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**THE EFFECTS OF PERSONAL AND CORPORATE  
INCOME TAX CHANGES ON THE ESTONIAN  
ECONOMY**

Master's thesis

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## Abstract

The paper analyses the dynamic effects of personal and corporate income tax rates on the Estonian economy using narrative tax shocks in instrumental variable approach in vector autoregressive model for the period 2000Q1 to 2017Q4. Surprisingly a reduction in the average personal income tax rate leads to a decrease in output, government purchases and employment and an increase in the unemployment rate. Furthermore, a reduction in the corporate income tax rate does not have an effect on government spending, but reduces the unemployment rate. Reductions in the average personal and corporate income tax rate produce opposite signs in the unemployment rate which may be caused by alterations in government spending and not directly due to tax changes.

**Keywords:** personal income taxes, corporate income taxes, VAR, Estonia

## Introduction

In order to make the best use of different policy instruments, policy makers need to know their estimated impact on the economy. Among these policy tools are taxes by means of which most countries accumulate a big part of their national budget. Changing the tax rates can have a strong impact on a country's economy and when assessing these effects, it is important to make a difference between anticipated and unanticipated tax shocks as it has been showed that analyses which ignore this aspect produce biased estimates (Leeper et al., 2013).

The current study estimates the influence of income tax rates on the Estonian macroeconomic aggregates and studies the transmission through labor market indicators such as employment and unemployment. The paper finds that a cut in the average personal income tax rate (APITR) by one percentage point leads to a decline in the Estonian economy. More specifically, APITR itself recovers to its pre-shock level in 2 quarters, output is shown to fall by approximately 0.5 percent while government purchases may be decreased by as much as 1 percent. As for the labor market, estimations imply a reduction in employment by roughly 0.5 percent and a rise in the unemployment rate by up to 3.4 percentage points as a result of reducing average personal income tax rate by one percentage point. Nevertheless, these last outcomes may not be pure effects of tax changes but rather a reaction to reduced government spending. All of these results are statistically significant at least at 68 percent confidence level.

A one percentage point reduction in the average corporate income tax rate (ACITR) does not lead to statistically significant changes in output and government purchases while ACITR itself recovers to its pre-shock level in 3 quarters after the cut. Nevertheless, employment is shown to increase by as much as 0.3 percent and the unemployment rate is decreased by up to 2.7 percentage points. Results for the labor market are statistically significant at 68 percent confidence level.

The paper uses a structural vector autoregressive (SVAR) model and quarterly data of various indicators for the period from 2000Q1 to 2017Q4. One of the main hindrances in estimating the aftermath of changes in tax policy is endogeneity in the identification of these changes. In the context of this study it will be dealt with by the use of narratively identified tax changes as did Romer and Romer (2010), and Mertens and Ravn (2013). This helps to identify the most important features of an immense information package related to tax policy changes. Effects of personal and corporate income tax rates are investigated separately and only unanticipated tax shocks are included in the analysis. Relevant tax changes were identified from the tax acts announced by the legislative power of Estonia.

The paper contributes to the literature in three aspects. First, Estonia is an interesting country to study because the country is in a relatively rare position as a small open economy striving for a balanced budget. Due to this aspiration changing the tax rates may have unexpected effects on its economy compared to many other countries. Secondly, in Estonia most of the changes in the tax rate are announced several months before their implementation which makes it difficult to estimate their effects. The paper at hand is dealing with this problem as only unanticipated tax shocks are used in the analysis. Thirdly, personal and corporate income tax base, hours per worker and labor force estimates are also included in this work. There do not seem to be any other studies for Estonia that incorporate these variables.

Most studies that contrast taxes to different economic variables are based on the U.S. data which is very different from Estonia by means of its size, openness and budget policy to mention only a few factors. Compared to the studies using Estonian data the main advantage of the present one is the use of narratively identified tax shocks which makes them more exogenous and their effects easily detectable as well as separating the unanticipated tax shocks from the anticipated.

Literature suggests that a lower tax rate of both personal and corporate income taxes generally leads to a higher level of GDP (Mertens and Ravn,

2013; Barro and Redlick, 2009; Mourougane and Vogel, 2008; Ahmad and Xiao, 2013; Font et al., 2018; Bajo-Rubio and Gomez-Plana, 2015; Prillaman and Meier, 2014; Sarker et al., 2014; Konopczyński, 2013). It can be both due to an increase in investments (Masso et al., 2013; Salotti and Trecroti, 2015; Abdioglu et al., 2016; Font et al., 2018; Bhattarai and Trzeciakiewicz, 2017) which leads to a higher level of output as well as through higher wages that cause an expansion in consumption (Masso and Meriküll, 2013; Bhattarai and Trzeciakiewicz, 2017). However the findings of the current study are in line with the paper by Hungerford (2018) who also finds that the relationship between corporate tax rates and GDP growth rate is weak and not statistically significant.

The findings on labor markets are not surprising. Literature seems to suggest that the direction and size of this impact is dependent on the method used and countries studied. Since there seems to be no universal rule for all countries in this matter, it is important that each country determines the nature of this relationship on their own. Knowing in which direction and how much changes in tax policy change the economic situation enables policy makers to achieve the desired effects more likely. For example, Staehr (2008) and Paulus et al. (2007) study the impact of income taxes on the labor market in Estonia. Staehr (2008) finds that a reduction in personal labor income tax results in an increase in employment and the study by Paulus et al. (2007) shows that a reduction in labor marginal income tax increases unemployment. The current study confirms the findings with the effects found in Paulus et al. (2007).

The rest of the paper is structured as follows. Section 1 gives an overview of the literature covering the linkage between taxation and macroeconomic effects focusing on the impact on output and its components as well as the labor market. Section 2 describes the dataset and method used to attain the results. Section 3 presents benchmark outcomes at first and then focuses on the labor market and other variables. Robustness of the results is also discussed in this section. The last section makes the concluding remarks of the paper.

# 1 Literature review

Several different methods and datasets have been used to assess the macroeconomic effects taxes impose on an economy. These methods can be divided into three groups: 1) macroeconomic regressions, 2) microeconomic regressions, and 3) various theoretical models. This paper uses structural vector autoregression model which belongs to the group of macroeconomic regressions. That approach is also used by Mertens and Ravn (2013), and Sarker et al. (2014).

There are many macroeconomic regression set-ups that use different single and simultaneous equations regression models with contemporaneous restrictions to determine the impact of taxes (see for example Salotti, S., and Trecroti, C., 2015; Prillaman and Meier, 2014; Abdioglu et al., 2016; Zellner and Ngoie, 2015; Staehr, 2008; Hungerford, 2018; Barro and Redlick, 2009; Vörk et al., 2007; Feldmann, 2011; Neverauskienė et al., 2017; Festa, 2015). Compared to this group the instrumental variable SVAR has the advantage of simultaneously regressing multiple variables and it is also robust to measurement errors arising from inaccurately determining the size, timing or motivation of used shocks. Compared to microeconomic regression analysis used by Benmarker et al. (2009) and Masso et al. (2013) SVAR has all the advantages mentioned in relation to macroeconomic regression analysis as well as the use of macroeconomic variables that consider a broader range of instruments.

The use of theoretical models is also very popular approach to evaluate the impact of taxes. See for example papers by Mourougane and Vogel, 2008; Ahmad and Xiao, 2013; Font et al., 2018; Bajo-Rubio and Gomez-Plana, 2015; Konopczyński, 2013; Wang, 1993; Bhattarai and Dixon, 2014; Bettendorf et al., 2009, Böhringer et al., 2005; Daveri and Tabellini, 2000; Paulus et al., 2007; Alho, 2006; Blanchard and Wolfers, 2000; Bhattarai and Trzeciakiewicz, 2017; García and Sala, 2008; and Halko, 2005. The most important advantage of SVAR over this method is that SVAR makes use of real data

and derives conclusions based on actual outcomes while theoretical models use a structure that does not necessarily reflect the world and can lead to erroneous conclusions.

As stated above, the present study makes use of an SVAR approach which is an expansion of VAR as it combines economic theory with time series analysis. Its main advantage is that economic theory is able to provide the necessary restrictions on the estimated model of reduced form. Depending on the temporal nature of the underlying shocks, these restrictions can either be contemporaneous or long-run (McCoy, 1997). Another advantage of this method is robustness to various types of measurement errors (Mertens and Ravn, 2013) which will be covered in more detail below.

Literature generally suggests that a reduction in business taxes has a positive effect on the economic aggregates, such as an increase in output and decreased unemployment rate. Thus a reduction in taxes has been one of the mechanisms governments use all over the world to boost the economy although not every article on this matter is supportive of this conclusion.

More specifically, multiple studies show that a reduction in income or business taxes gives rise to an increase in output (Mertens and Ravn, 2013; Masso and Meriküll, 2011; Barro and Redlick, 2009; Mourougane and Vogel, 2008; Ahmad and Xiao, 2013; Font et al., 2018; Bajo-Rubio and Gomez-Plana, 2015; Prillaman and Meier, 2014; Sarker et al., 2014; Konopczyński, 2013). Quantitative results of these studies imply that a one percentage point cut in labor taxes increases GDP by roughly 0.4-0.5 percent compared to the baseline scenario. A study by Zellner and Ngoie (2015) uses a different approach, but its outcome that reducing the personal income tax rate provides a boost to the annual GDP growth is in alignment with the ones mentioned earlier.

Nevertheless, a recent study by Hungerford (2018) finds contradicting evidence and argues that high corporate tax rates do not have any effect on economic growth. He says that between 1946 and 2016 real GDP growth and the one-year lag of the statutory corporate tax rate share a correlation coefficient of +0.19, and from 1954 to 2006 real GDP growth rate and one-year

lagged value of the effective marginal tax rate on capital income share a correlation coefficient of -0.07. Neither of these results are said to be statistically significant.

As for the components of GDP, reduction in income taxes is argued both to decrease consumption (Font et al., 2018) as well as increase it (Bhattarai and Trzeciakiewicz, 2017) while investments are shown to increase (Salotti and Trecroti, 2015; Abdioglu et al., 2016; Font et al., 2018; Bhattarai and Trzeciakiewicz, 2017) as a result of cutting income tax rates. In case of Estonia it is shown that cutting the corporate income taxes leads to a higher level of consumption and lower level of government spending (Masso and Meriküll, 2011) as well as a higher level of investments (Masso et al., 2013).

Numerous articles have studied the effect of taxes on employment and unemployment, results range from negative to positive. These results depend on the model and the prevailing circumstances of a country. It is shown on several occasions that raising the tax rate leads to an increase in employment. See for example papers by Berger and Everaert, 2010; Carcía and Sala, 2008 and Daveri and Tabellini, 2000; Bajo-Rubio and Gomez-Plana, 2015; Font et al., 2018; Staehr, 2008; Bettendorf et al., 2009; Neveauskienė et al., 2017; Planas et al., 2007; Hagedorn et al., 2016; Vörk et al., 2007; Alho, 2006; Coenen et al., 2008; or Böhringer et al., 2005. In these studies a tax rate cut of one percentage point is shown to increase the employment rate by 0.2-0.7 percentage points.

Other studies find no statistically significant relationship between taxes and (un)employment (Cruces et al., 2010; Blanchard and Wolfers, 2000; Bennmarker et al., 2009 and Hoel, 1989) and there are even some studies that imply that reducing the tax rates leads to an expansion of unemployment. Feldmann (2011) shows that corporate tax decrease by 1 percentage point increases the unemployment rate by 0.21 percentage points and Paulus et al. (2007) show that a one percentage point cut in marginal income tax rate leads to an increase in the unemployment rate by 1.6 percentage points. Pril-

laman and Meier (2014) find that one percentage point reduction of business taxes decreases the employment rate by 0.7172 percent.

Ahmad and Xiao (2013) also consider the effects on the hours worked and find that a reduction in labor hours can be achieved by lowering corporate income taxes. These effects can be contrasted to the ones obtained by Mertens and Ravn (2013) who argue that lowering the corporate tax rate has no statistically significant effect on hours per worker and that they can even be increased by decreasing personal income taxes.

There are two studies on the (un)employment based on Estonian data included in this literature review. First one is by Paulus et al. (2007). They show that lower labor marginal income tax rate leads to an increase in the unemployment rate while Staehr (2008) finds that an increase of the personal labor income tax rate by 1 percentage point decreases employment by 0.36 percentage points. The first paper is based on Estonian Labour Force Survey conducted in 2004 and the second one is based on results of the same survey a year later.

It is clear that literature fails to produce an answer to how the labor market is influenced by tax rates that works on all circumstances. The direction and amplitude of this impact depend on the prevailing economic situation in the country and also on the approach used for the estimation as the shocks might include for example anticipated effects in case of early announcements of tax changes or shocks.

## **2 Data and method**

### **2.1 Data**

The paper first identifies narrative tax shocks for Estonia during the years 2000 – 2017. Similarly to Mertens and Ravn (2013) a differentiation is made between the effects of changes in average personal income tax rates (APITR)

and the effects of changes in average corporate income tax rates (ACITR). Tax changes for which the time between their announcement and implementation is more than one quarter are not included due to the fact that anticipated tax changes may affect the economy ahead of their implementation. This phenomenon has been studied on several occasions, including by House and Shapiro (2006), Yang (2005), Auerbach (1989) and Hall (1971).

Identification and determination of the size and timing of narrative tax changes is done similarly to Romer and Romer (2009). I identify the relevant tax changes from the announced tax acts imposed by Riigikogu – the legislative power in Estonia – and study the changes in income tax, social tax, funded pensions and unemployment insurance acts. Overall there are 117 legal instruments that make amendments in the income tax act, 13 of which are changing the tax revenue. In case of social tax act there are 71 modifying legal instruments, 9 of which change the revenue.

There are 31 legal instruments amending the funded pensions act and 47 instruments amending the unemployment insurance act. There is only one document for each of these acts that changes the tax revenue. After accounting for the implementation lag less than one quarter I find four unanticipated tax changes both in case of income tax and social tax. Descriptions of these changes are included in Appendix A and together they contribute to eight alterations in personal income taxes and two changes in corporate income taxes. Contributions to social insurance are included as a part of personal income taxes. Volumes of these tax changes are found by dividing the changes in tax revenue with real GDP and they are depicted in Figure 1 along with the average personal income tax rate and average corporate income tax rate which are calculated as

$$\mathbf{APITR}_t = (\text{Personal Current Taxes}_t + \text{Contrib. for Govt. Social Insurance}_t) / \text{Personal Taxable Income}_t$$

$$\mathbf{ACITR}_t = \text{Taxes on Corporate Profits}_t / \text{Corporate Profits}_t,$$

where all taxes are at the state level.

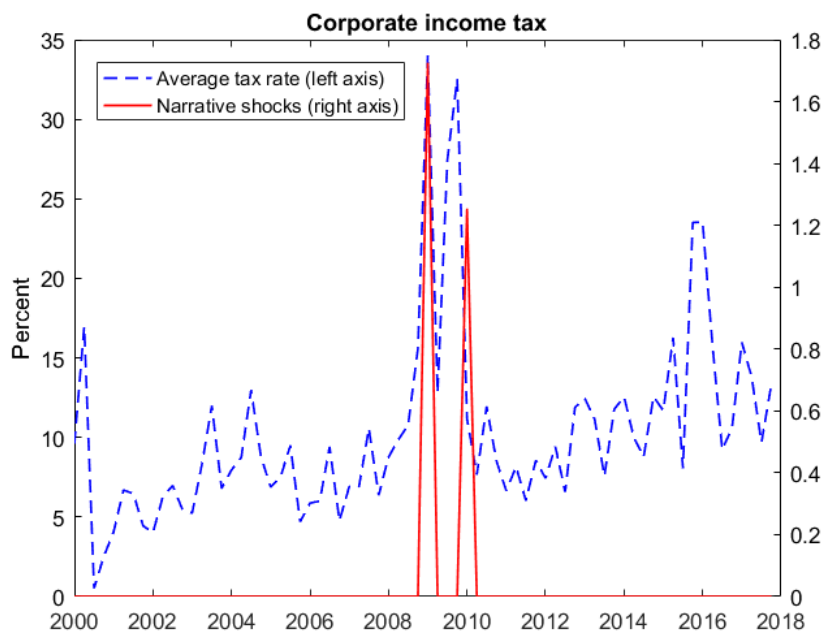
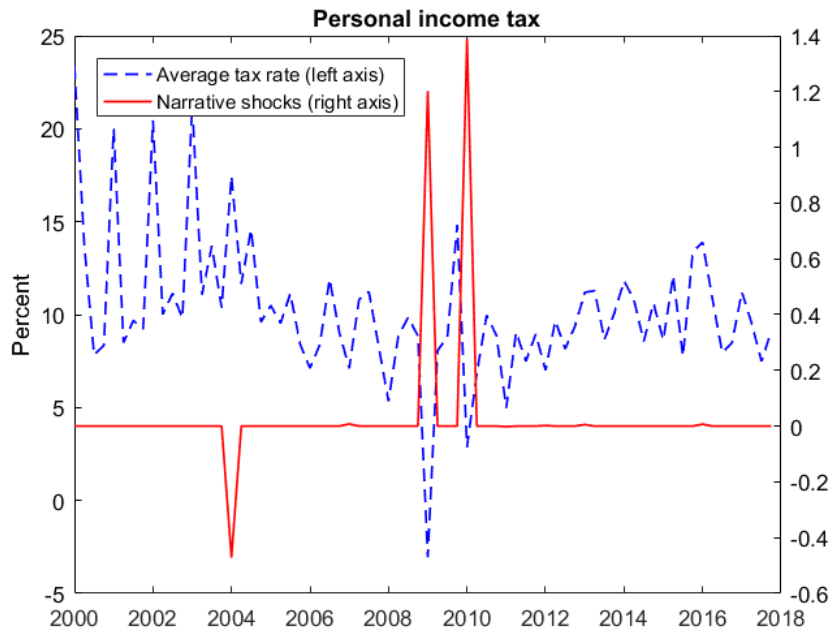


Figure 1: Average tax rates and narrative shock measures, Estonia 2000:I - 2017:IV

Correlation between personal and corporate income narrative tax changes is high for this sample and stands at 0.9424. It is only natural since both legal instruments that make changes to the average corporate income tax rate also change the average personal income tax rate. However, it does not seem to be an issue as changing the sequence of the identification does not have a strong effect on the results.

Time series of average tax rates and narrative tax shocks in 2000-2017 are depicted in Figure 1 and it can be seen that both the average personal and the average corporate income tax rates are very volatile even after seasonal adjustment. Both of them behave abnormally when compared to the rest of the time frame during the financial crisis of 2009-2010. From 2000 to 2005 the level of APITR fluctuates between 8 to 23 percent, after that it stays between 7-13 percent except in 2009 and 2010 when it first drops below zero and then jumps back up to 15 percent. Average corporate income tax rate shows a slight trend of increase during the time frame starting from around 5 percent and reaching an average of about 10 percent in 2017. Big jumps in the average tax rate occur in 2009 and 2010 when it reaches 34 and 33 percent respectively.

Several quarterly variables of the Estonian economy will be used to assess the kind of effects achievable by changing the tax policy. I opt for the following variables: personal and corporate tax shock proxies which are estimated by subtracting the mean of non-zero narrative tax shock observations, average personal income tax rate, average corporate income tax rate, personal income tax base, corporate income tax base, government purchases, real gross domestic product, the unemployment rate, employment, hours per worker and labor force. Figure 2 shows how these variables have changed over time and a more detailed construction of the data is included in the Appendix B.

The data for central bank profits which is used in the estimation of ACITR and the corporate income tax base is acquired from the website of Eesti Pank. All other data is retrieved from the database of Statistics Estonia.

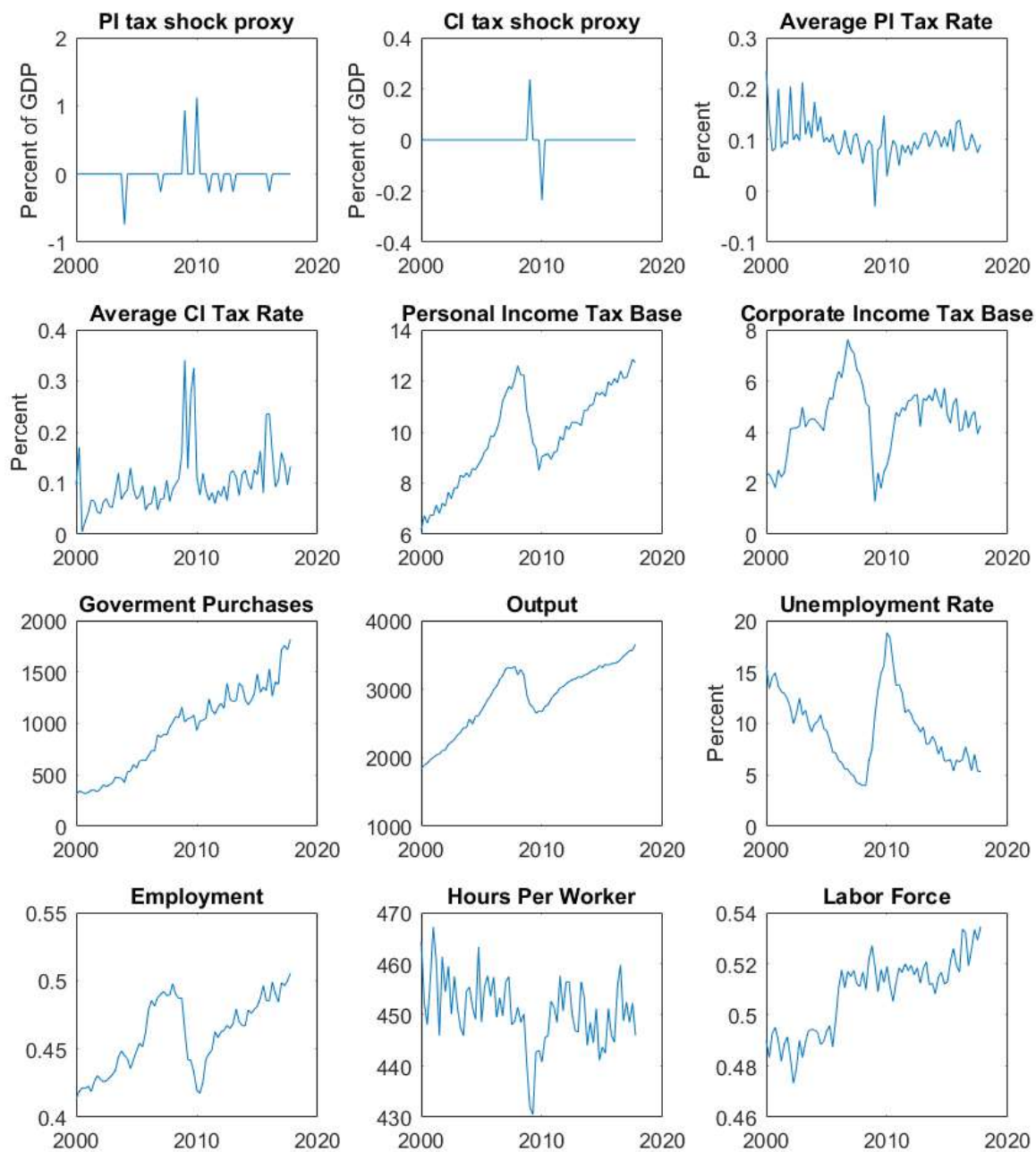


Figure 2: Time series of several indicators on the Estonian economy

Notes: All fiscal variables are given in real terms. Personal and corporate income tax base, government purchases, output, employment and labor force are given per capita.

## 2.2 Method

In order to estimate the effect of tax changes on the economy I use the narrative accounts mentioned above to identify structural shocks in a SVAR framework. The approach follows closely Mertens and Ravn (2013), the notation of the methodology in what follows is the same and more details can be found in Mertens and Ravn (2013). The idea is to use external instruments to identify the exogenous changes in the tax rate.

Let  $\mathbf{Y}_t$  be an  $n \times 1$  vector of observables. It is assumed that the dynamics of the observables are described by a system of linear simultaneous equations,

$$\mathbf{A}\mathbf{Y}_t = \sum_{j=1}^p \boldsymbol{\alpha}_j \mathbf{Y}_{t-j} + \boldsymbol{\varepsilon}_t, \quad (1)$$

where  $\mathbf{A}$  is an  $n \times n$  nonsingular matrix of coefficients (meaning that its determinant is not equal to zero),  $\boldsymbol{\alpha}_j$ ,  $j = 1, \dots, p$  are  $n \times n$  coefficient matrices and  $\boldsymbol{\varepsilon}_t$  is an  $n \times 1$  vector of structural shocks with  $E[\boldsymbol{\varepsilon}_t] = 0$ ,  $E[\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t'] = \mathbf{I}$ ,  $E[\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_s'] = 0$  for  $s \neq t$ , where  $\mathbf{I}$  is the identity matrix. The last expression means that individual shocks are uncorrelated with each other. Deterministic terms and exogenous regressors in equation (1) are omitted for notational brevity.  $\mathbf{Y}_t$  can also be expressed as

$$\mathbf{Y}_t = \sum_{j=1}^p \boldsymbol{\delta}_j \mathbf{Y}_{t-j} + \mathbf{B}\boldsymbol{\varepsilon}_t, \quad (2)$$

where  $\mathbf{B} = \mathbf{A}^{-1}$ ,  $\boldsymbol{\delta}_j = \mathbf{A}^{-1} \boldsymbol{\alpha}_j$ .

In the context of SVAR  $\boldsymbol{\varepsilon}_t$  is treated as a vector of latent variables that are estimated on the basis of the prediction errors of  $\mathbf{Y}_t$  dependent on the information encompassed in the vector of lagged dependent variables  $\mathbf{X}_t = [\mathbf{Y}'_{t-1}, \dots, \mathbf{Y}'_{t-p}]'$ , and by imposing identifying assumptions. Reduced form residuals are denoted by  $n \times 1$  vector  $\mathbf{u}_t$  and related to the structural shocks as

$$\mathbf{u}_t = \mathbf{B}\boldsymbol{\varepsilon}_t. \quad (3)$$

Using  $E[\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}'_t] = \mathbf{I}$  implies that  $E[\mathbf{u}_t \mathbf{u}'_t] = \mathbf{B} \mathbf{B}'$  and thus an estimate of the covariance matrix of  $\mathbf{u}_t$  provides  $n(n+1)/2$  independent identifying restrictions. An identification of at least one of the column elements of  $\mathbf{B}$  requires even more restrictions.

