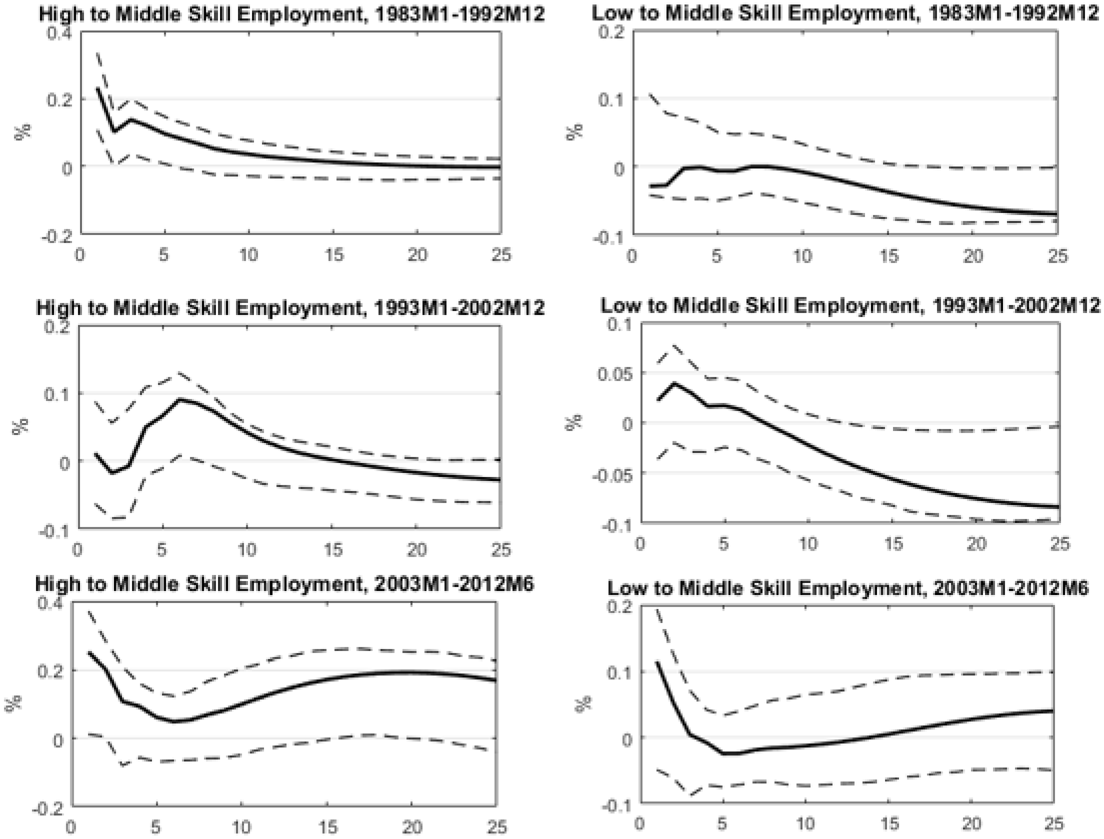

Figure A.7. Impulse response functions for employment ratios during different periods

Notes: solid line is an impulse response function to 1 standard deviation shock. Dashed lines are 90 percent confidence intervals. Monetary policy shock is defined using three-month ahead funds rate future surprise. The horizontal axes are in months.

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