Following the example of Mertens and Ravn (2013) covariance restrictions will be obtained from proxies for the latent shocks. They denote these proxy variables as a  $k \times 1$  vector  $\mathbf{m}_t$  correlated with  $k$  structural shocks of interest but orthogonal to other shocks. Partition of  $\boldsymbol{\varepsilon}_t$  as  $\boldsymbol{\varepsilon}_t = [\boldsymbol{\varepsilon}'_{1t}, \boldsymbol{\varepsilon}'_{2t}]'$  consists of a  $k \times 1$  vector  $\boldsymbol{\varepsilon}'_{1t}$  of the shocks of interest and a  $(n-k) \times 1$  vector  $\boldsymbol{\varepsilon}'_{2t}$  containing all other shocks. It is assumed without the loss of generality that the expected values of these proxies are zero, i.e.  $E[\mathbf{m}_t] = 0$ .

Identification of  $\mathbf{B}$  will make use of these proxy variables of  $\mathbf{m}_t$  and requires that they are correlated with the shocks of interest and uncorrelated with all other shocks. These two conditions can be expressed with the following equations:

$$E[\mathbf{m}_t \boldsymbol{\varepsilon}'_{1t}] = \boldsymbol{\Phi} \quad (4)$$

$$E[\mathbf{m}_t \boldsymbol{\varepsilon}'_{2t}] = 0, \quad (5)$$

where  $\boldsymbol{\Phi}$  is an unknown nonsingular matrix of dimensions  $k \times k$ .

Now consider the following partitioning of  $\mathbf{B}$ :

$$\mathbf{B} = \begin{bmatrix} \boldsymbol{\beta}_1 & \boldsymbol{\beta}_2 \\ n \times k & n \times (n-k) \end{bmatrix}, \quad \boldsymbol{\beta}_1 = \begin{bmatrix} \boldsymbol{\beta}'_{11} & \boldsymbol{\beta}'_{21} \\ k \times k & k \times (n-k) \end{bmatrix}', \quad \boldsymbol{\beta}_2 = \begin{bmatrix} \boldsymbol{\beta}'_{12} & \boldsymbol{\beta}'_{22} \\ (n-k) \times k & (n-k) \times (n-k) \end{bmatrix}',$$

where  $\boldsymbol{\beta}_{11}$  and  $\boldsymbol{\beta}_{22}$  are nonsingular. This partitioning has the same purpose as the partitioning of  $\boldsymbol{\varepsilon}_t$  – to account for the shocks of interest separately from all other shocks. From the equations (3)-(5) can be derived

$$\boldsymbol{\Phi} \boldsymbol{\beta}'_1 = E[\mathbf{m} \mathbf{u}'] \quad (6)$$

of dimensions  $n \times k$ . This system depends on the  $k^2$  unknown elements of  $\boldsymbol{\Phi}$  and because the only assumption on  $\boldsymbol{\Phi}$  is its nonsingularity, equation (6) provides  $(n-k)k$  additional identification restrictions. Using this equation

and partitioning  $E[\mathbf{mu}'] = [E[\mathbf{mu}'_1] \ E[\mathbf{mu}'_2]]$ , where  $E[\mathbf{mu}'_1]$  is of dimensions  $k \times k$  and  $E[\mathbf{mu}'_2]$  is of dimensions  $k \times (n - k)$ , gives

$$\boldsymbol{\beta}_{21} = (E^{-1}[\mathbf{mu}'_1] \ E[\mathbf{mu}'_2])' \boldsymbol{\beta}_{11}. \quad (7)$$

The value of  $E^{-1}[\mathbf{mu}'_1] \ E[\mathbf{mu}'_2]$  can be estimated and thus this system creates a collection of covariance restrictions. This estimation process can be divided into the following three stages:

- **First stage:** Estimation of the reduced form VAR by least squares.
- **Second stage:** Estimation of  $E^{-1}[\mathbf{mu}'_1] \ E[\mathbf{mu}'_2]$  from regressions of the VAR residuals on  $\mathbf{m}_t$ .
- **Third stage:** Imposing the restrictions in (7) and estimating the objects of interest. Additional identifying assumptions might be included.

In case of a single shock ( $k = 1$ ) restrictions in (7) are sufficient to identify the impact of coefficients  $\boldsymbol{\beta}_1$  and  $\boldsymbol{\varepsilon}_{1t}$  is identified up to a sign convention. However, in case of more than a single shock ( $k > 1$ ) additional restrictions that may vary with the particular application are needed to accompany the ones in (7). To identify the other shocks  $\boldsymbol{\varepsilon}_{2t}$  for which proxies might not be available, traditional short and long run restrictions can also be used.

Currently, the estimate of  $E^{-1}[\mathbf{mu}'_1] \ E[\mathbf{mu}'_2]$  is equal to the two-stage least squares (2SLS) estimator in a regression from  $\mathbf{u}_{2t}$  on  $\mathbf{u}_{1t}$  using  $\mathbf{m}_t$  as instruments for  $\mathbf{u}_{1t}$ . As a result, conditions (4)–(5) can be taken as the instrument validity conditions for this regression. Described procedure avoids direct assumptions on the elements of  $\mathbf{B}$  and the main requirement is the availability of proxies that satisfy these two conditions. Imitating Mertens and Ravn (2013), narratively identified measures of exogenous shocks to average tax rates will be used to identify structural tax shocks. It is assumed henceforth that the proxy variables are orthogonal to the history of  $\mathbf{Y}_t$ , i.e.  $E[\mathbf{m}_t \mathbf{X}'_t] = 0$ .

An important advantage of the described approach is robustness to various types of measurement errors since the exact nature of them does not have an impact on the identification of the impulse responses as long as conditions (4)–(5) are met. These errors may arise from falsely evaluating any of the parameters of narratively identified shocks that include size, timing and motivation.

To incorporate this robustness in the model, specific assumptions are made on the outline of proxies and latent shocks. Consider a structure of the SVAR in equation (2) and the following measurement equations:

$$\mathbf{m}_t = \mathbf{D}_t(\mathbf{\Gamma}\boldsymbol{\varepsilon}_{1t} + \mathbf{v}_t), \quad (8)$$

where  $\mathbf{\Gamma}$  is a nonsingular  $k \times k$  matrix,  $\mathbf{v}_t$  is a  $k \times 1$  vector of measurement errors such that  $E[\mathbf{v}_t] = 0$ ,  $E[\mathbf{v}_t\boldsymbol{\varepsilon}'_{1t}] = 0$  and  $E[\mathbf{v}_t\mathbf{v}'_s] = 0$  for  $s \neq t$ , and  $\mathbf{D}_t$  is a  $k \times k$  diagonal matrix of ones and zeros tracking zero observations. Assumptions on  $\mathbf{D}_t$  are that its diagonal elements are perfectly correlated meaning that if  $k > 1$  then proxy variables are identically censored and  $E[\mathbf{D}_t\mathbf{v}_t\boldsymbol{\varepsilon}'_{1t}] = 0$ . It is not required that the censoring process of  $\mathbf{D}_t$  is independent of  $\boldsymbol{\varepsilon}_{1t}$ .

The stochastic process for the proxies in (8) recognizes arbitrary scale which removes the scaling problem relevant for narratively identified tax shocks. These scaling problems arise because tax base is generally assumed to remain unchanged. Other allowances of system (8) are additive correlated measurement errors  $\mathbf{v}_t$  and censoring, meaning that realizations  $\boldsymbol{\varepsilon}_{1t}$  with larger absolute values are more likely to be detected.

Merging equations (2) and (8) gives the following model:

$$\mathbf{Y}_t = \boldsymbol{\theta}'\mathbf{X}_t^* + \mathbf{w}_t, \quad (9)$$

where  $\mathbf{X}_t^* = [\mathbf{Y}'_{t-1}, \dots, \mathbf{Y}'_{t-p}, \boldsymbol{\varepsilon}'_{1t}]'$ ,  $\boldsymbol{\theta} = [\boldsymbol{\delta}', \boldsymbol{\beta}_1]'$ ,  $\boldsymbol{\delta} = [\boldsymbol{\delta}_1, \dots, \boldsymbol{\delta}_p]'$  and  $\mathbf{w}_t = \boldsymbol{\beta}_2\boldsymbol{\varepsilon}_{2t}$ . Because  $\boldsymbol{\varepsilon}_{2t}$  is comprised in the expression of  $\mathbf{w}_t$ , it is not fully observable.

Equation (9) will be used to determine the dynamic effects of personal and corporate income tax rates, where  $\mathbf{Y}_t$  consists of the time series of different macroeconomic variables depicted in Figure 2,  $\mathbf{X}_t^*$  includes their lagged values and shocks of interest, and  $\mathbf{w}_t$  includes the other shocks for which proxies are not available.

## 3 Results

### 3.1 Main results

To assess the dynamic effects of tax changes I use the main model of seven variables: average personal and corporate income tax rates, the personal income tax base ( $B_t^{PI}$ ), the corporate income tax base ( $B_t^{CI}$ ), government purchases ( $G_t$ ), gross domestic product ( $GDP_t$ ) and the unemployment rate ( $UNR_t$ ). Expression of  $\mathbf{Y}_t$  in equation (9) thus takes the following form:  $\mathbf{Y}_t = [APITR_t, ACITR_t, \ln(B_t^{PI}), \ln(B_t^{CI}), \ln(G_t), \ln(GDP_t), \ln(UNR_t)]$ . All fiscal variables are in real per capita terms and on the state level for Estonia. Precise constructions of all variables are included in the Appendix B. I use quarterly observations from 2000Q1 to 2017Q4 in the model and implement a lag of two periods. Impulse responses are for a 1 percentage point decrease in either APITR or ACITR and predictions are made for 12 quarters. Results show 68 percent confidence intervals using 1000 bootstrap replications.

Figure 3 depicts the effects of one percentage point cut in the average personal income tax rate for different orderings of APITR and ACITR. It can be seen that the initial cut of 1 percentage point in the average personal income tax rate recovers to the pre-shock level after only about two quarters. The personal income tax base is not initially affected by the tax cut, but decreases by approximately 0.5 percent around three quarters after the cut and does not recover to the initial level during the four-year period of interest.

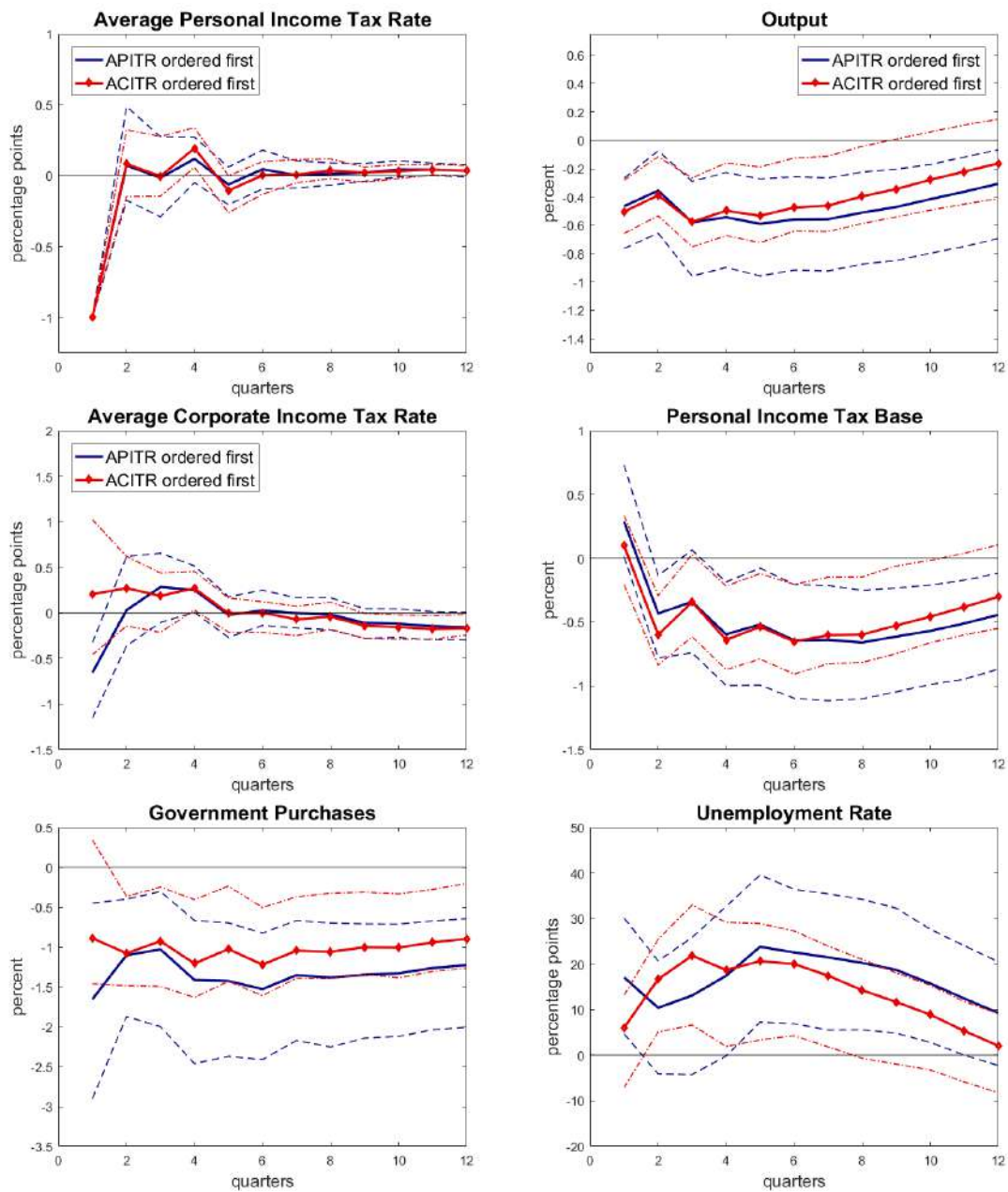


Figure 3: Average personal income tax rate cut with the unemployment rate in the model

Rather surprisingly the results of this model indicate that a tax cut in the average personal income tax rate leads to a general decline in the economy since output and government purchases significantly (at the 68 percent level)

reduce and the unemployment rate is increases. Initially output reduces by 0.5 percent and it stays below the expected level for the whole four year period while the results are statistically significant for two years after the tax cut. Government purchases decrease by approximately 1-1.5 percent and stay around this level for the whole time frame of 12 quarters. The unemployment rate is not affected by much right after the shock, but it reaches its peak of increasing by approximately 23 percentage points 3 to 5 quarters after the tax cut. Responses in output and the unemployment rate may not necessarily be direct outcomes of the tax cut as they can also reflect the reduced government spending. Thus, caution should be taken when interpreting these results as pure effects of a tax cut. Results for the average personal income tax rate, average corporate income tax rate and the unemployment rate are nor statistically significant during the whole period when we count out the initial reduction of APITR by 1 percentage point.

Figure 4 depicts the effects of one percentage point cut in the average corporate income tax rate for different orderings of APITR and ACITR. It can be seen that after this initial cut of APITR, it recovers to its pre-shock level after 3 quarters. This cut induces an initial 3 percent increase in the corporate income tax base that reaches its expected level after a year and stabilizes at 0.2 percent below this level 7 quarters after the shock. Output is not significantly affected this time as it stays close to its expected level. When ACITR is ordered first, output is not altered at all right after the impact and it slowly starts decreasing two quarters after the shock. Four years after the cut it is at -0.2 percent. When APITR is ordered first, the results show a similar path but at a slightly higher level by 0.2 percent right after the shock and by 0.1 percent after four years. When ACITR is ordered first then government purchases initially decrease by 1 percent, after two quarters peak at -0.1 percent and then stabilize at -0.5 percent after about five to seven quarters. The response is similar for when APITR is ordered first, but they are at a higher level by 0.5-0.6 percent during the whole period. The unemployment rate responds to the average corporate tax rate cut with an initial decrease of 15 percentage points. When ACITR is ordered first the

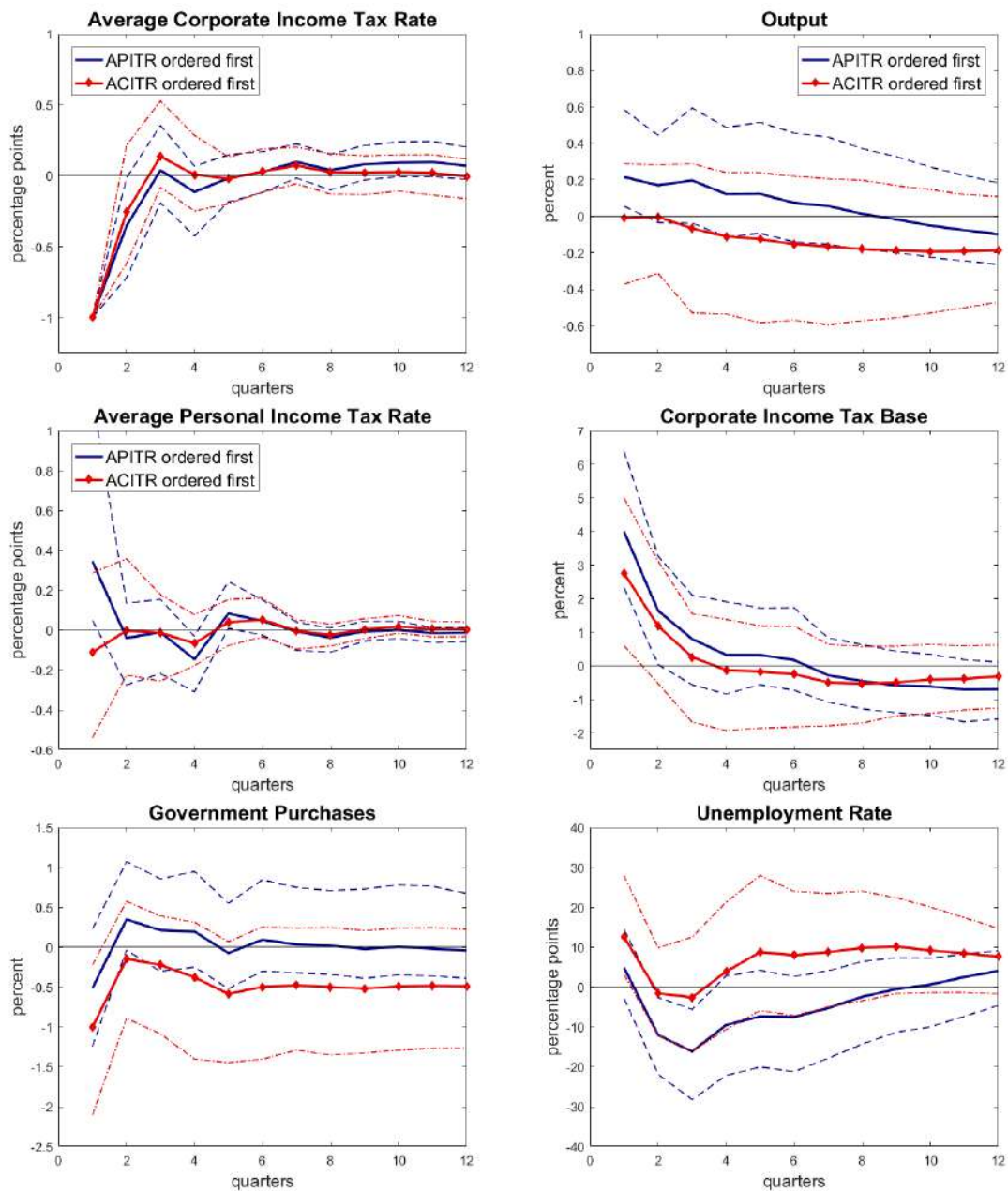


Figure 4: Average corporate income tax rate cut with the unemployment rate in the model

unemployment rate reaches its minimum three quarters after the shock at -1 percentage points, then starts to increase and stabilizes at 9 percentage points two years after the cut. Results for when APITR is ordered first are

analogous, but lower by approximately 15 percentage points. Except for the initial cut in the average corporate income tax rate and the consequent increase in the corporate income tax base, none of the results are statistically significant in this model for one percentage point cut in ACITR.

In order to assess whether the model is a good fit for the data I find an F statistic of 4.08 and robust F statistic of 13.65 for this model. According to Stock et al. (2002) a robust F statistic considerably larger than ten in case of one instrument first stage regression implies that one can be relatively confident that weak instrument problem is minimized. Tests for heteroscedasticity imply that null hypothesis of no ARCH effects should be rejected in case of ACITR and the unemployment rate ( $p < 0.05$ ). In case of APITR I find a p-value equal to 0.0732 and for others it is considerably larger meaning that there is no evidence to reject the null hypothesis of no ARCH effects. I also find an R-squared value of 10.86% and adjusted R-squared value of 8.20% for this model.

Another test to consider is Granger causality because it is assumed in the model that proxy variables for tax shocks are orthogonal to the history of economic variables. It ensures that the changes in economic variables are affected by the changes in tax rates and not vice versa. I estimate the F statistics and critical values and keep in mind that the null hypothesis that y does not Granger Cause x can be rejected if the F statistic is greater than the critical value. In the context of this work x is the time series of either personal or corporate income tax shocks and y are the instruments used in the model:  $\mathbf{y} = [APITR_t, ACITR_t, \ln(B_t^{PI}), \ln(B_t^{CI}), \ln(G_t), \ln(GDP_t), \ln(UNR_t)]$ . In case of personal income tax shocks I get the following results: F statistics  $F = [4.0953, 10.5645, 7.2175, 5.9914, 0.5314, 8.1052, 6.2002]$  and critical values  $c = [1.1981, 1.0034, 1.1907, 1.1959, 1.0034, 1.1895, 1.1907]$ . In most cases the F statistic is bigger than its corresponding critical value, which means that the null hypothesis that the instruments do not Granger cause tax shocks can be rejected. The only exception is government purchases.

Since there are eight narrative shocks in personal income tax I can check whether the results for Granger causality change if tax shocks in 2009 and 2010 are omitted. It is indeed the case as this time the F statistics  $F = [0.0283, 0.3818, 0.7087, 0.0245, 1.5425, 0.9045, 0.0334]$  are smaller than the critical values  $c = [1.0034, 1.0034, 1.0034, 1.0034, 1.0034, 1.0034, 1.0034]$  in most cases. It means that when the situation during the financial crisis is excluded from the analysis then tax changes are not motivated by the current state of most economic variables. The only exception is again government purchases.

An explanation for this probably relies on the fact that during the underlying time frame Estonia has aspired for a balanced national budget. Not only was this motivated by the objective to start using Euro as a national currency but also by the shift in perception as the resources for financing budget deficit seemed to be difficult or even impossible to acquire (Ross, 2014). It means that in order to keep the national budget in balance, government spending was adjusted to the amount of available resources. Thus, if taxes were raised then the government was also able to spend more even if raising the taxes was not directly motivated by the desire of a more expansive budget policy. This statement is supported by the results discussed above as we found evidence for a situation in which the rise in taxes leads to a higher level of government consumption or as it was previously presented – a cut in average personal income tax leads to a statistically significant reduction in government purchases.

In case of corporate income narrative tax changes I find F statistics  $F = [0.4801, 4.0118, 9.8938, 7.7798, 0.0201, 13.7309, 7.1465]$  and critical values  $c = [1.0040, 1.1995, 1.1972, 1.1942, 1.0040, 1.1852, 1.1942]$ . Again, null hypothesis that the instruments do not Granger cause tax shocks can be rejected in most cases, but not in case of the average personal income tax rate and government purchases. Since the only two shocks for corporate income taxes emerged during the financial crisis, it is only natural that these shocks are motivated by the prevailing situation in the economy as the government was trying to alleviate the effects of the crisis. Keeping that in mind we should

be careful when interpreting the results attained in relation to the shocks of the average corporate income tax rate.

Another thing worth mentioning is the phenomenon referred to as the law of small numbers according to which one should be careful when interpreting results derived from a small sample size. Only a short time frame from 2000 to 2017 with eight shocks of personal income tax and two shocks of corporate income tax meets the criteria of the present study. This means that tests for Granger causality may present strong correlations in the results even if this causality may actually be due to chance.

The present study uses the same method as Mertens and Ravn (2003) and thus the results of the two papers are easily comparable. Two of the main differences in the setup of our works are the country of interest and the fact that I substitute government debt for the unemployment rate in the benchmark model. The reason behind it relies on the matter that government debt plays a more important role for the American economy than it does for Estonia. National debt as a percentage of gross domestic product has not risen above 11 percent between 2000 and 2018 in Estonia while in the U.S. it has grown from around 55 percent to 105 percent. Results of a model incorporating government debt are included in the robustness analysis.

Differences in the results of the current study and the one by Mertens and Ravn (2013) are remarkable. While Mertens and Ravn (2003) observe that a reduction in taxes provides a boost to the economy in case of the U.S., results of this study imply that in the context of Estonia the opposite is the case. Judging from the confidence intervals both findings of this paper that upon the reduction of the personal income tax rate output falls and their conclusion that it rises are statistically significant. It is worth mentioning here that I use 68 percent confidence level due to a small sample size while Mertens and Ravn (2003) use 95 percent confidence level. Another difference worth mentioning concerns government purchases which I find to be negatively affected by the reduction of APITR. In case of the U.S. APITR cut does not have such a

strong effect on government purchases immediately after the tax cut, but there are signs of declining four years later.

One percentage point cut in the average corporate income tax rate does not have a strong effect on output and government purchases in the context of this study, but they are slightly increased in case of America according to Mertens and Ravn (2003). The corporate income tax base is statistically significantly increased upon the impact in both of our works by 3-4 percent and then falls back to its pre-shock level.

In addition, Barro and Redlick (2011) use average marginal income tax rates to study the output response based on annual American data. They estimate that one percentage point cut in the average marginal tax rate results in an increase of next year GDP by 0.5 percent. Their results for output are very similar to the ones attained by Mertens and Ravn (2003) and thus in contrast to the current ones by means of the direction of the change.

There are several other studies demonstrating a negative relationship between tax rates and GDP (Mourougane and Vogel, 2008; Ahmad and Xiao, 2013; Font et al., 2018; Bajo-Rubio and Gomez-Plana, 2015; Prillaman and Meier, 2014; Sarker et al., 2014; Konopczyński, 2013). These studies show that a cut in business tax rates by one percentage point increases GDP by 0.4-0.5 percent compared to the baseline scenario. On the other hand, a recent study by Hungerford (2018) finds no statistically significant relationship between corporate tax rates and economic growth. From Figure 4 it can be seen that the present study agrees with those results.

As for the Estonian data, a study by Masso and Meriküll (2011) indicates that by reducing corporate tax rates output is increased and government purchases is decreased while the present study reveals no statistically significant impact of corporate income tax rates on these two variables.

## 3.2 Detailed results

### Labor market

Next I will discuss the dynamic effects of tax changes on the labor market. As it was already discussed above many studies show that a reduction of taxes leads to a lower unemployment rate. However, there are also studies that find no relationship between tax shocks and unemployment and even some which suggest that lowering taxes leads to a higher level of unemployment. To investigate the situation in Estonia I compose a model encompassing the following variables: average personal and corporate income tax rate, government purchases ( $G_t$ ), unemployment rate ( $UNR_t$ ), employment ( $EMP_t$ ), hours per worker ( $HperW_t$ ) and labor force ( $LF_t$ ). It means that the expression of  $\mathbf{Y}_t$  in equation (9) looks as follows:  $\mathbf{Y}_t = [APITR_t, ACITR_t, \ln(G_t), \ln(GDP_t), \ln(UNR_t), \ln(EMP_t), \ln(HperW_t), \ln(LF_t)]$ . All fiscal variables are in real terms and on the state level; and all variables except hours per worker and the unemployment rate are given per capita.

Figure 5 shows the impact of one percentage point cut in the APITR on the left panel and in the ACITR on the right panel. It can be seen that a cut in personal income tax initially does not affect the employment, but it is reduced by almost 0.5 percent a year after the shock. It starts rising again after the fifth quarter and reaches the expected level at the end of the time frame of four years. These results are statistically significant from the second until the eighth quarter. Hours per worker are significantly lower than the expected level by 0.14 percent on the impact of lowering PI tax rates by one percentage point and after two quarters reach its minimum of 0.23 percent. The level of hours per worker then starts to rise and reaches a value statistically significantly above the expected level seven quarters after the shock at 0.05 percent where it stays until the end of the time frame.

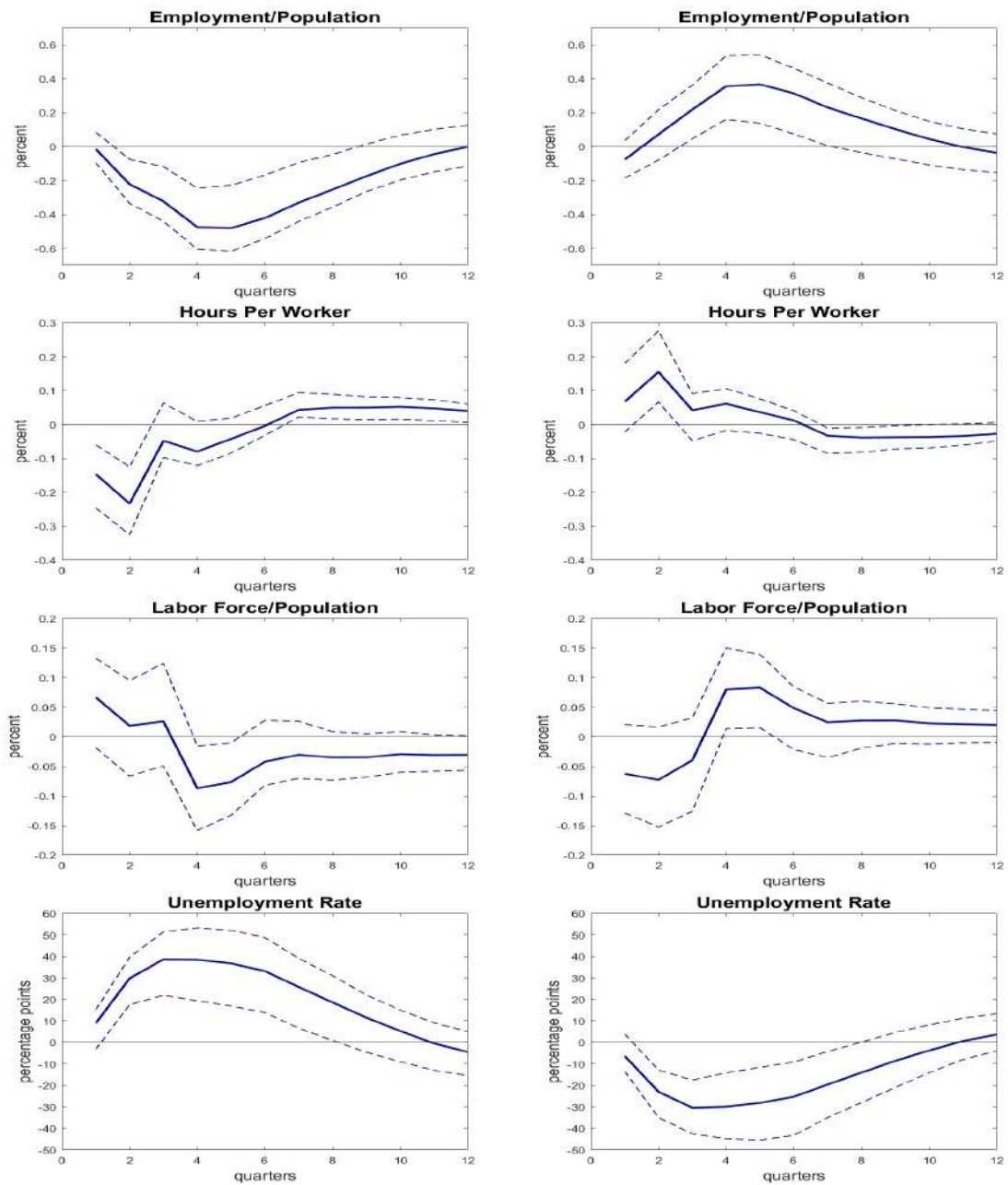


Figure 5: Labor market responses to tax cuts. Left panel: average personal income tax rate cut, right panel: average corporate income tax rate cut

Labor force is only affected by a small amount as it is raised by 0.07 percent at first, but then it starts to fall and is statistically significantly below the

expected level four to five quarters after the shock at -0.09 percent. It stabilizes about seven quarters after the impact at -0.03 percent. Based on this model the unemployment rate is increased by 9 percentage points upon the reduction of PI tax rate and reaches its maximum of 38 percentage points three quarters after the cut. After that the unemployment rate starts to fall and returns to its pre-shock level four years after the cut. Responses in the unemployment rate are statistically significant at 68 percent confidence level for two years after the tax cut.

These results indicate that a cut in the average corporate income tax rate has reverse effects on the labor market when compared to the effects evoked by a cut in the average personal income tax rate. More specifically, employment is lowered by 0.05 percent when there is a reduction by one percentage point in CI tax rate and reaches its maximum one year after the cut at 0.4 percent. Between the third and seventh quarter employment is statistically significantly above its pre-shock level and four years after the shock it is back to a negative 0.05 percent.

Hours per worker initially rise by 0.7 percent, peak at 1.6 percent above the expected level 2 quarters after the tax cut, then gradually decrease and stabilize five quarters later at around -0.03 percent being statistically significantly below the level zero from seventh to tenth quarter after the impact. Labor force is reduced by 0.06 percent upon the impact and during the next quarter by another 0.01 percent. Then it starts to increase and is at its maximum of 0.08 percent four to five quarters after the shock, when the results are also statistically significant. The level of labor force stabilizes at 0.02 percent above the pre-shock level about six quarters after the cut. The unemployment rate is significantly reduced upon the impact until the eighth quarter. Initially it is lowered by 5 percentage points, during the third quarter it is at its minimum of -9 percentage points. After that it slowly recovers to its pre-shock level at the end of the time frame of four years and even slightly surpasses it by 3 percentage points.

For the labor market model I estimate an F statistic of 7.58 and robust F statistic of 49.59. Again, one can be relatively sure that the weak instrument problem is not present. Tests for heteroscedasticity show that the null hypothesis of no ARCH effects should be rejected in case of ACITR ( $p = 0.0178$ ), GDP ( $p = 0.0251$ ) and the unemployment rate ( $p = 0.0354$ ). In case of other variables the null hypothesis should not be rejected. R-squared value for this model turns out to be 18.44% and adjusted R-squared 16.01%.

As in case of the previous model tests for Granger causality are performed. When all PI tax shocks are included then I get the following F statistics:  $F = [3.5089, 12.3089, 0.6963, 12.8318, 9.9348, 4.4550, 2.7300, 2.5529]$  and critical values:  $c = [1.1995, 1.0040, 1.0040, 1.1880, 1.1918, 1.1992, 1.0040, 1.0040]$ . From these it can be deduced that Granger causality is present for all variables except government purchases.

I exclude the tax shocks in 2009 and 2010 when the economy was in an abnormal state and find new values of F statistics  $F = [0.0283, 0.3818, 1.5425, 0.9045, 0.0334, 0.2362, 0.3954, 0.3096]$  and critical values  $c = [1.0034, 1.0034, 1.0034, 1.0034, 1.0034, 1.0034, 1.0034, 1.0034]$ . As before, it can be seen that after eliminating tax shocks that occurred during the financial crisis the remaining tax shocks are not influenced by most economic indicators included in the model except government purchases.

Unfortunately, in case of CI tax the only shocks included in the model came into force during the financial crisis. Thus, Granger causality test results in F statistics  $F = [0.0140, 6.8125, 0.3463, 22.0974, 12.5653, 0.7360, 3.0398, 4.2057]$  and critical values  $c = [1.0040, 1.0040, 1.0040, 1.1852, 1.1992, 1.0040, 1.0040, 1.0040]$  which imply that CI tax shocks during the financial crisis were influenced by the state of the average corporate income tax rate, GDP, the unemployment rate, hours per worker and labor force and not by the state of the average personal income tax rate, government spending and employment. The explanation is again related to the governments intent to alleviate the situation during the financial crisis by modifying the tax rate, but this corre-

lation may also be due to chance as with small sample size extreme outcomes are more likely to occur than in case of a big sample size.

Again I compare these results to the ones attained by Mertens and Ravn (2003) and see that in general the direction of the impact is different for the two economies. Present results indicate that a cut in average personal income tax rate leads to a lower level of employment which corresponds to an increase in the unemployment rate. Mertens and Ravn (2003) find that employment per capita is initially increased by 0.3 percent and it peaks at 0.8 percent five quarters after the impact while responses in the unemployment rate show an initial fall by 0.3 percentage points and the strongest response of -0.5 during the fifth quarter. Hours per worker are negatively affected upon the impact in the present study and positively affected in Martens and Ravn's (2003) work.

From the left panel of Figure 5 it can be said that cutting the average corporate income tax rate results in an increase in employment per capita and reduces the level of the unemployment rate. Mertens and Ravn (2003) found no statistically significant response for either of these variables as well as for hours per worker and labor force per population. Estonian data suggests that hours per worker are slightly increased and labor force fluctuates from below to above the pre-shock level for seven quarters until it stabilizes.

Articles by Staehr (2008) and Paulus et al. (2007) show how tax policies affect the labor market in the context of Estonia. Staehr (2007) finds that by reducing the labor income taxes employment is increased. Paulus et al. (2007) find that by reducing the labor marginal income tax the unemployment rate is increased by 1.6 percentage points. Results of the present study are in accordance with the ones attained by Paulus et al. (2007) since the left panel of Figure 5 shows an increase in the unemployment rate by 3.4 percentage points as a result of a one percentage point cut in the average personal income tax rate.

Other studies on this matter generally imply a negative relationship between the tax rate and the employment rate as a cut in different tax rates by one

percentage point increases the employment rate by 0.2-0.7 percentage points (Berger and Everaert, 2010; Carcía and Sala, 2008 and Daveri and Tabellini, 2000; Bajo-Rubio and Gomez-Plana, 2015; Font et al., 2018; Bettendorf et al., 2009; Neverauskienė et al., 2017; Planas et al., 2007; Hagedorn et al., 2016; Vörk et al., 2007; Alho, 2006; Coenen et al., 2008; Böhringer et al., 2005). Contradicting these results but agreeing with the ones attained in the present study are presented by Feldmann (2011) and Prillaman and Meier (2014). Other studies find no evidence in either direction (Cruces et al., 2010; Blanchard and Wolfers, 2000; Benmarker et al., 2009 and Hoel, 1989). Ahmad and Xiao (2013) show that a reduction in corporate income taxes lowers the labor hours while the present paper suggests an increase in hours per worker when the average corporate income tax rate is decreased.

### **Other macroeconomic variables**

As already mentioned, the model of benchmark results incorporates average personal and corporate income tax rates, log levels of personal and corporate income tax base, log level of government purchases, log level of real gross domestic product, and log level of the unemployment rate. I experiment with different compositions of this model by substituting the unemployment rate with government debt, investments, and consumption of nondurables and services. Compared to alternative models the one I present as the benchmark model produces the most consistent results when altering the ordering of APITR and ACITR. Results of these alternative models can be found in the Appendix C as Figures 6-11.

In case of the model that includes government debt, all results portraying APITR cut become statistically insignificant and outcomes of ACITR cut only change their volume. Government debt itself stays close to its expected level in both cases. Substituting the unemployment rate with investments produces a slower recovery of output and personal income tax base to their pre-shock level. In fact, they are both still statistically significantly below this level four years after the cut in APITR. Investments are statistically

significantly reduced from the third quarter. Results for ACITR cut do not change their statistical insignificance. The last alternative model incorporating consumption of nondurables and services does not change any on the results for either APITR or ACITR cut in an important way. Consumption itself is statistically significantly reduced from the second quarter by a cut in APITR and not statistically significantly altered by a cut in ACITR.

Literature suggests that there is a negative relationship between the income tax rate and investments (Masso et al., 2013; Salotti and Trecroti, 2015; Abdioglu et al., 2016; Font et al., 2018; Bhattarai and Trzeciakiewicz, 2017) meaning that by reducing the tax rate investments increase. The present study does not support this argument, but also does not produce a strong evidence to claim otherwise as only 68 percent confidence levels are used. Consumption has been argued both to increase (Bhattarai and Trzeciakiewicz, 2017; Masso and Meriküll, 2011) and decrease (Font et al., 2018) after a cut in income taxes. Results of the present paper agree with the ones attained by Font et al. (2018) as it is found that by cutting the personal income tax rate consumption is decreased while a cut in the corporate income tax rate does not produce a statistically significant outcome in investments nor consumption.

### **3.3 Robustness**

In order to assess the level of influence of individual tax shocks I will now describe what happens when personal income tax shocks are excluded one at a time. These results are depicted in Figures 12-35 in the Appendix C. In the event of removing personal income tax shock in 2004 reductions in output, personal income tax base, and government purchases as a result of a cut in APITR lose their statistical significance at 68 percent confidence level, but the general behavior of these variables over time remains the same compared to the original results. Also, by excluding personal income tax shock in 2011 or 2012, the unemployment rate is statistically significantly increased from

fifth to tenth quarter after APITR shock. Removal of other personal income tax shocks does not alter the results in any apparent way.

Next, I exclude personal income tax changes in 2009 and 2010. As can be seen from Figures 36-38 in Appendix C, macroeconomic responses to income tax shocks are not altered when the effects of a financial crisis are eliminated.

In addition to that I include personal income tax changes one by one while keeping both corporate income tax changes intact (Figures 39-56 in Appendix C). Responses are unstable and fall outside of confidence intervals when personal income tax change either only in 2011 or 2013 is included. Since these results are not feasible for interpretation, they are not included in the Appendix C. If the only included personal income tax change is the one that happened in 2004 then government purchases increase right after an APITR shock by 1.8 percent, but after a few quarters are back to their expected level and fall significantly below this level by the end of four years. Interesting transformations happen when the only included personal income tax change is the one in 2007. Responses in output, personal income tax base and the unemployment rate change their direction after an APITR shock meaning that the tax shock in 2007 caused output and the personal income tax base to increase and the unemployment rate to fall. However, only 68 percent confidence level is used and the mentioned responses are barely statistically significant even at that level. Other results are similar to the original results changing only their statistical significance in some cases.

Lastly, I include only one corporate income tax shock and either all personal income tax changes or only the ones in 2009 and 2010 (Figures 57-68 in Appendix C). There are no alterations worth mentioning in these results.

## 4 Conclusions

The paper studies how average personal and corporate income tax rates influence the Estonian economy by the use of narratively identified tax changes

and SVAR methodology. Surprisingly a reduction of the average personal income tax rate by one percentage point decreases output by up to 0.6 percent and government purchases by as much as 1.5 percent. Moreover, this reduction in the average personal income tax rate reduces employment by 0.5 percent and increases the unemployment rate by 3.4 percentage points. All of these results are statistically significant at 68 percent confidence level.

A one percentage point cut in the average corporate income tax rate does not lead to statistically significant changes in output and government purchases. Nevertheless, employment is shown to increase by 0.4 percent and the unemployment rate is shown to decrease by 2.7 percentage points as an aftermath of a cut in the average corporate income tax rate by one percentage point. The fact that government spending is not changed by a reduction in corporate taxes indicates that Estonian government purchases are not heavily financed through corporate income tax revenues.

The main contribution of this paper lies in the use of narratively identified tax shocks that are identified from the legislative tax acts; and the differentiation between anticipated and unanticipated tax shocks. Another importance is the separation of personal and corporate income taxes and the use of Estonian data as a small open economy with conservative budget policy as all these factors make Estonia an interesting subject for macroeconomic analysis.

The main limitation of this study is a short time frame (2000-2017) that results in a small sample of relevant tax shocks. There are only eight changes of personal income tax and two changes of corporate income tax meeting the requirements that they are not expected long before implementation. It is also important to mention that two of the personal income tax shocks and both of the corporate income tax shocks occurred during the financial crisis. However, robustness analysis shows that the results are consistent and not strongly transformed by any individual shock. Effects resulting from a cut in either the average personal or average corporate income tax rate have opposite signs for employment and unemployment. It is likely due to

the reaction of government spending. Therefore caution must be taken in interpreting the effects as the pure effects of tax changes.

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## Appendix A. Tax changes

### 1. **Income tax act of 2003**

Change in tax revenue: 2004Q1: -45.8 million euros (-716 million Estonian kroons) (PI)

The basic exemption deductible from the income of a resident natural person during a period of taxation is changed from 12 000 kroons to 16 800 kroons.

### 2. **Social tax act of 2006**

Change in tax revenue: 2007Q1: 1.3 million euros (20 million Estonian kroons) (PI)

Monthly rate of social tax is changed from 14000 kroons to 2000 kroons.

### 3. **Income tax act of 2008**

Change in tax revenue: 2009Q1: 170.0 million euros (PI); 244.1 million euros (CI)

The rate of income tax is changed from the announced 20 per cent to 21 per cent; and the basic exemption deductible from the income of a resident natural person during a period of taxation is changed from the announced 30 000 kroons to 27 000 kroons.

### 4. **Income tax act of 2009**

Change in tax revenue: 2010Q1: 204.5 million euros (PI); 184.3 million euros (CI)

The rate of income tax is changed from the announced 20 per cent to 21 per cent; and the basic exemption deductible from the income of a resident natural person during a period of taxation is changed from the announced 30 000 kroons to 27 000 kroons.

### 5. **Income tax act of 2010**

Change in tax revenue: 2011Q1: -0.3 million euros (PI)

The basic exemption deductible from the income of a resident natural person during a period of taxation is changed from 27 000 kroons to 1728 euros.

**6. Social tax act of 2011**

Change in tax revenue: 2012Q1: 0.4 million euros (PI)

Monthly rate of social tax is changed from 278.02 euros to 290 euros.

**7. Social tax act of 2012**

Change in tax revenue: 2013Q1: 1.0 million euros (PI)

Monthly rate of social tax is changed from 290 euros to 320 euros.

**8. Social tax act of 2015**

Change in tax revenue: 2016Q1: 1.5 million euros (PI)

Monthly rate of social tax is changed from 390 euros to 430 euros.

## Appendix B. Data definitions

**Personal income tax base** is logarithm of personal income plus contributions to government social insurance less government transfers divided by GDP deflator and by population; **corporate income tax base** is logarithm of corporate profits less Central Bank profits divided by GDP deflator and by population; **average personal income tax rate** is personal income tax revenues including contributions to government social insurance divided by personal income plus contributions to government social insurance less government transfers; **average corporate income tax rate** is corporate income tax revenues divided by corporate profits less Central Bank profits; **government spending** is logarithm of real government consumption and investment expenditures divided by population; **output** is logarithm of real gross domestic product divided by population; **government debt** is logarithm of government debt divided by GDP deflator and by population;

**employment** is logarithm of total economy employment divided by population; **hours per worker** is logarithm of total economy hours worked divided by total economy employment; **labor force** is logarithm of labor force (sum of employed and unemployed) divided by population; **consumption of nondurables and services** is logarithm of chain-aggregated nondurable consumption and service goods consumption divided by population; **unemployment rate** is the level of unemployment rate; **investments** is logarithm of gross fixed capital formation and valuables.

## Appendix C. Robustness

### Experimenting with different models

Model: APITR, ACITR, PITB, CITB, government spending, output, government debt.

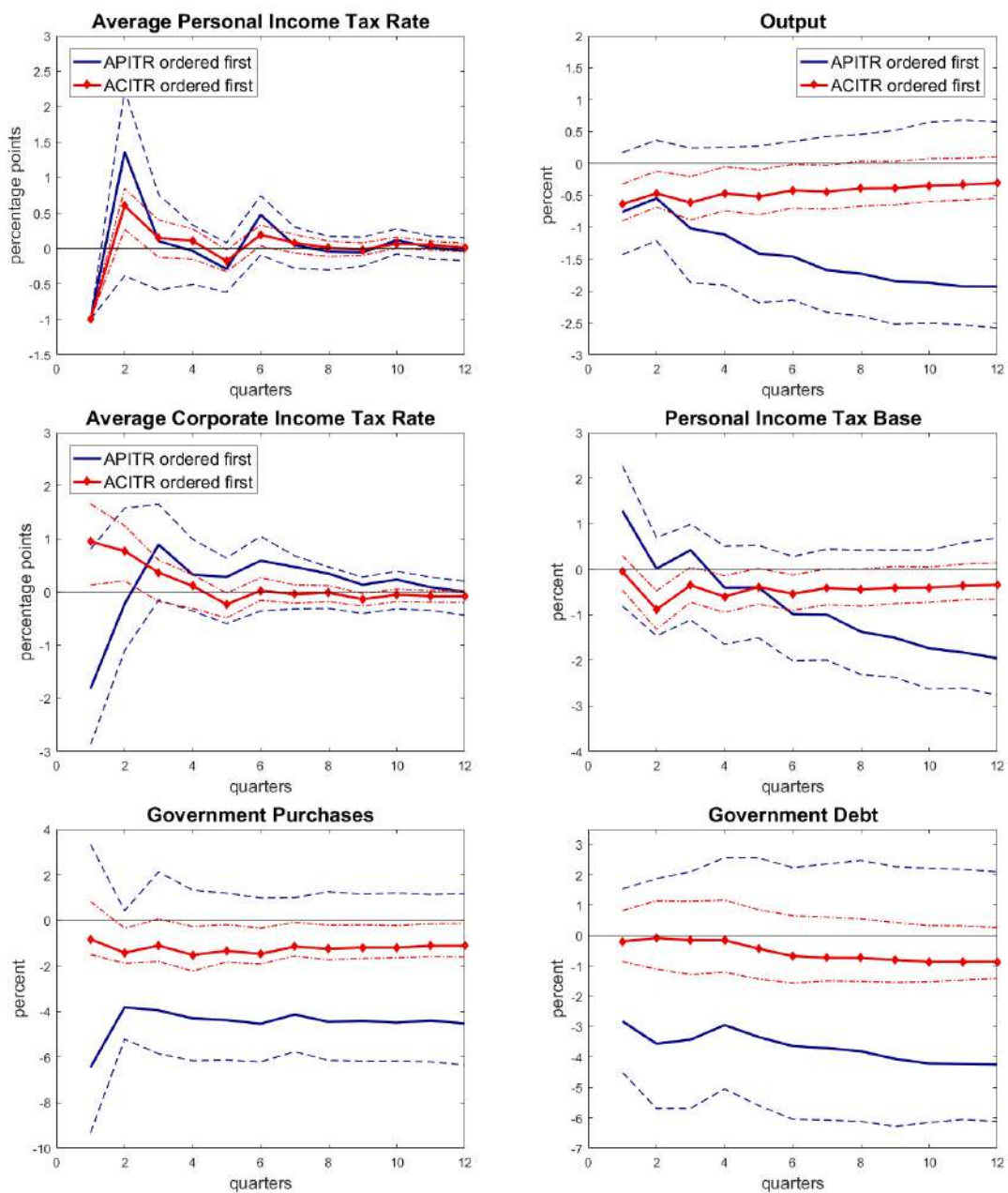


Figure 6: APITR cut with government debt in the model

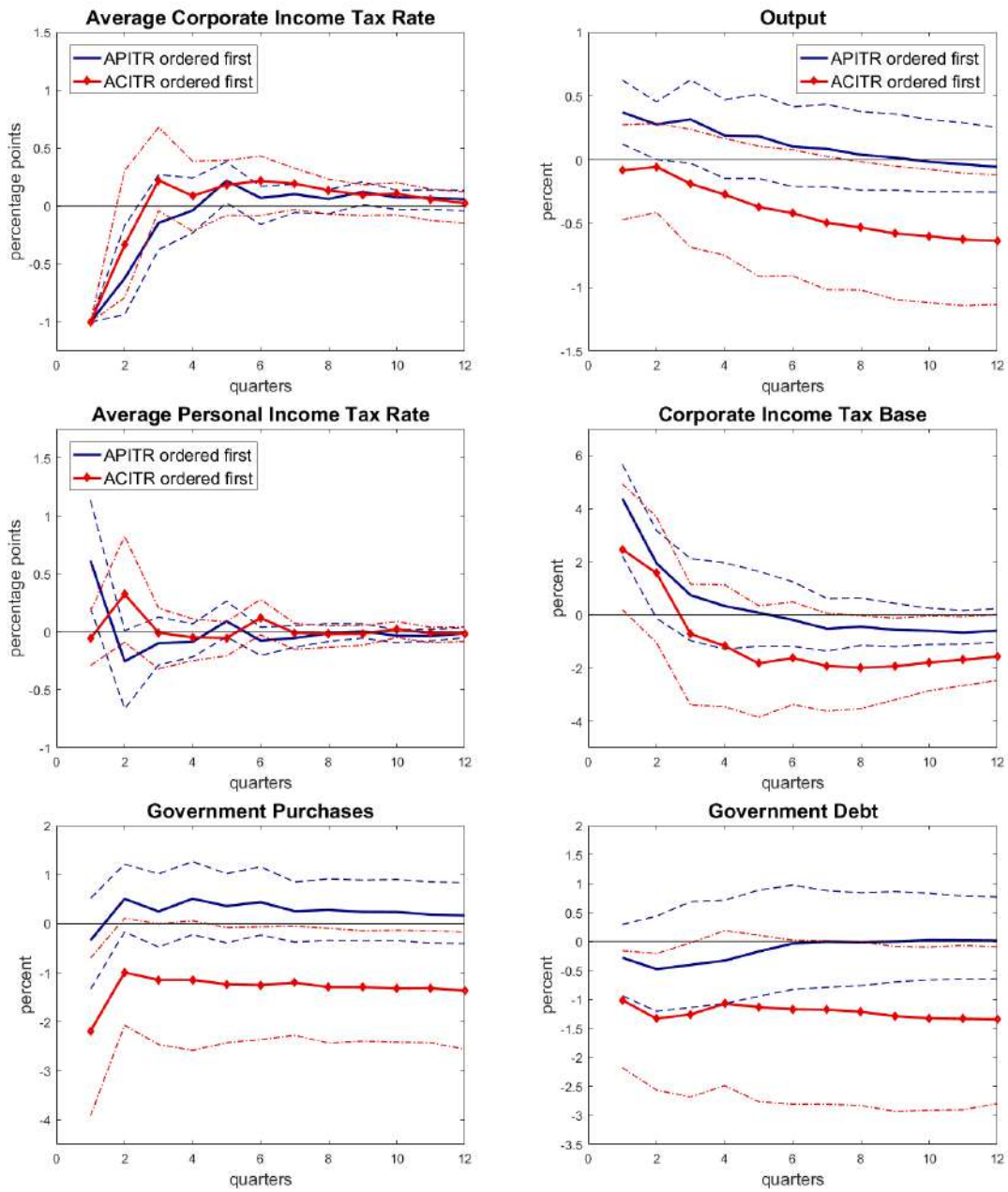


Figure 7: ACITR cut with government debt in the model

Model: APITR, ACITR, PITB, CITB, government spending, output, investments.

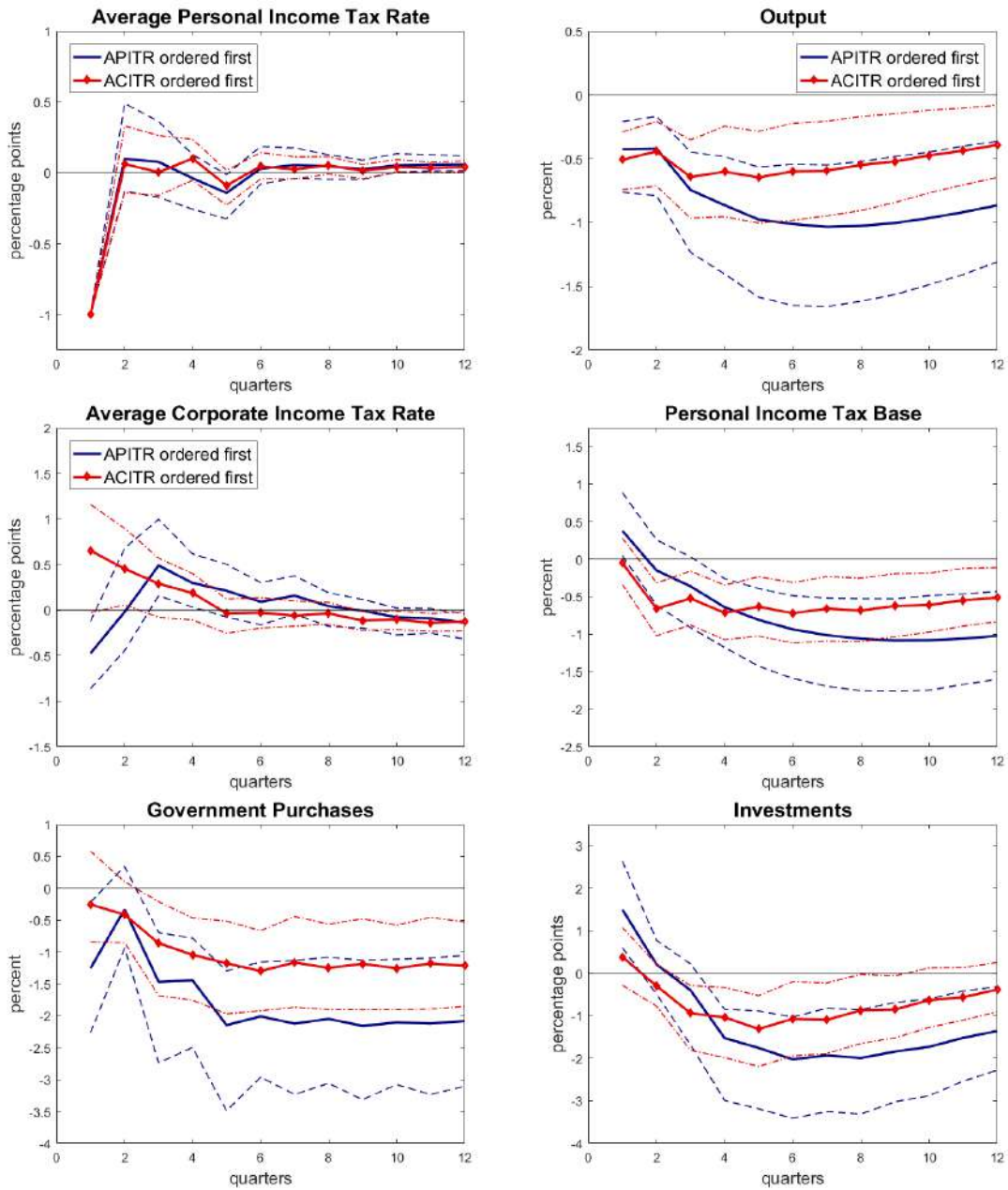


Figure 8: APITR cut with investments in the model

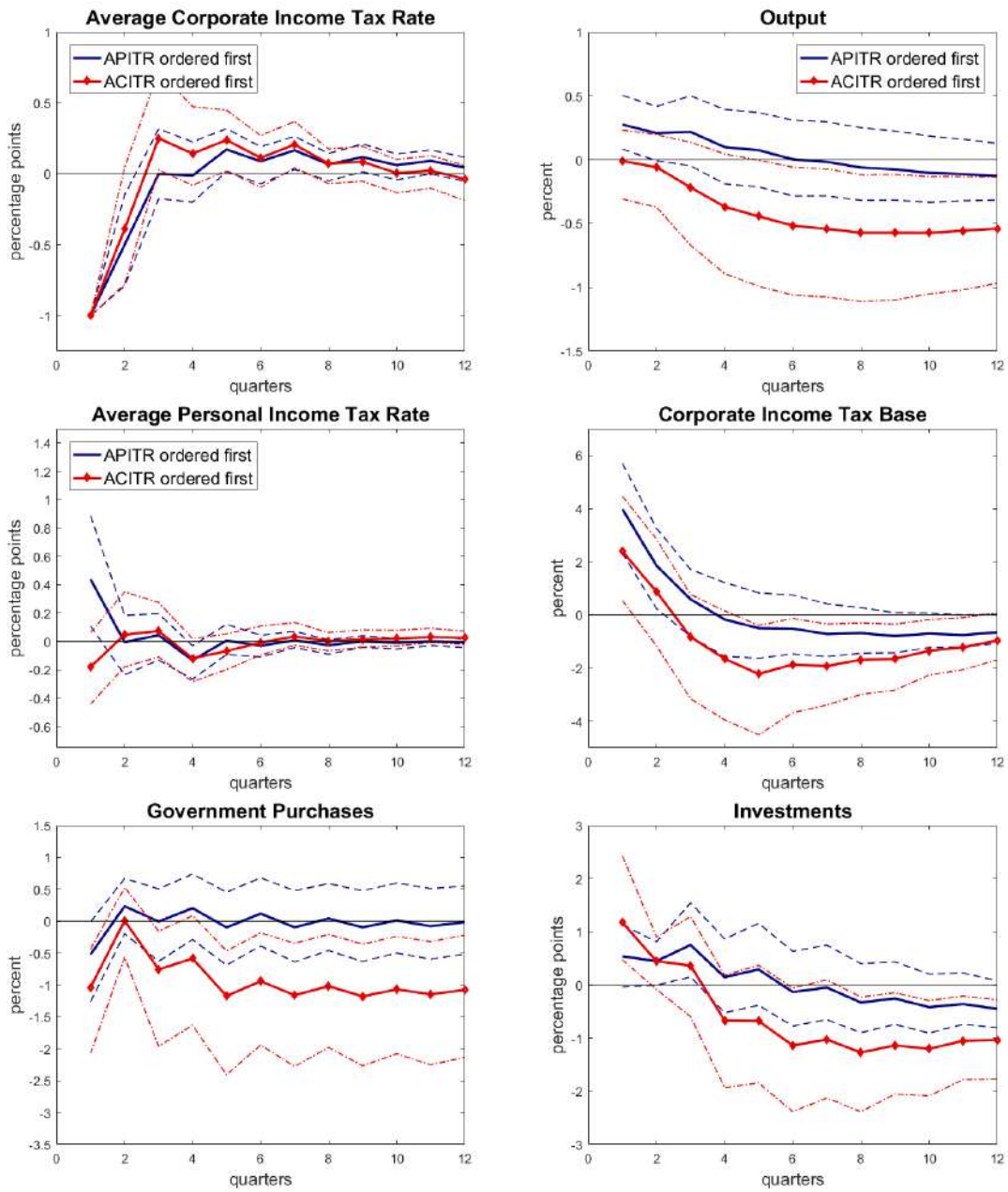


Figure 9: ACITR cut with investments in the model

Model: APITR, ACITR, PITB, CITB, government spending, output, consumption of nondurables and services.

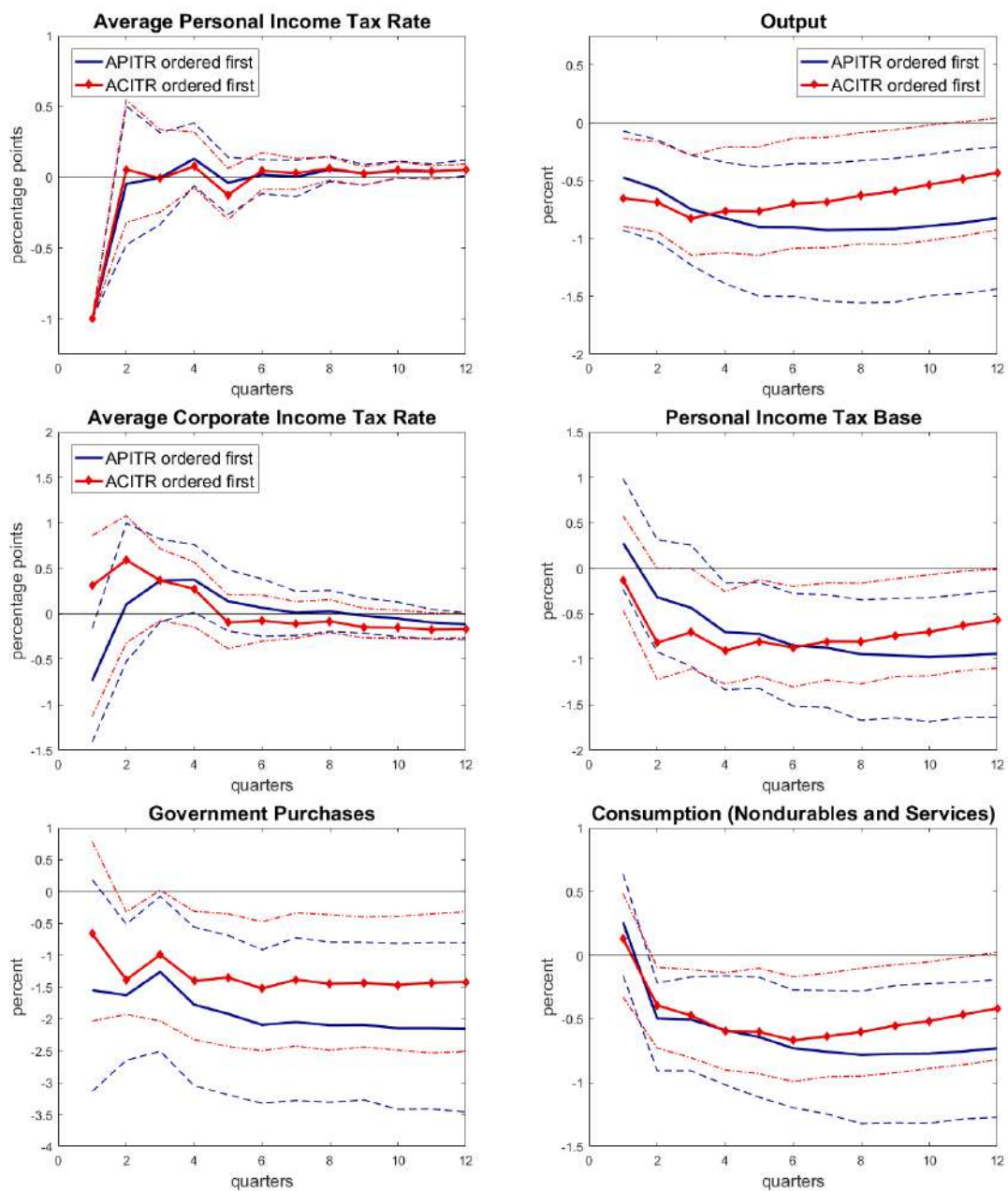


Figure 10: APITR cut with consumption of nondurables and services in the model

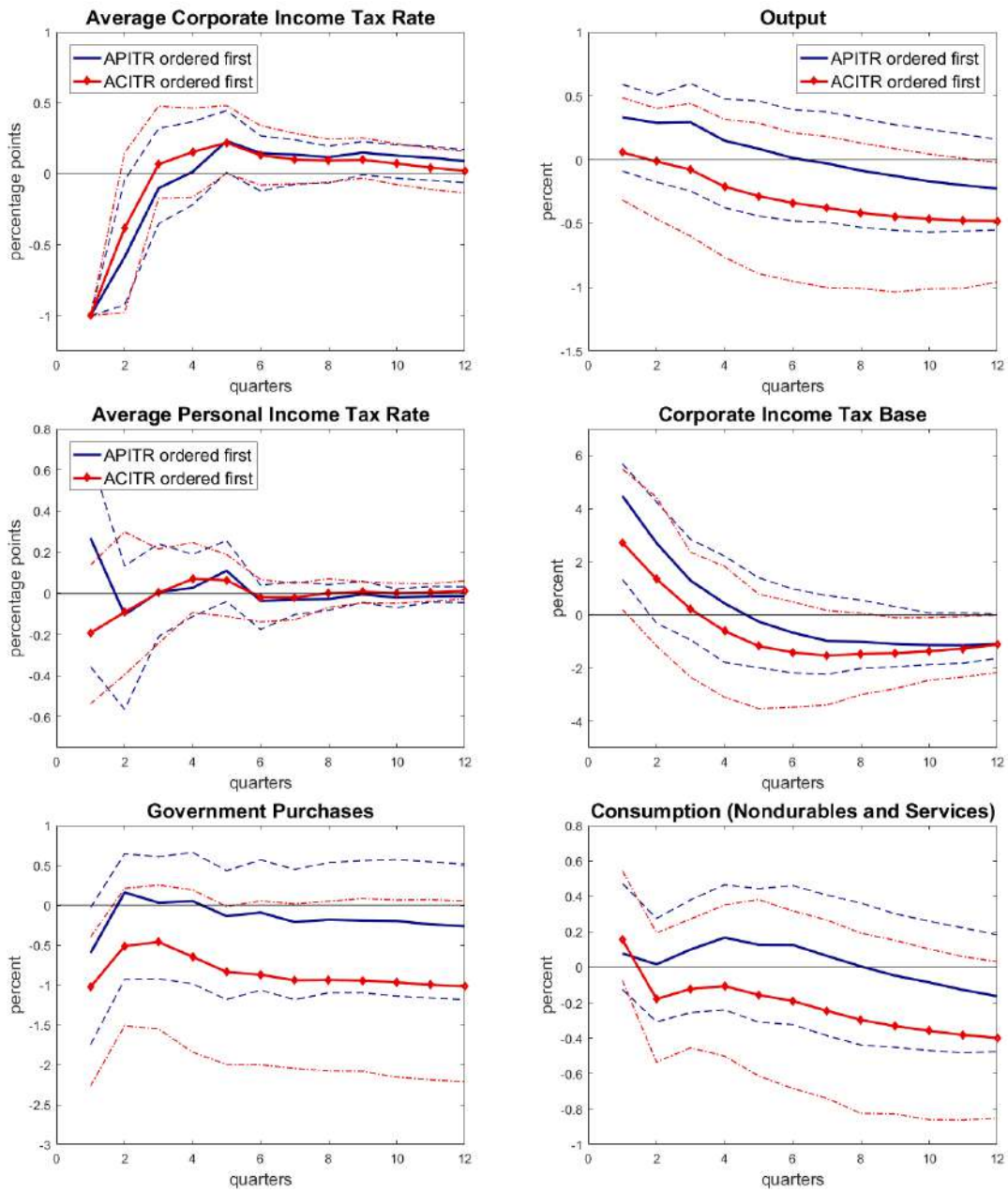


Figure 11: ACITR cut with consumption of nondurables and services in the model

## Exclude PI taxes one by one

### Exclude PI tax change in 2004

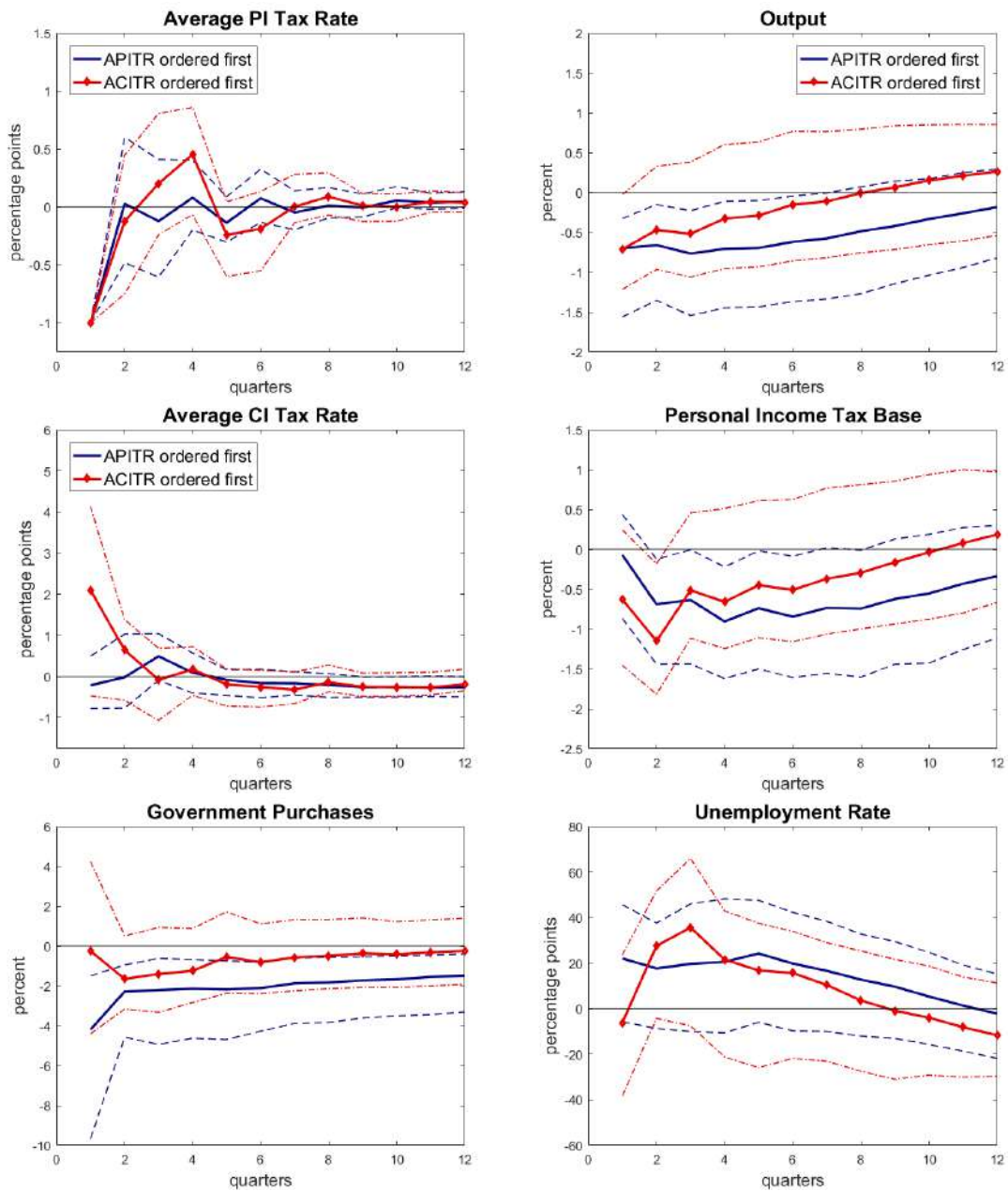


Figure 12: APITR cut with unemployment rate in the model

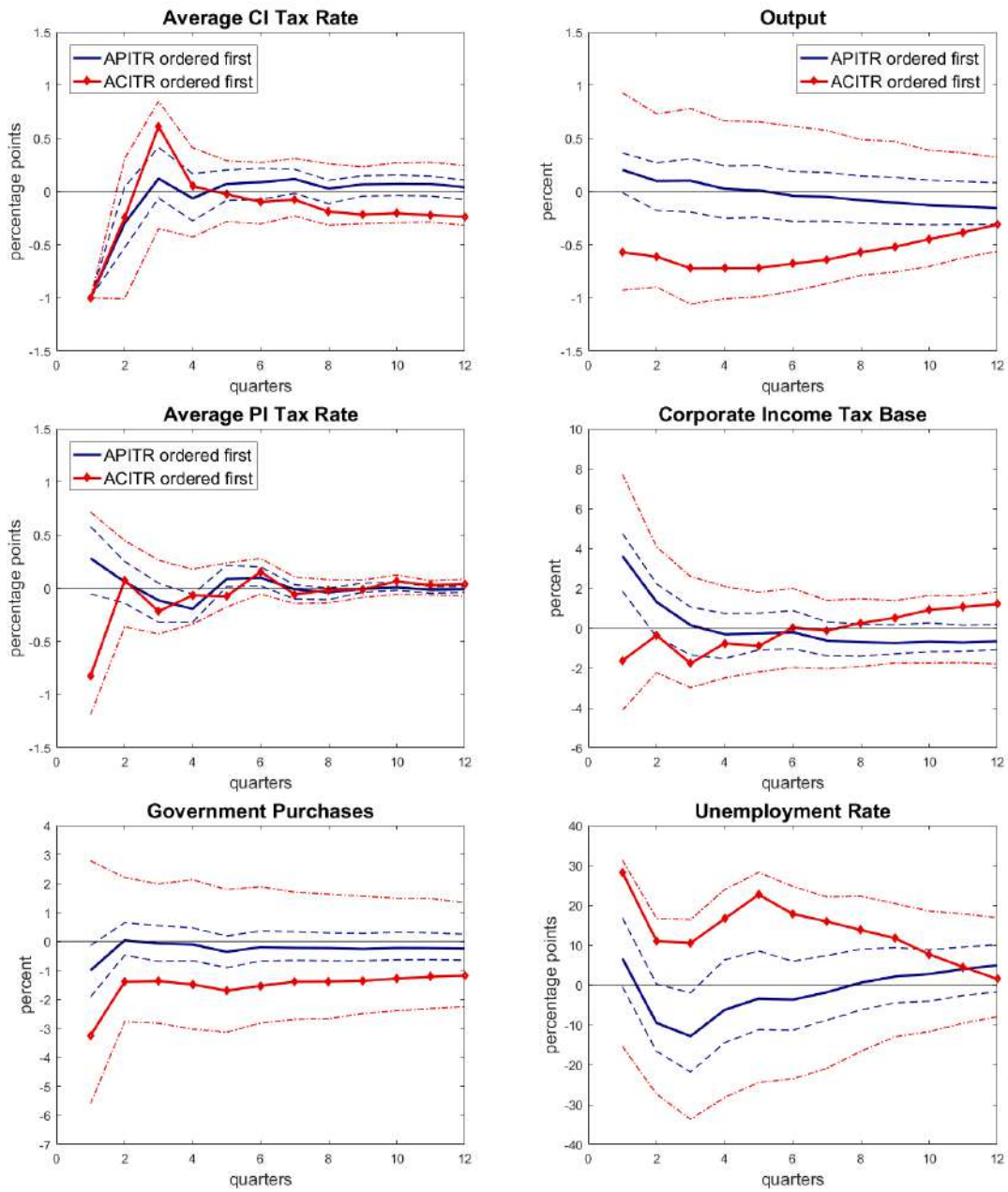


Figure 13: ACITR cut with unemployment rate in the model

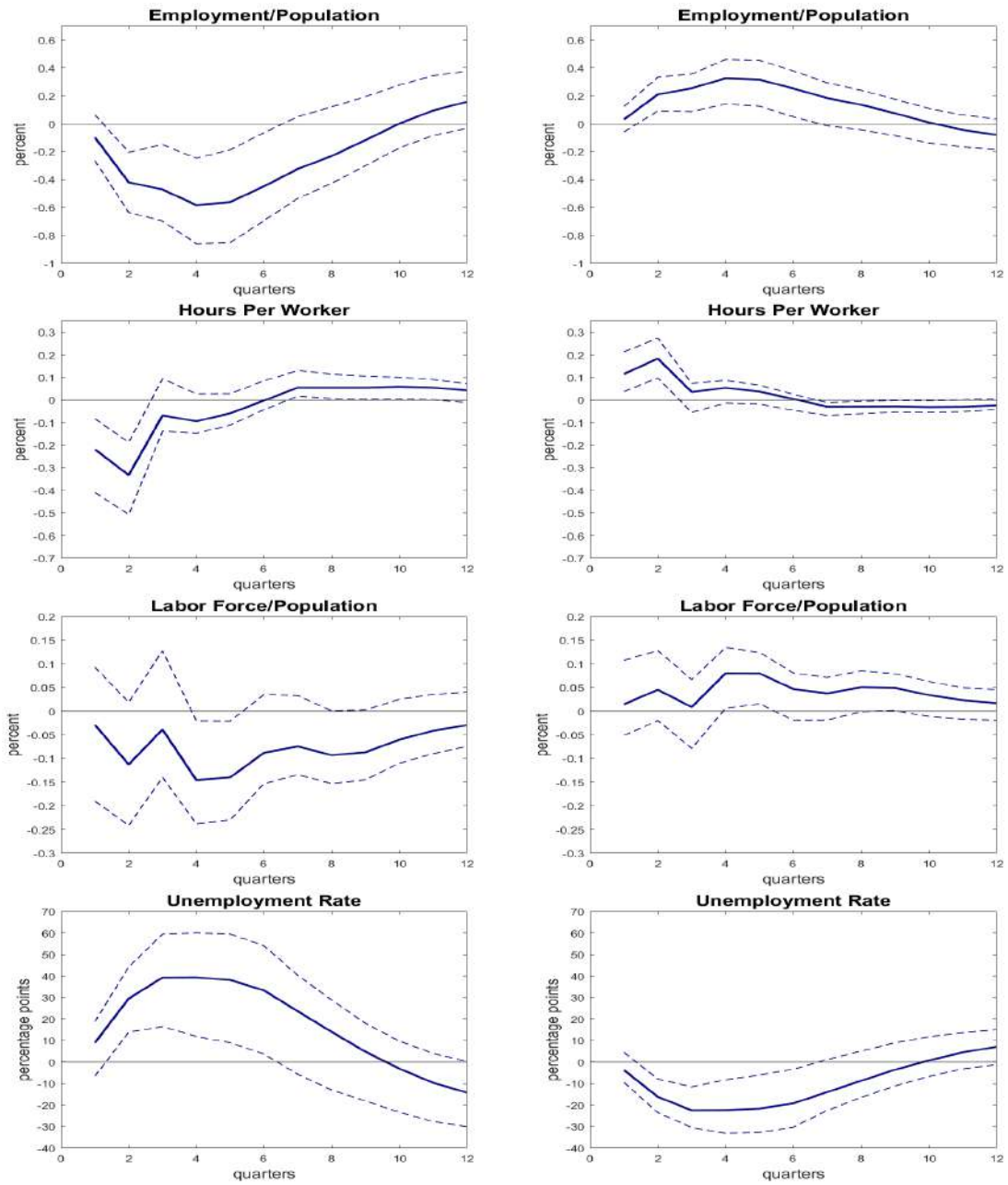


Figure 14: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Exclude PI tax change in 2007

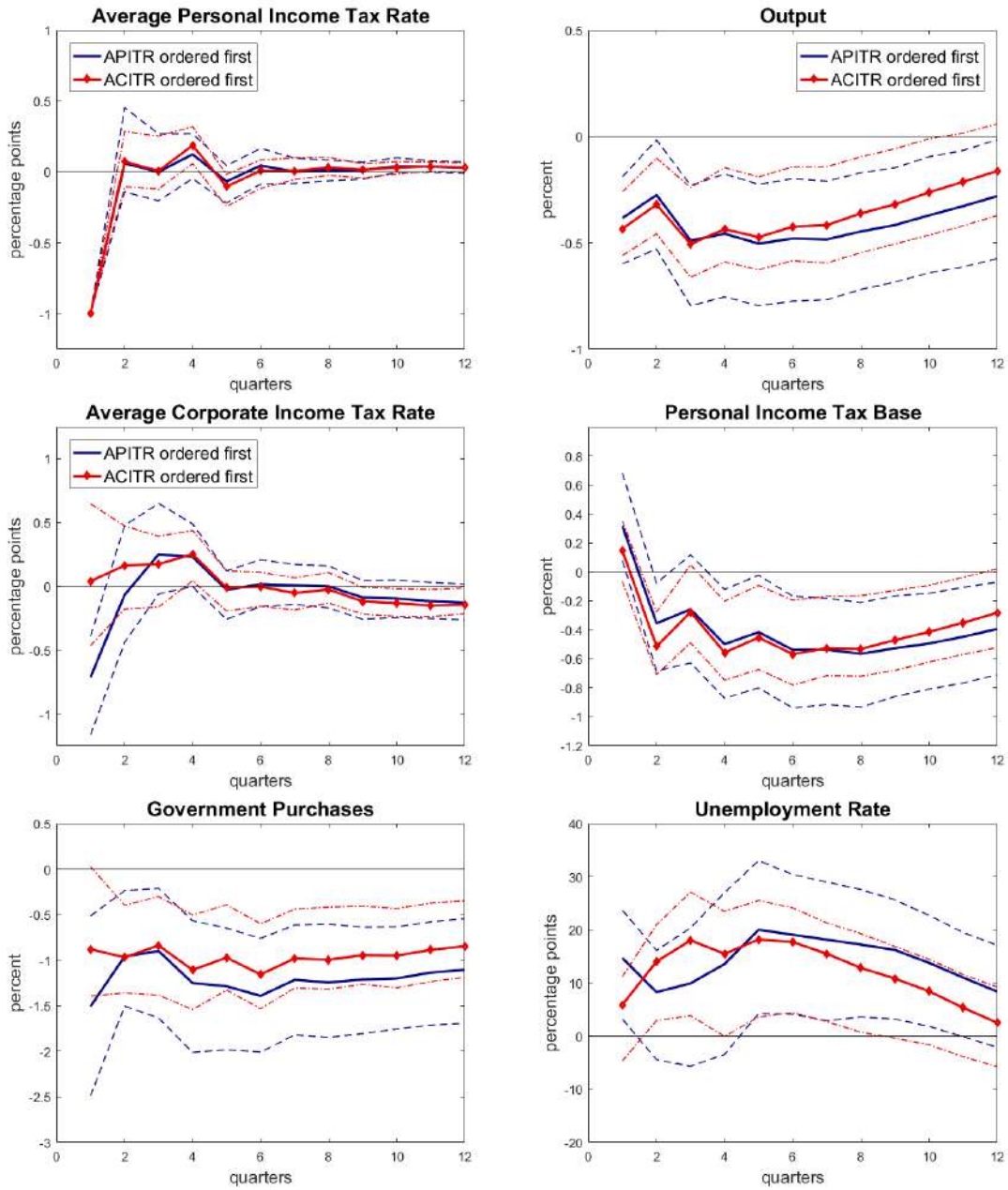


Figure 15: APITR cut with unemployment rate in the model

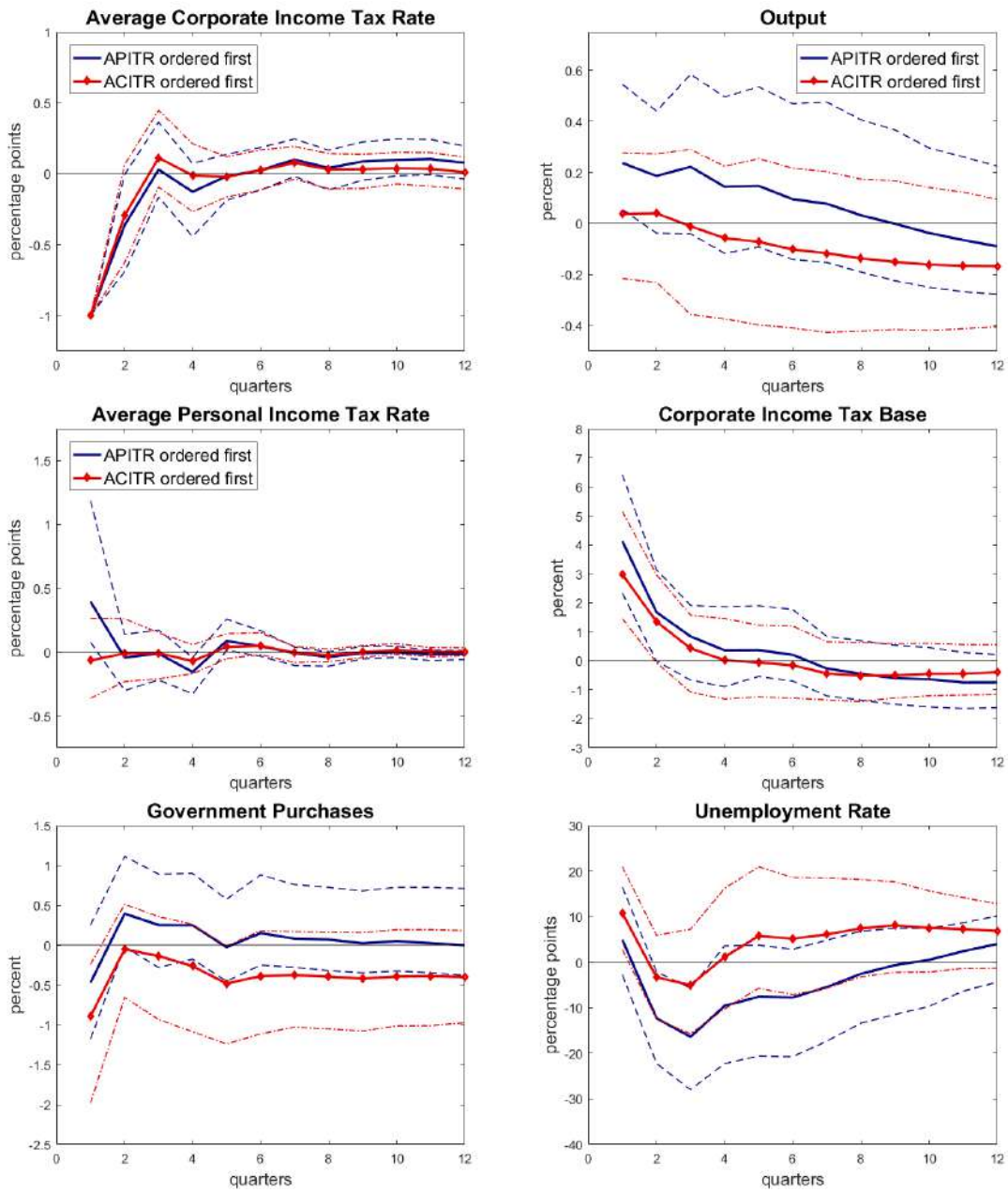


Figure 16: ACITR cut with unemployment rate in the model

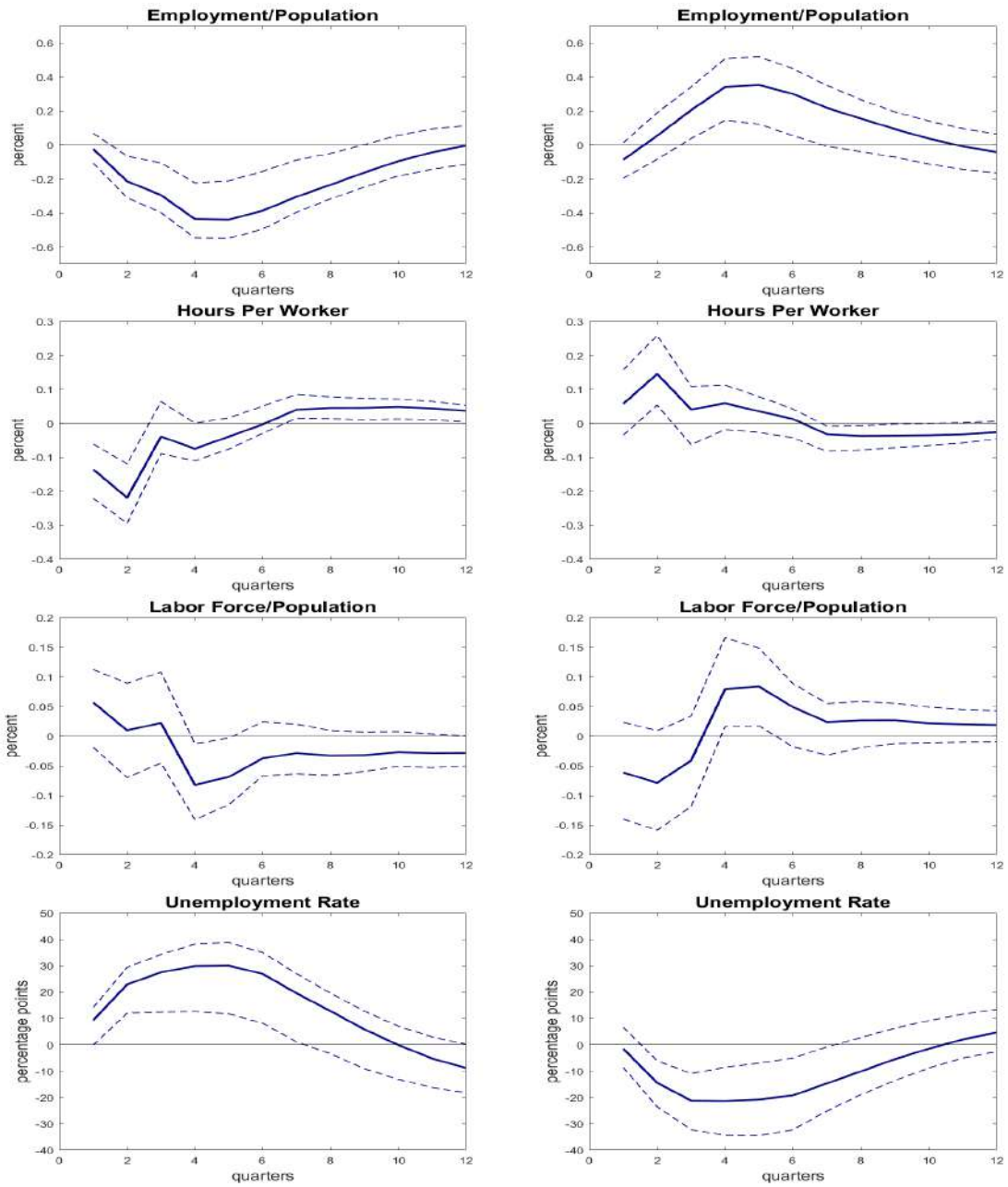


Figure 17: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Exclude PI tax change in 2009

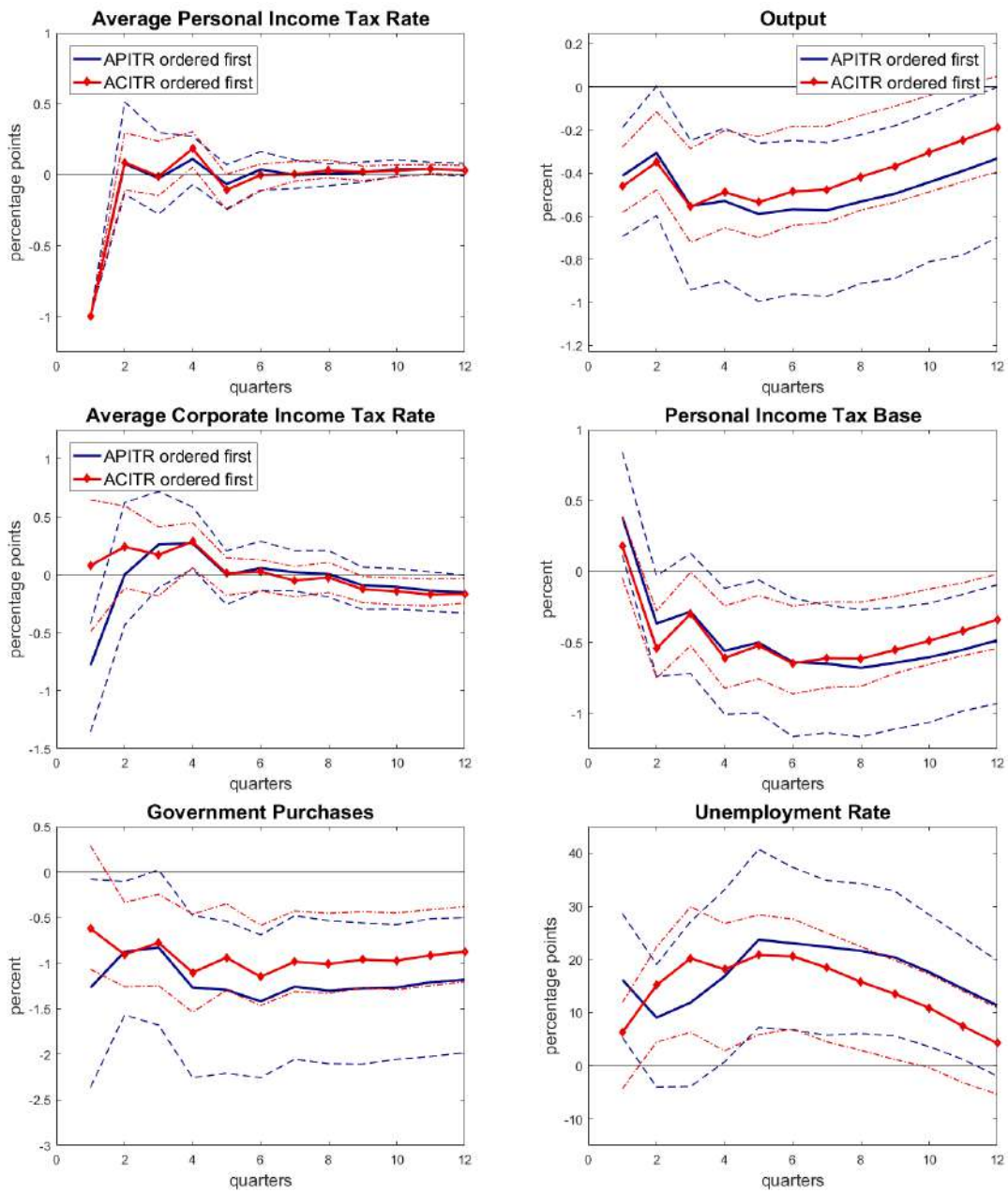


Figure 18: APITR cut with unemployment rate in the model

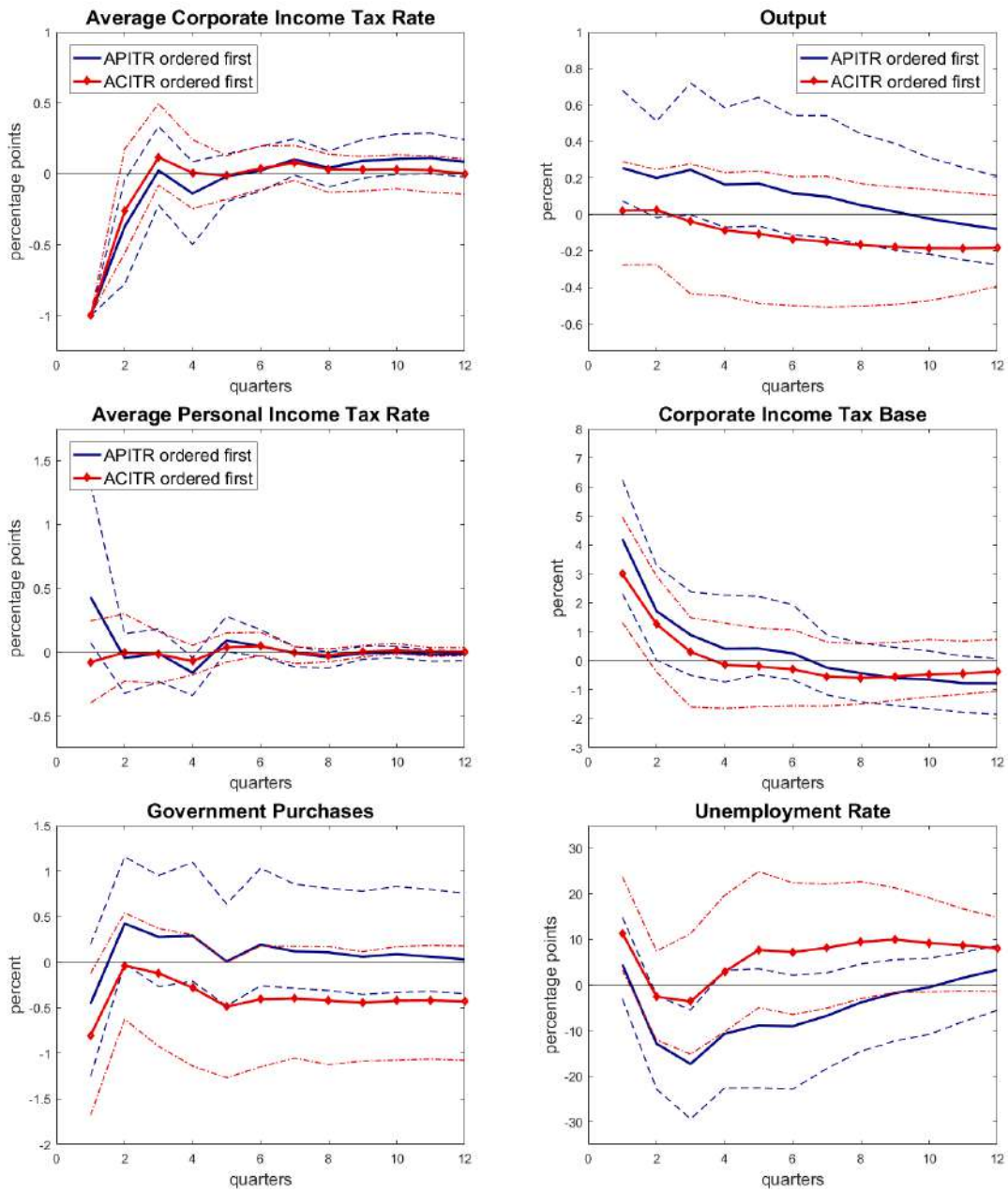


Figure 19: ACITR cut with unemployment rate in the model

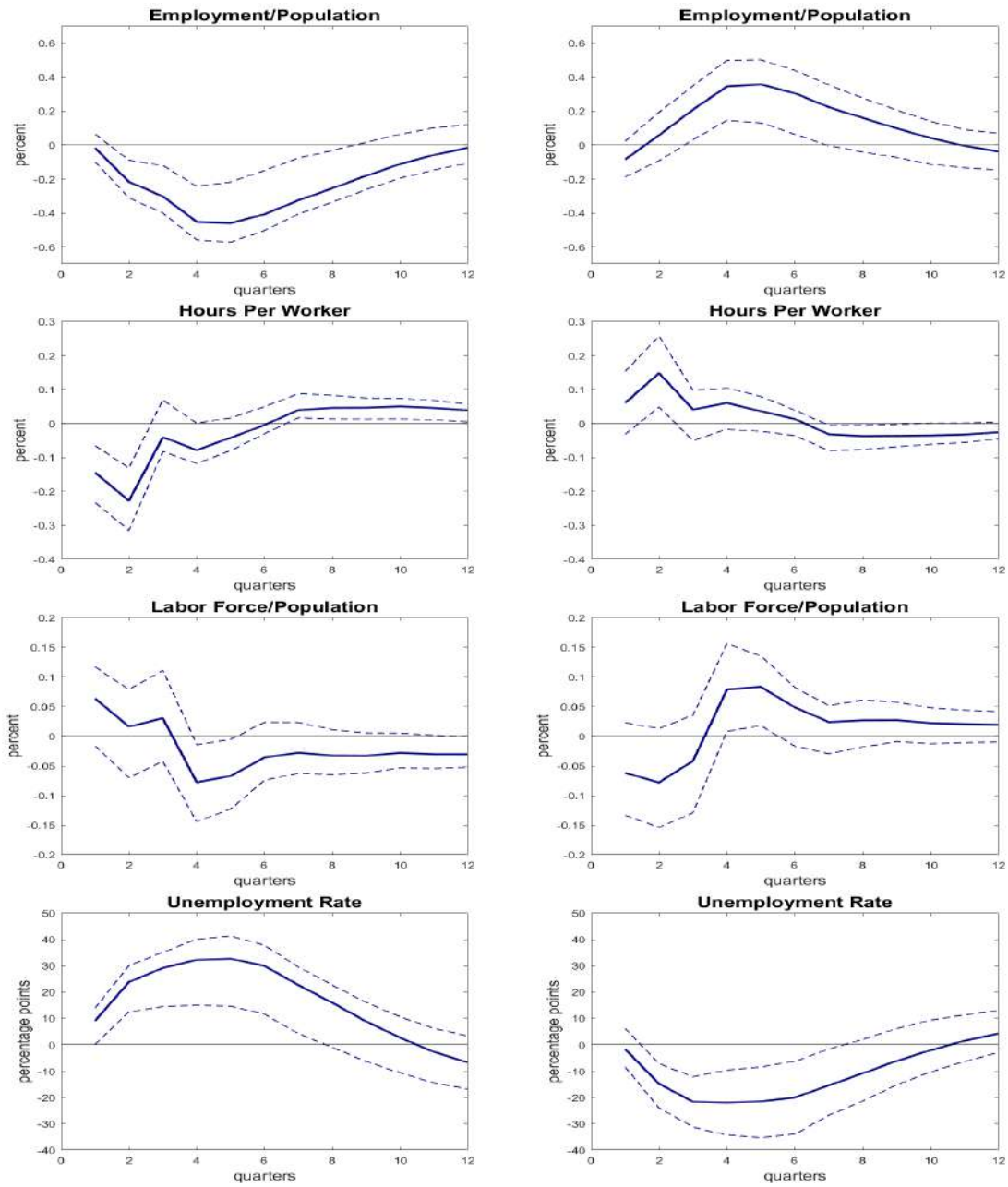


Figure 20: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Exclude PI tax change in 2010

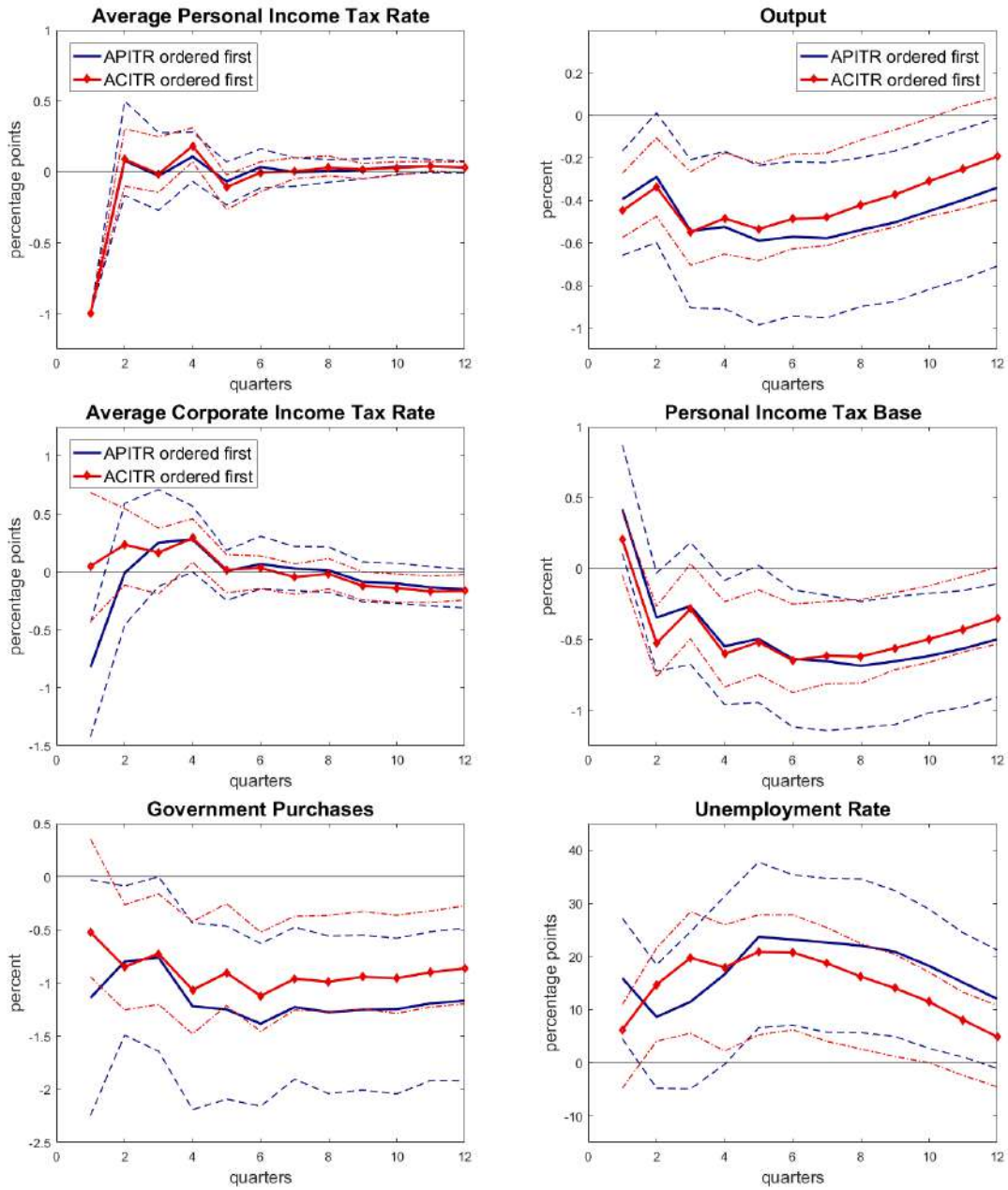


Figure 21: APITR cut with unemployment rate in the model

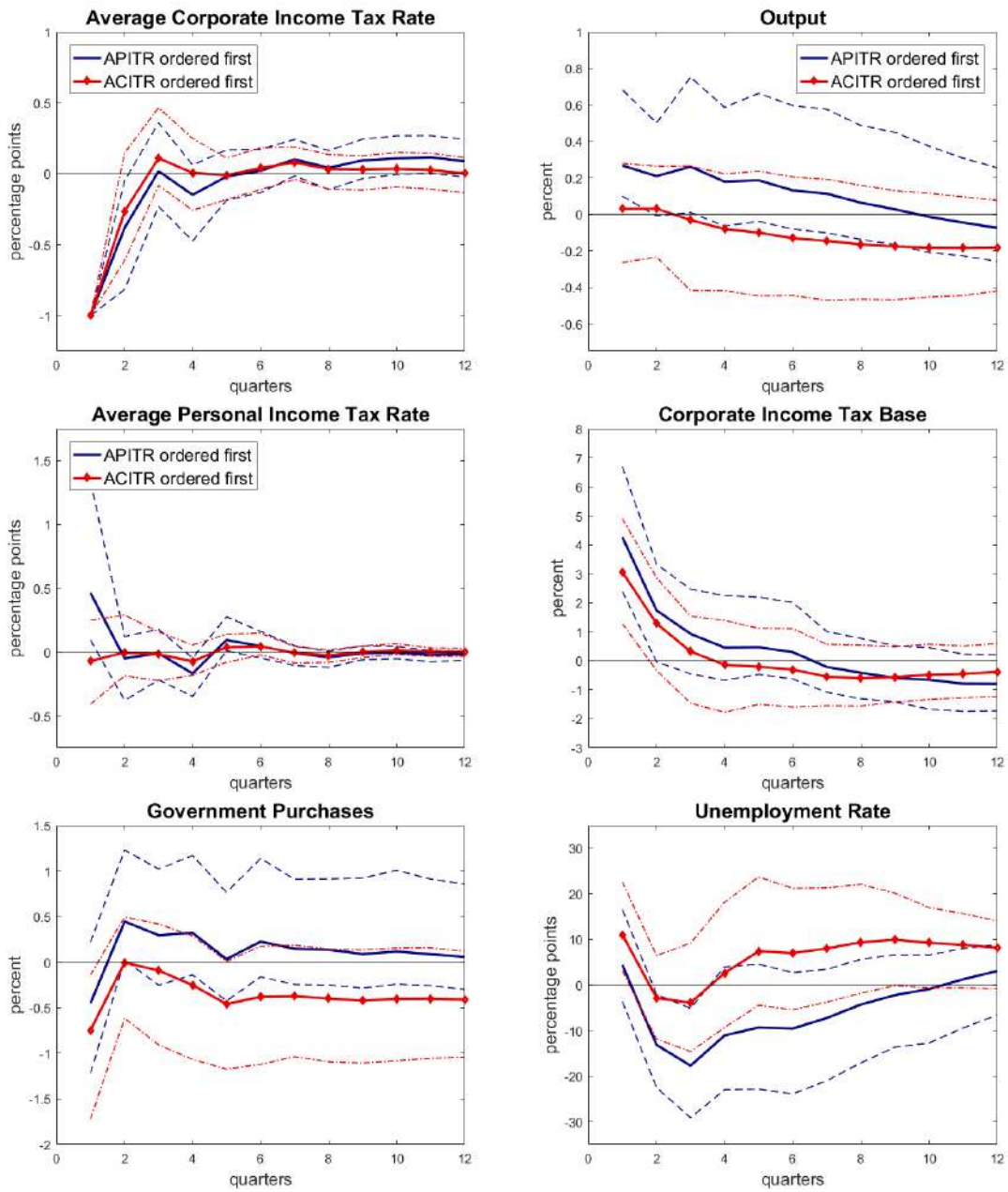


Figure 22: ACITR cut with unemployment rate in the model

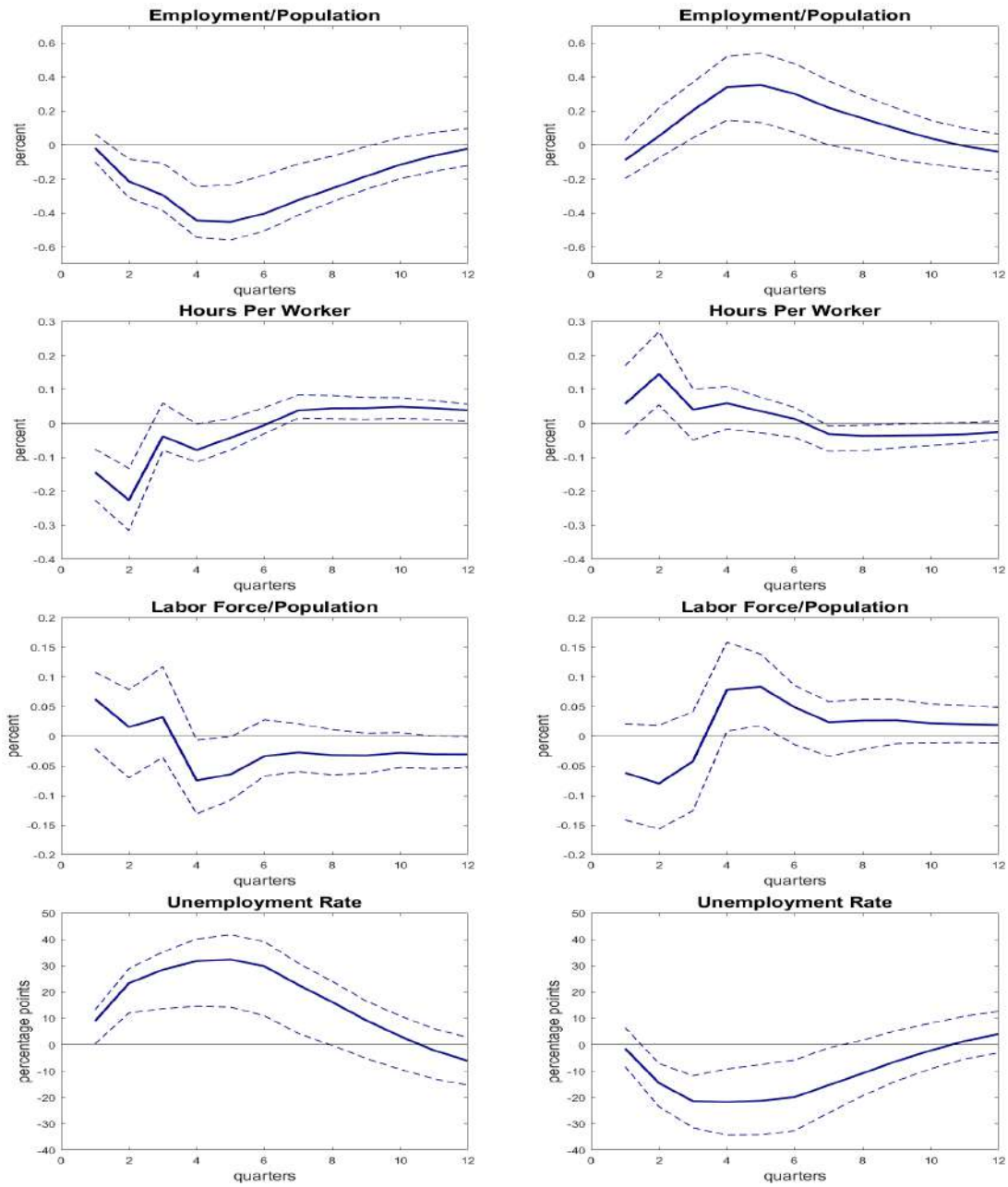


Figure 23: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

## Exclude PI tax change in 2011

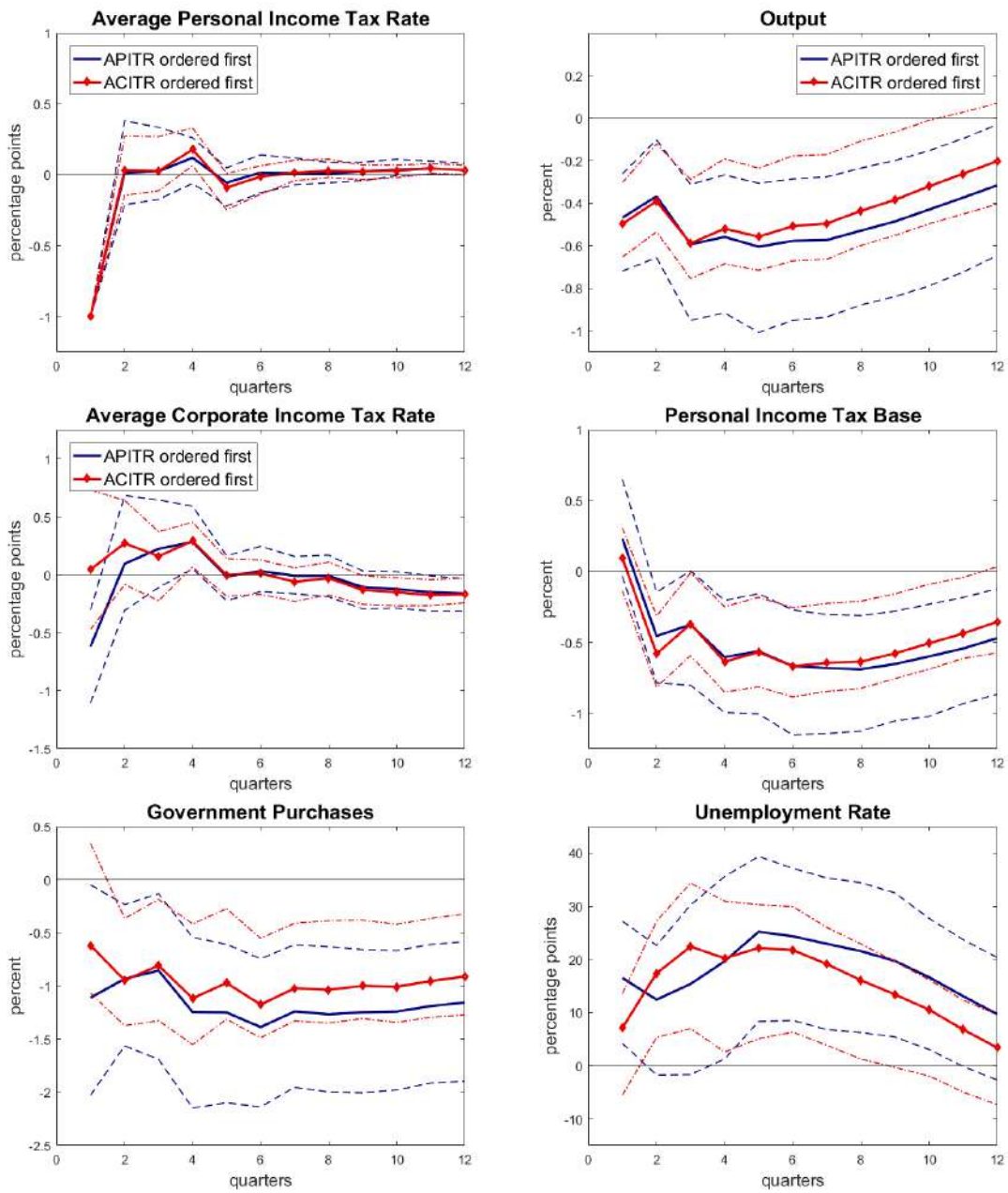


Figure 24: APITR cut with unemployment rate in the model

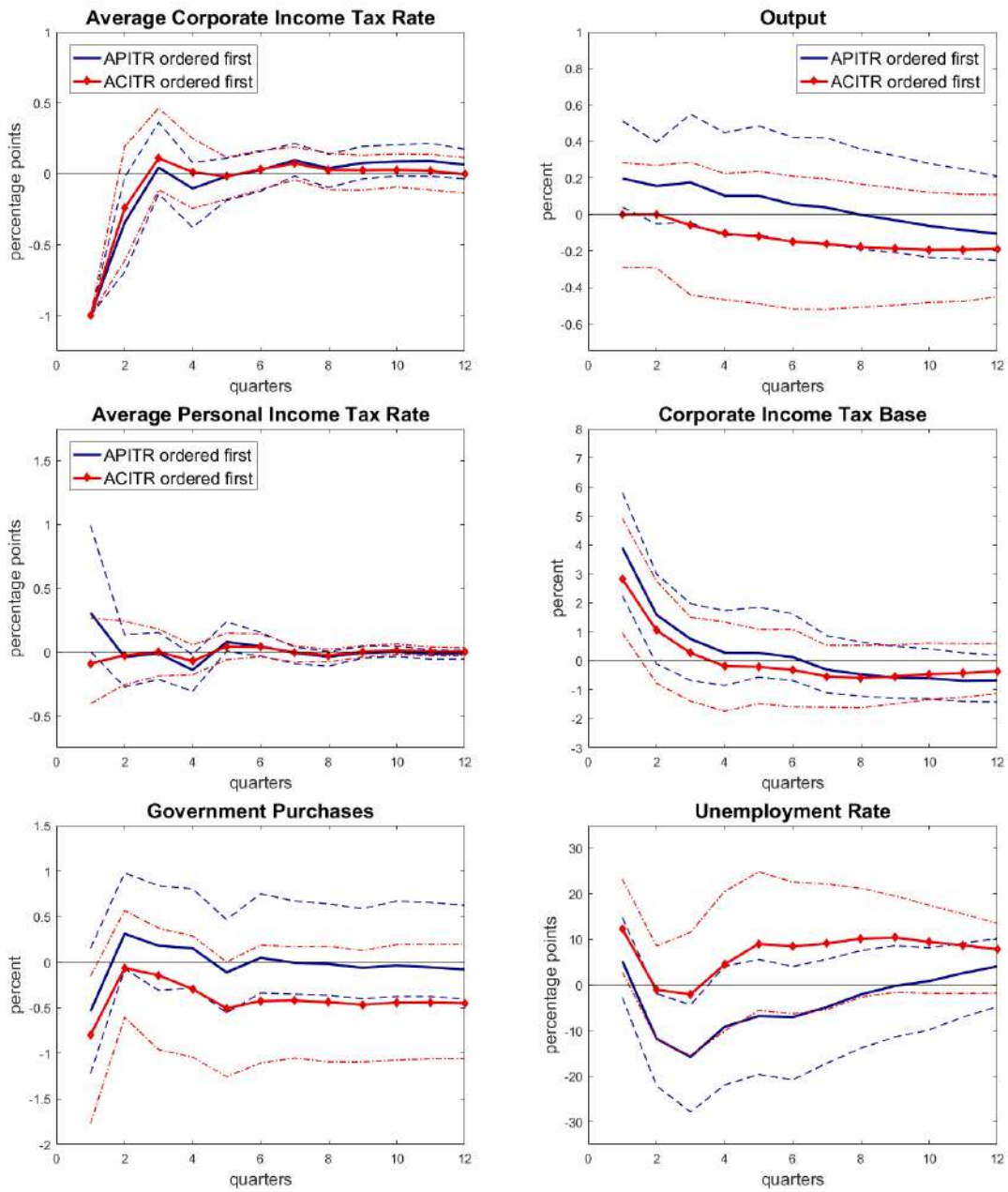


Figure 25: ACITR cut with unemployment rate in the model

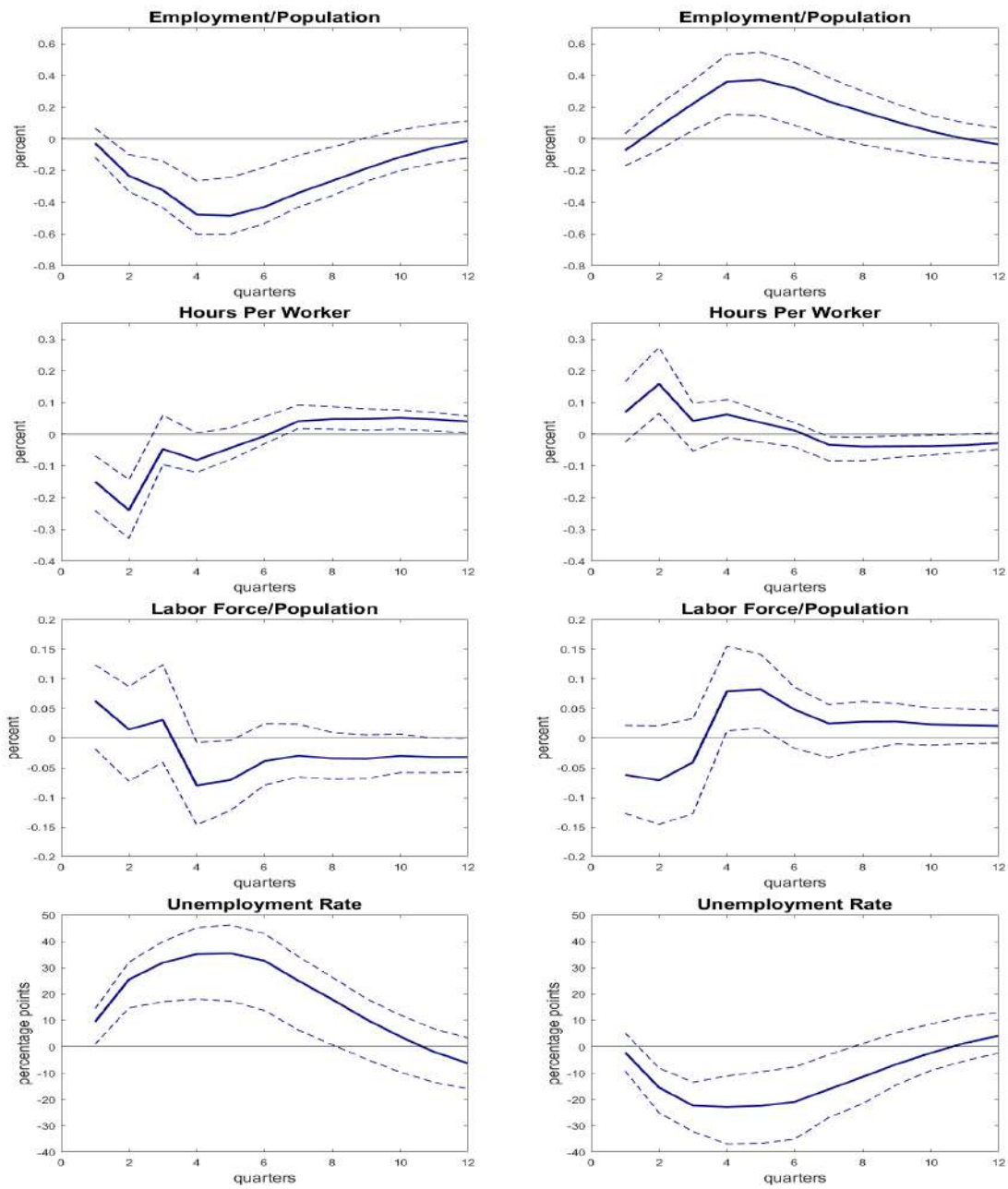


Figure 26: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Exclude PI tax change in 2012

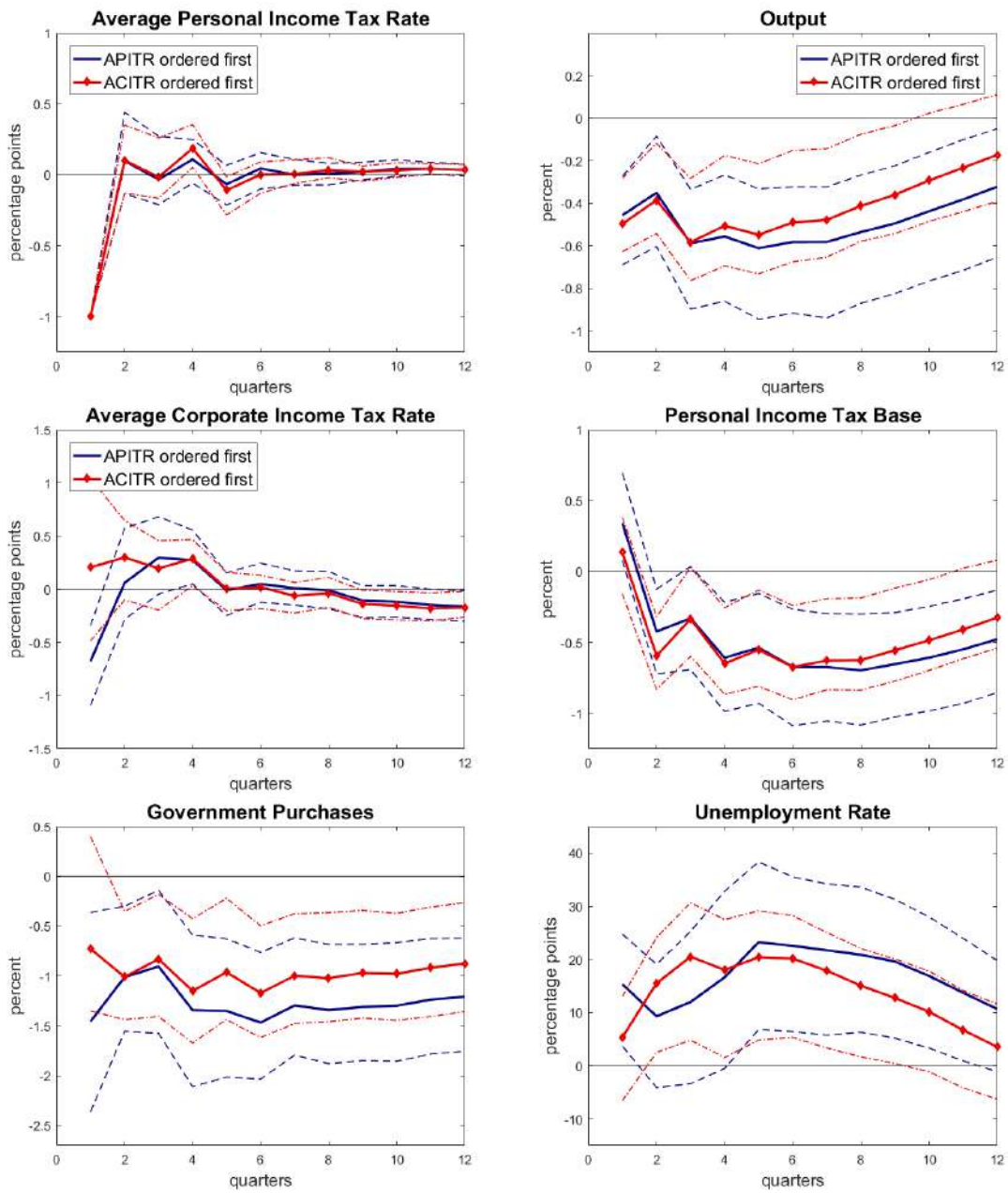


Figure 27: APITR cut with unemployment rate in the model

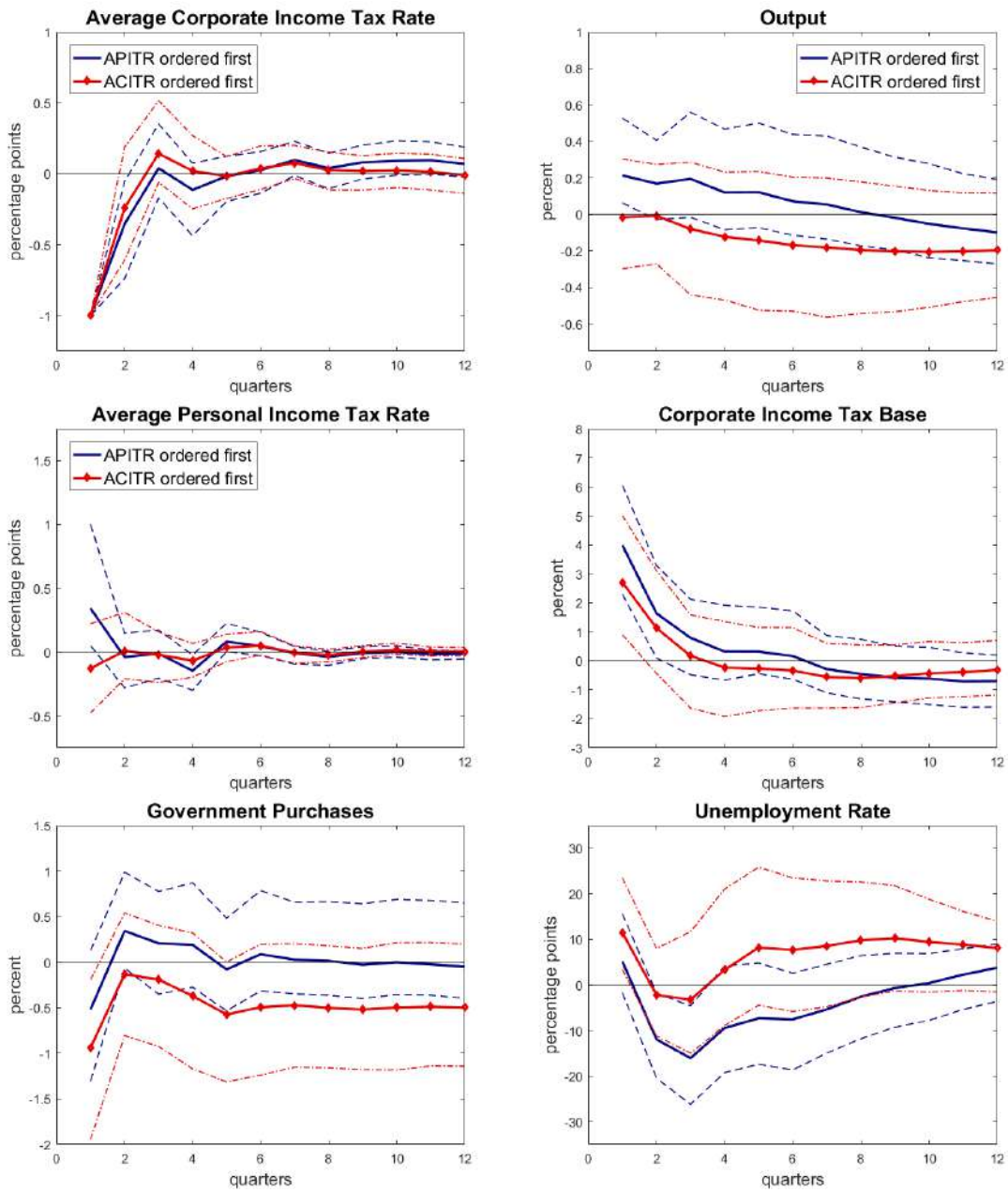


Figure 28: ACITR cut with unemployment rate in the model

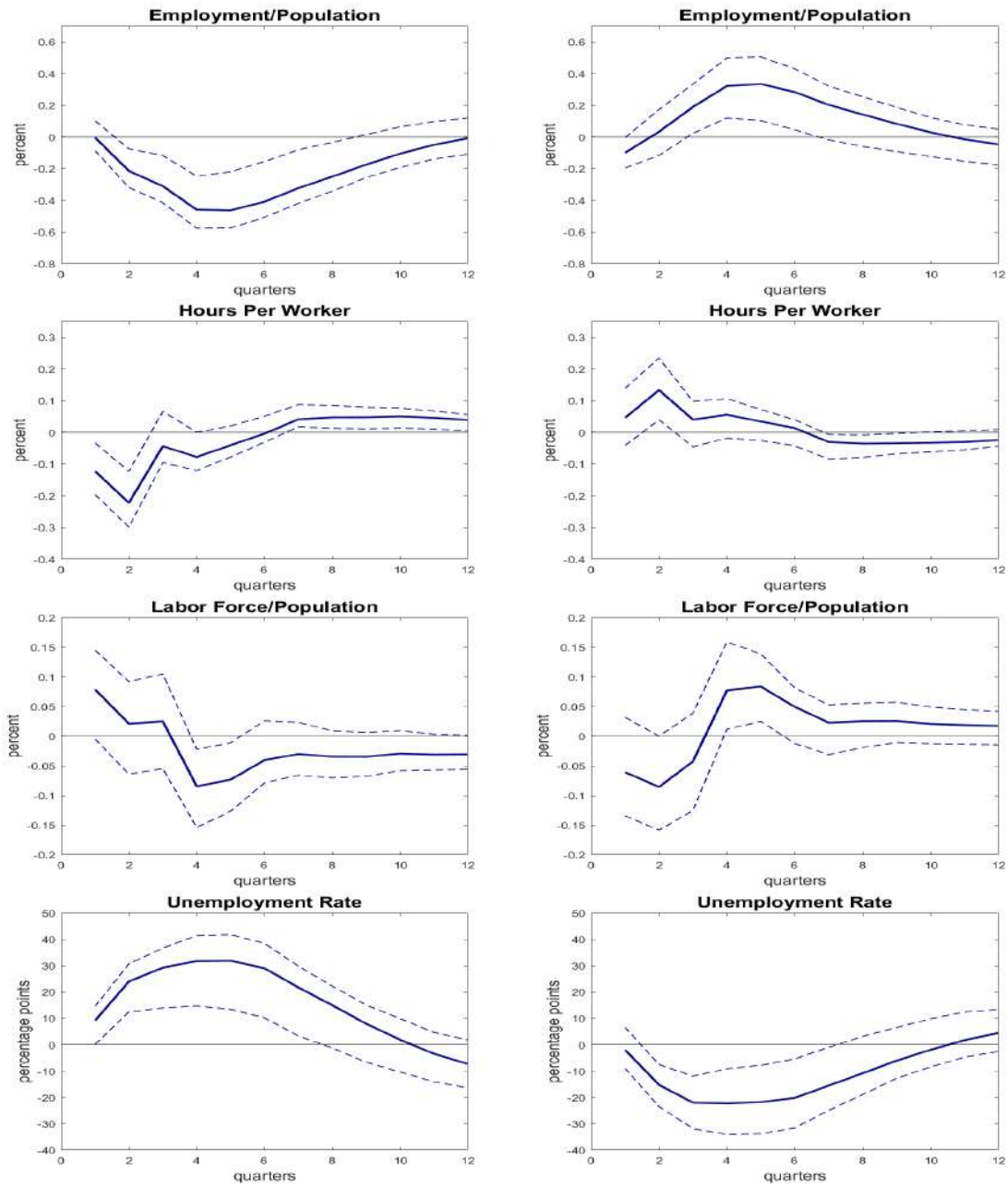


Figure 29: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

## Exclude PI tax change in 2013

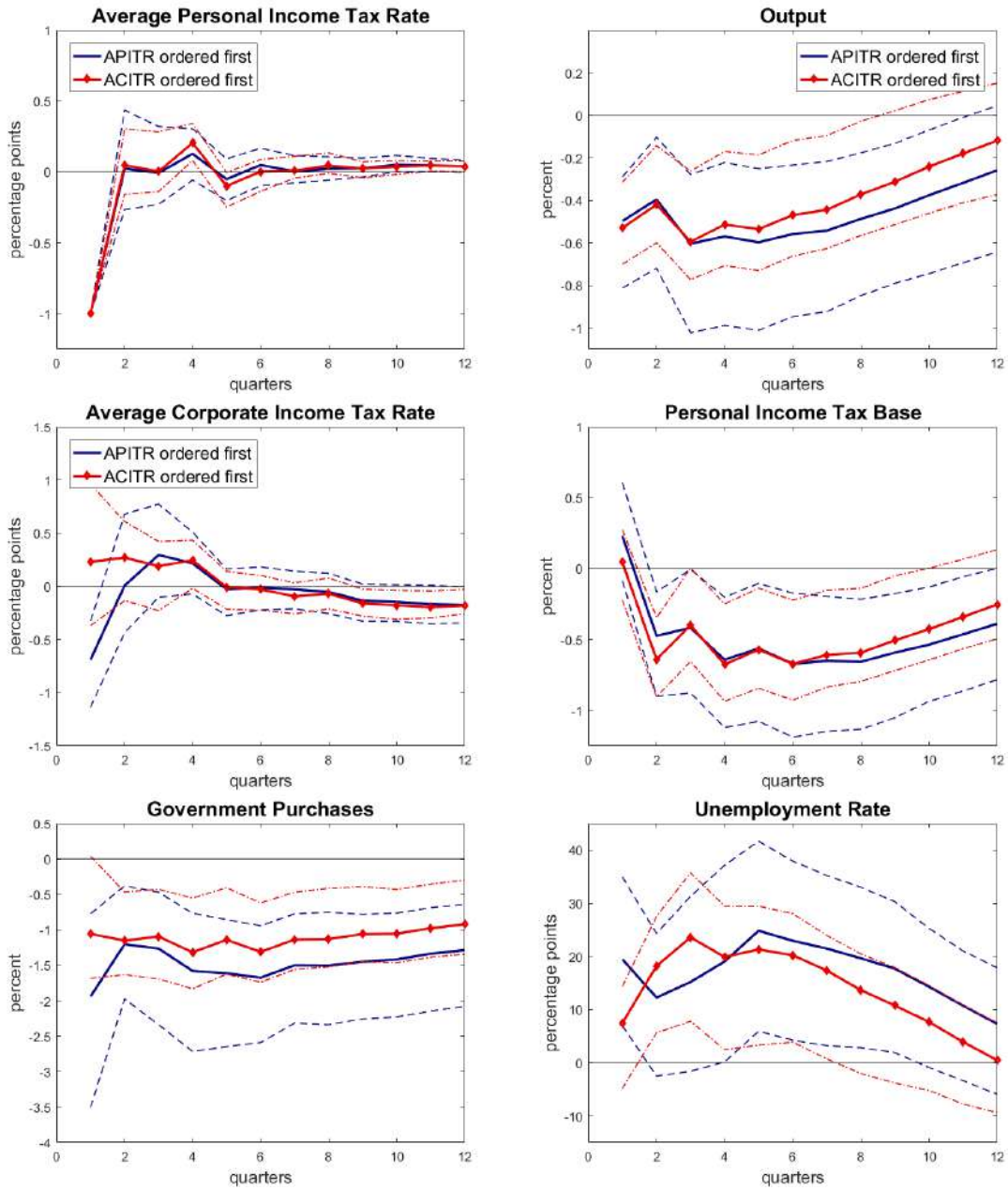


Figure 30: APITR cut with unemployment rate in the model

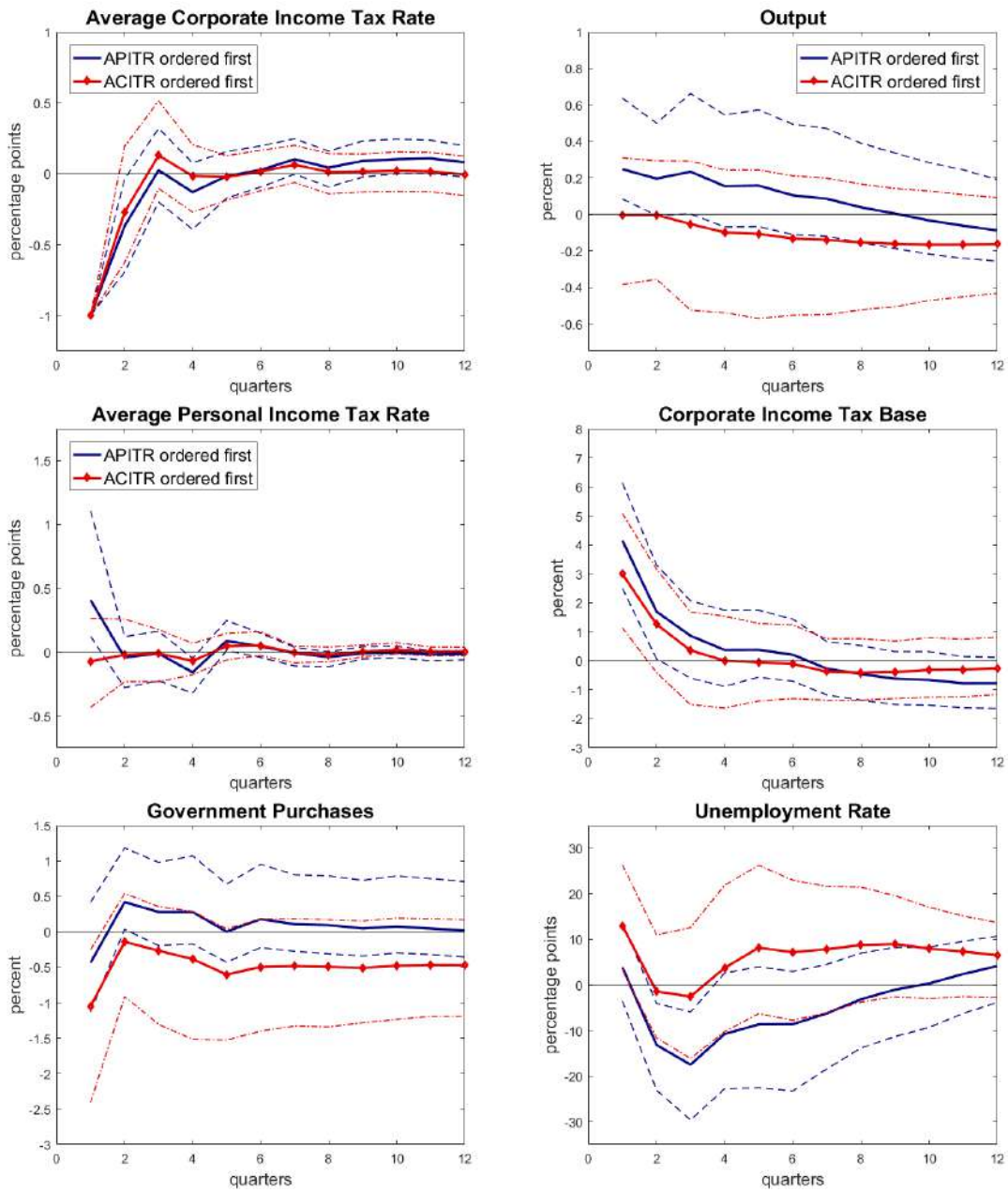


Figure 31: ACITR cut with unemployment rate in the model

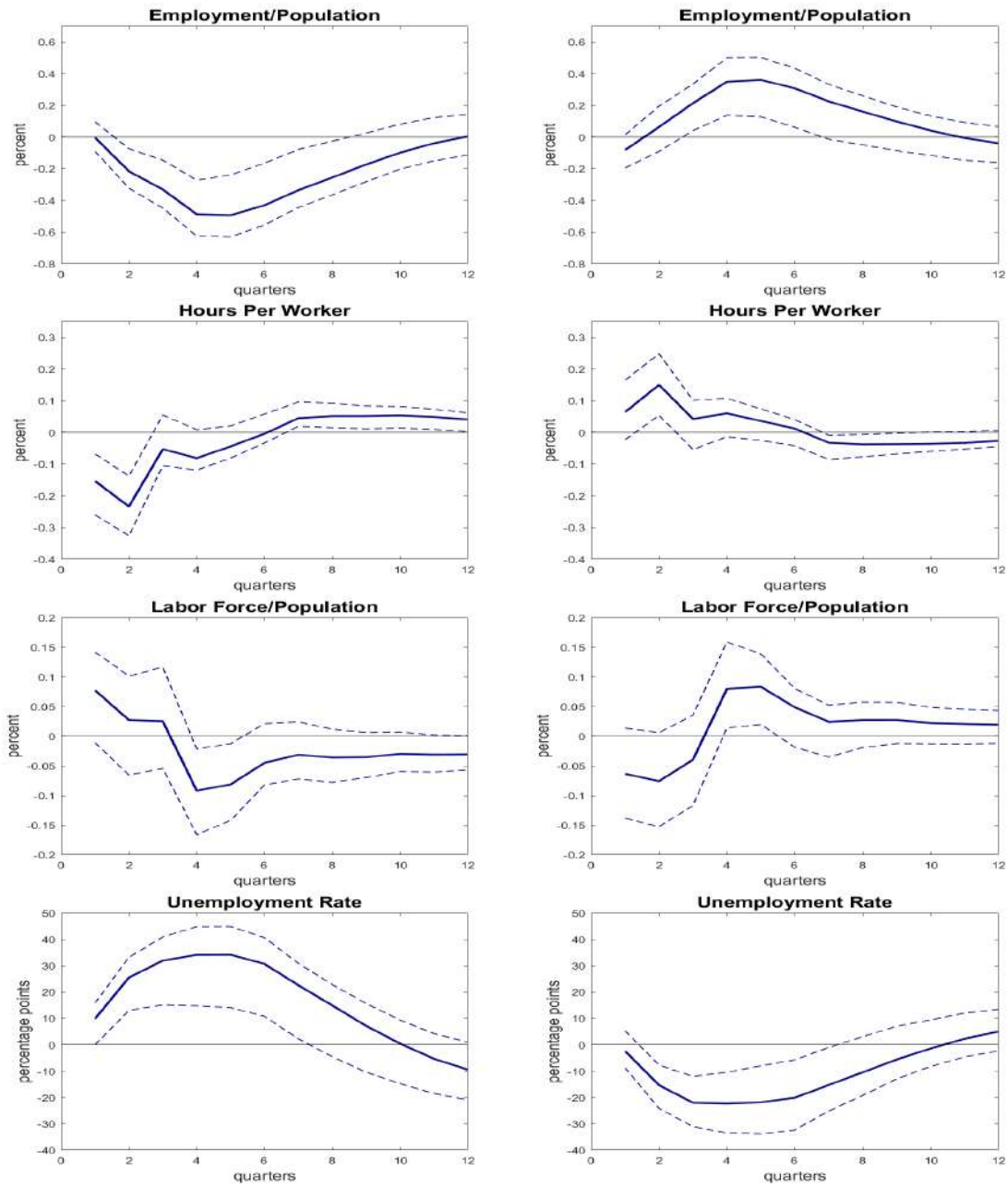


Figure 32: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Exclude PI tax change in 2016

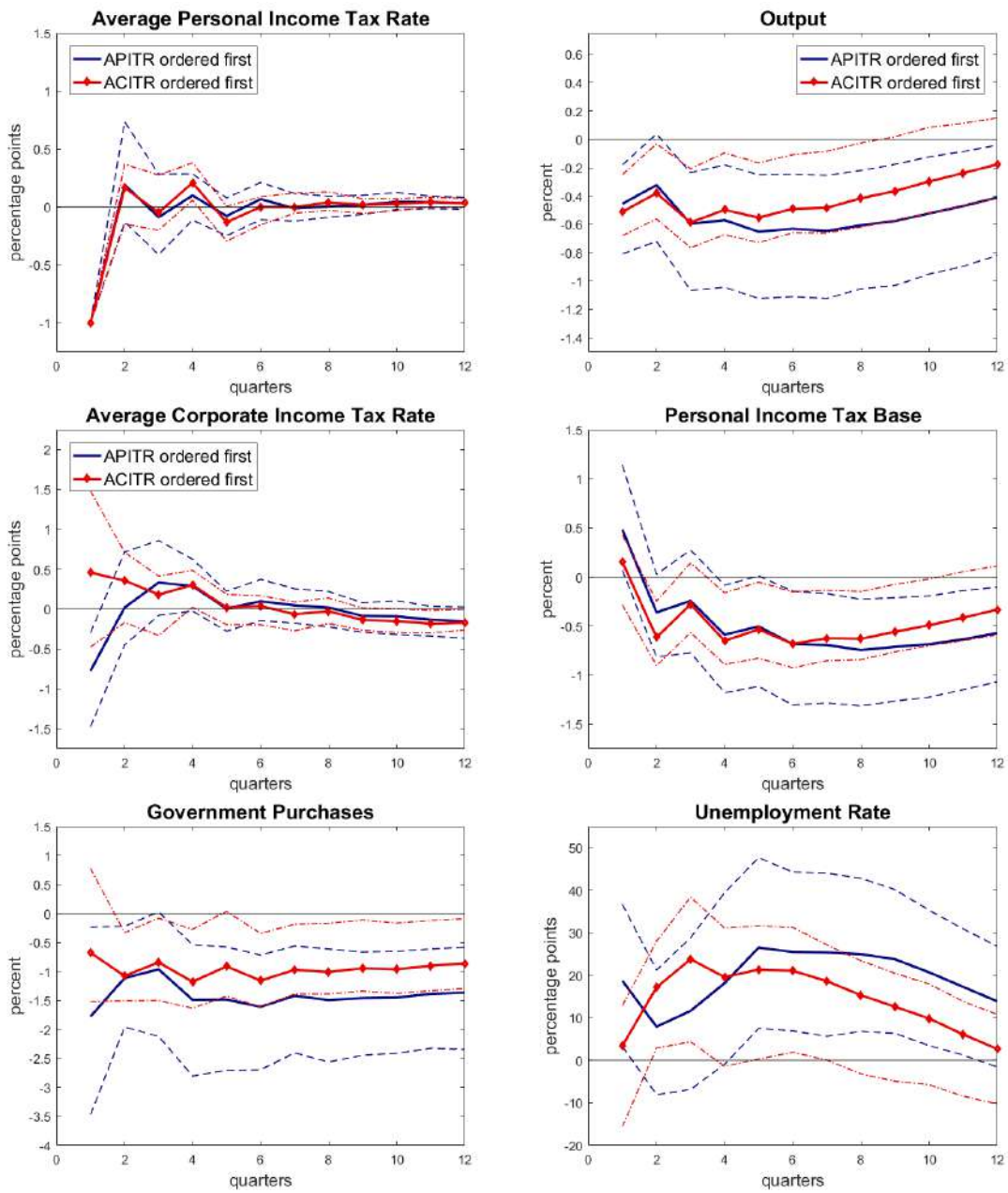


Figure 33: APITR cut with unemployment rate in the model

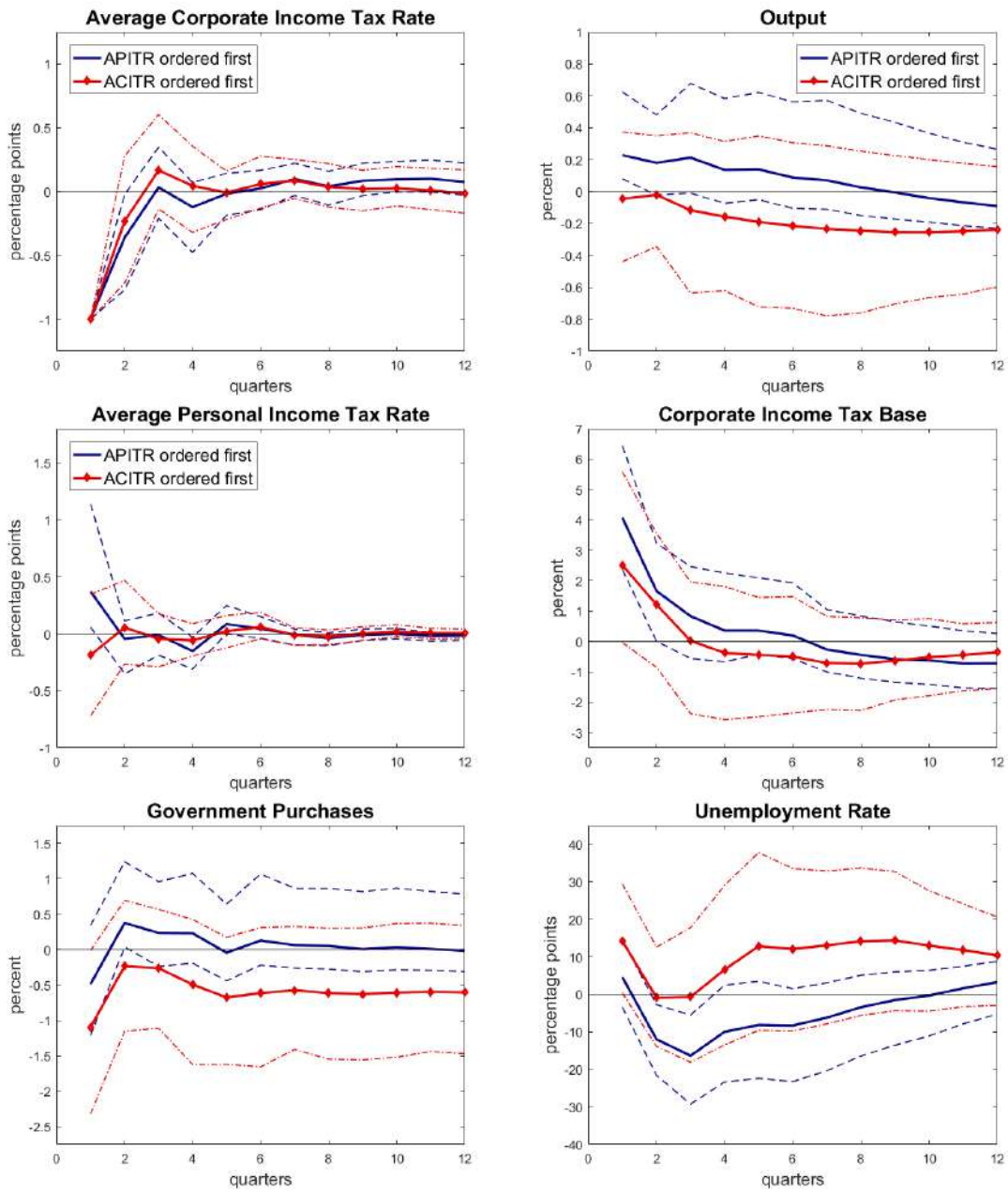


Figure 34: ACITR cut with unemployment rate in the model

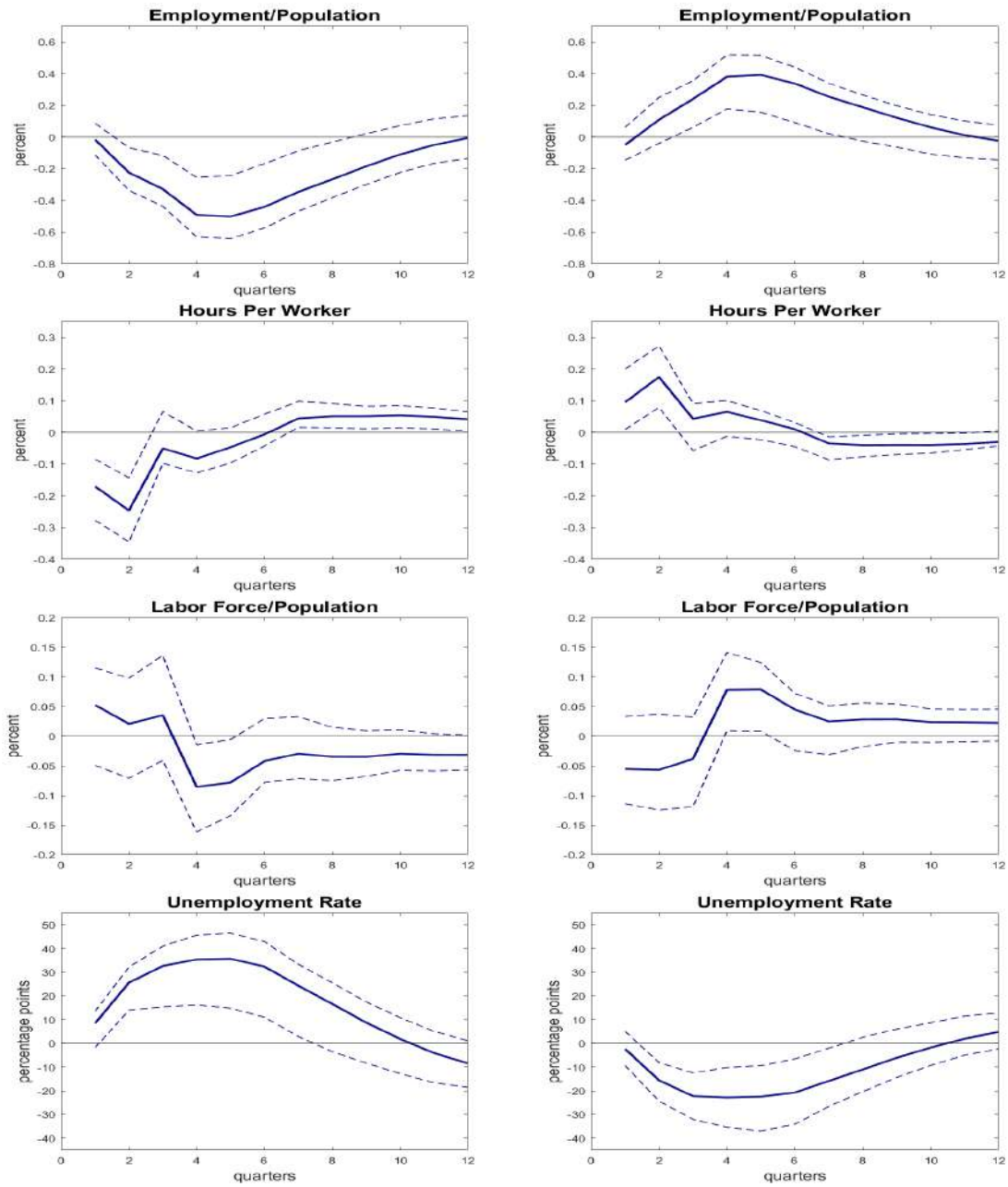


Figure 35: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Exclude PI tax changes in 2009 and 2010

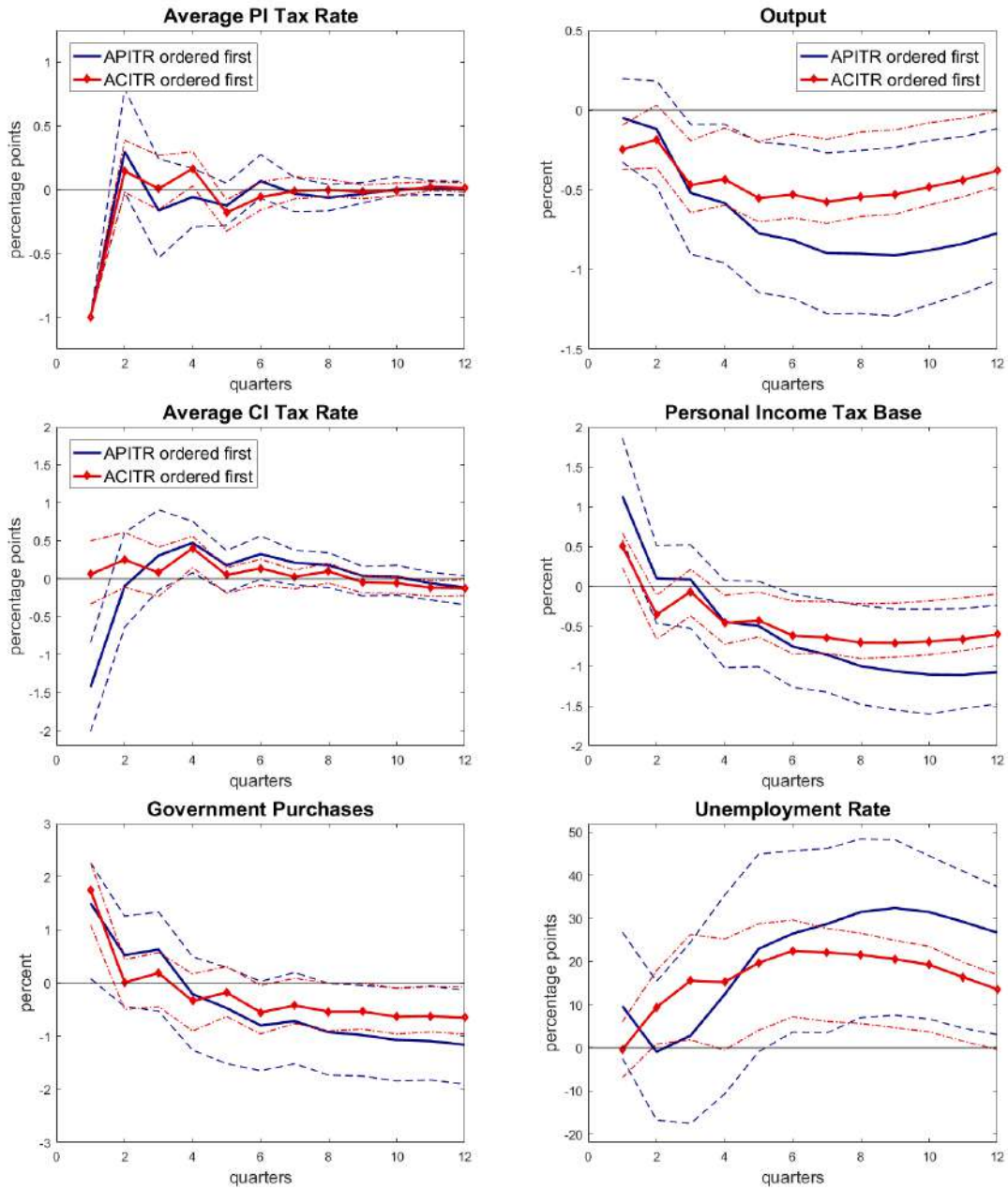


Figure 36: APITR cut with unemployment rate in the model

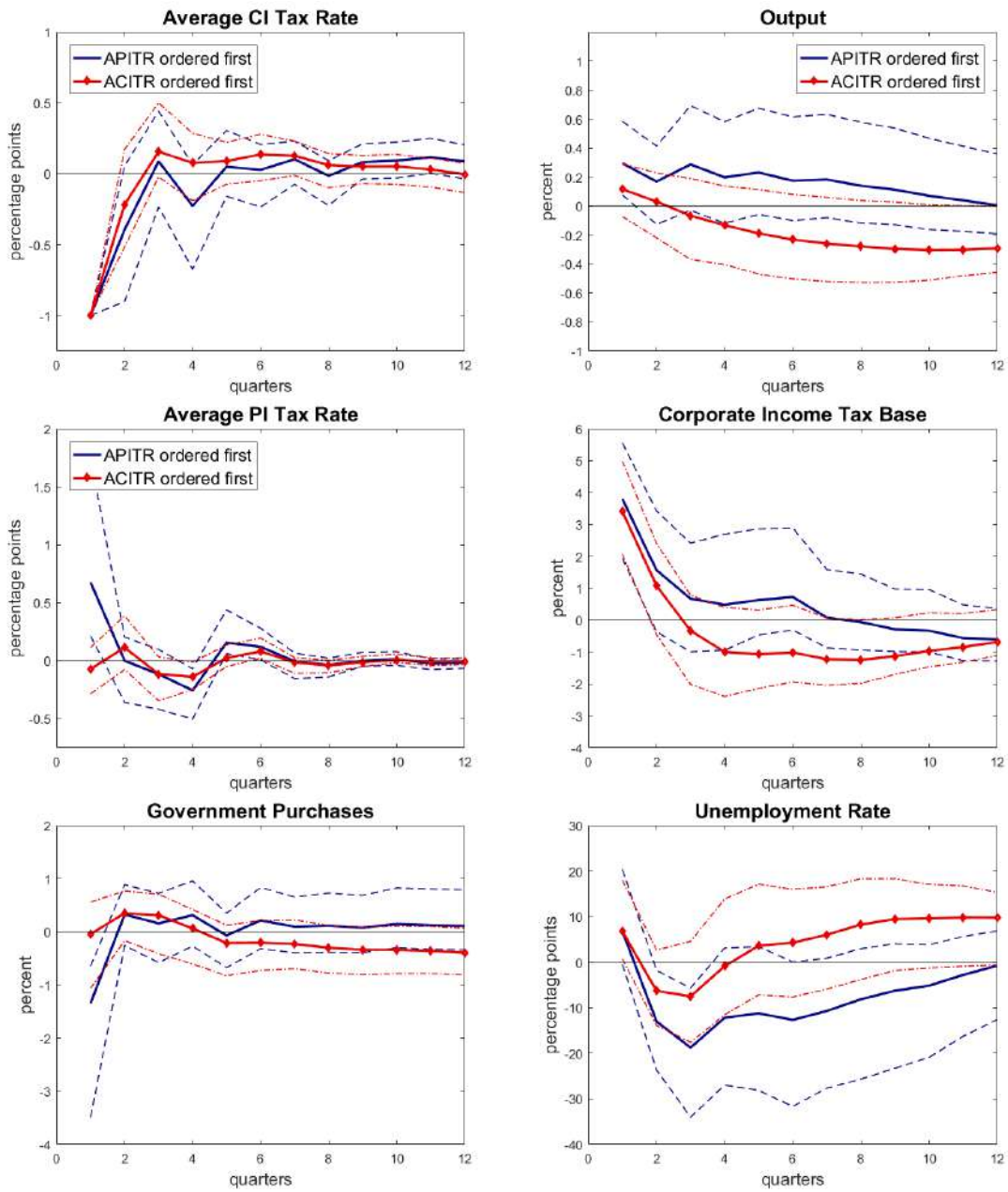


Figure 37: ACITR cut with unemployment rate in the model

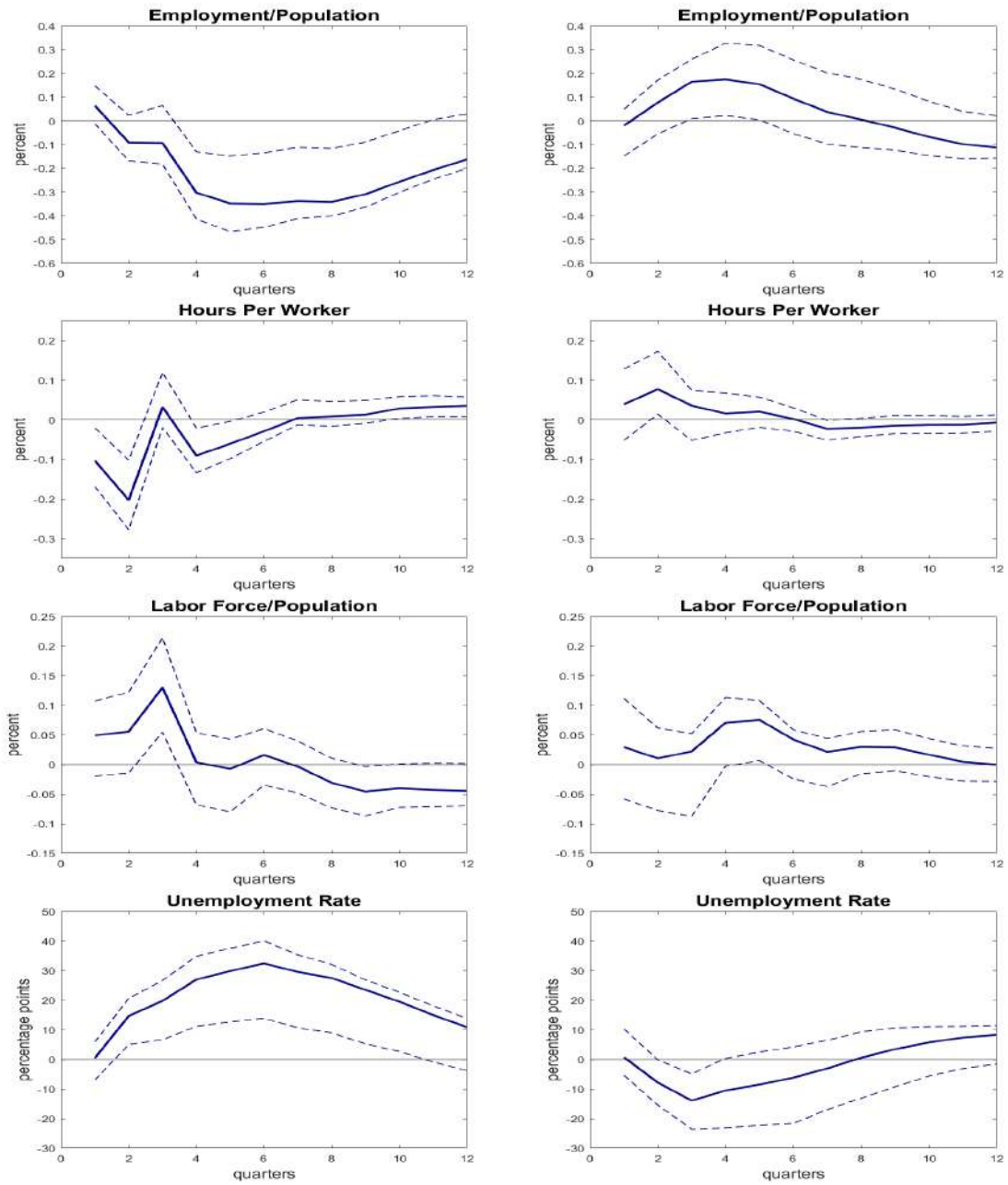


Figure 38: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include PI tax changes one by one

Include both CI tax changes and PI tax change in 2004

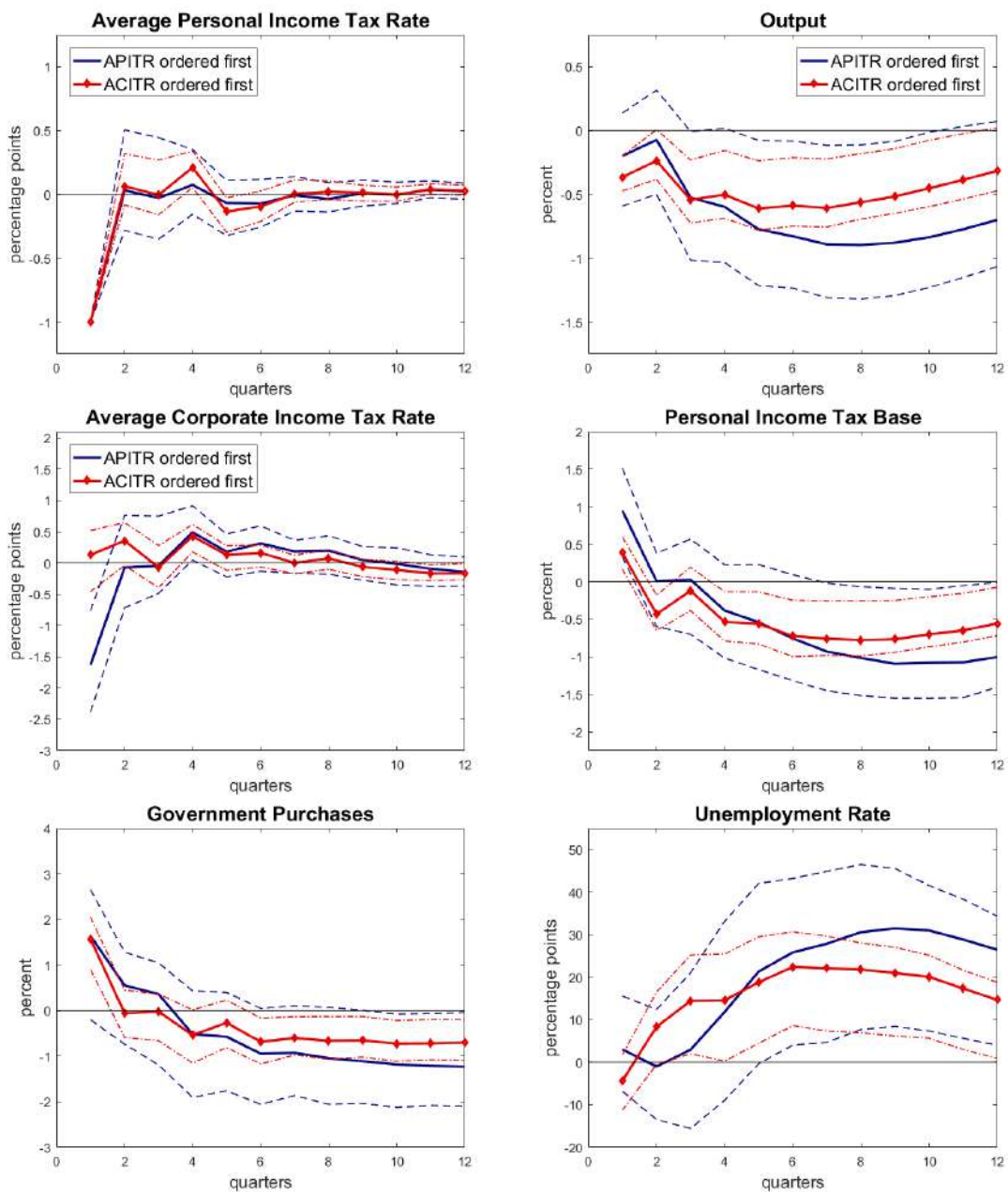


Figure 39: APITR cut with unemployment rate in the model

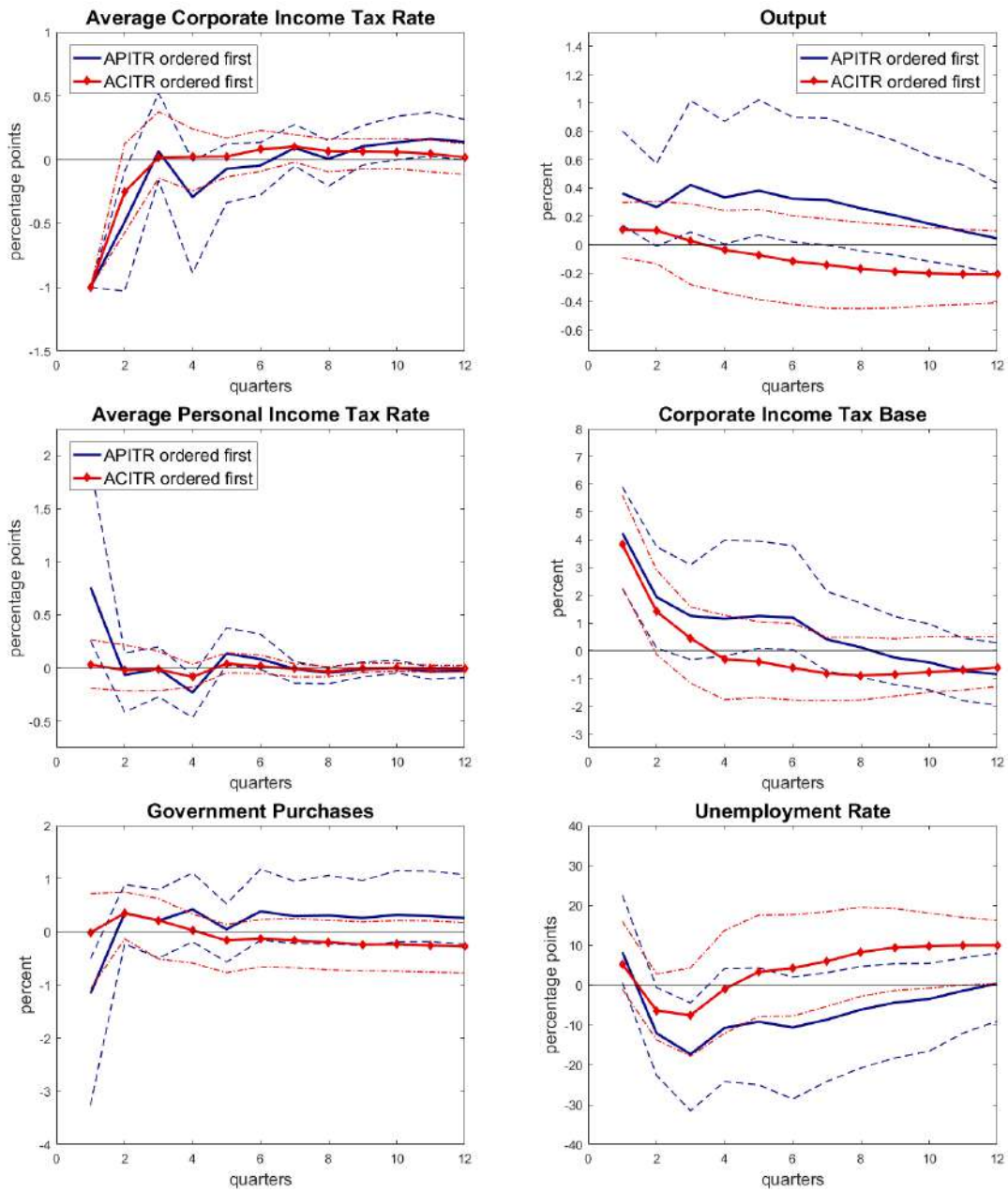


Figure 40: ACITR cut with unemployment rate in the model

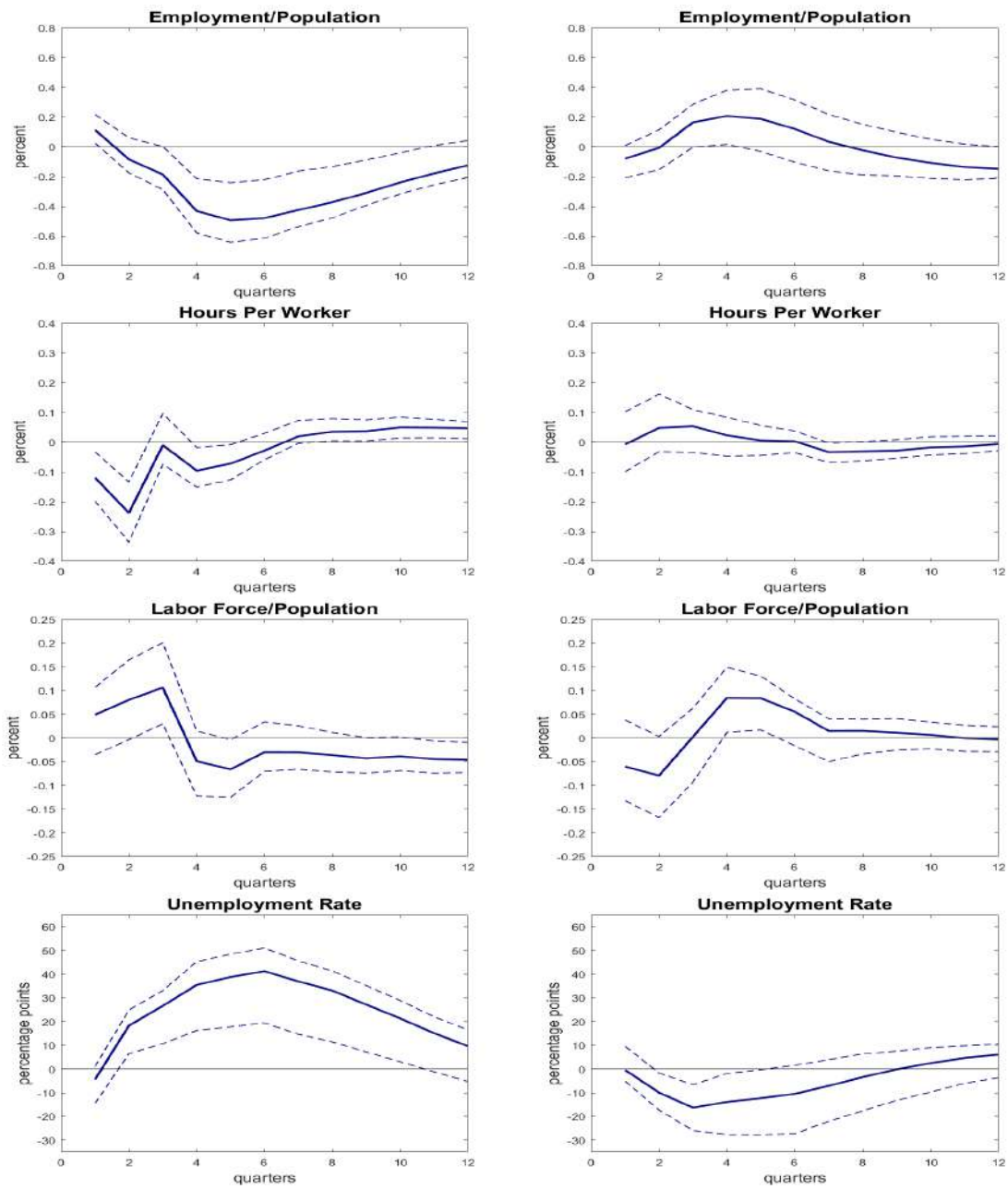


Figure 41: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include both CI tax changes and PI tax change in 2007

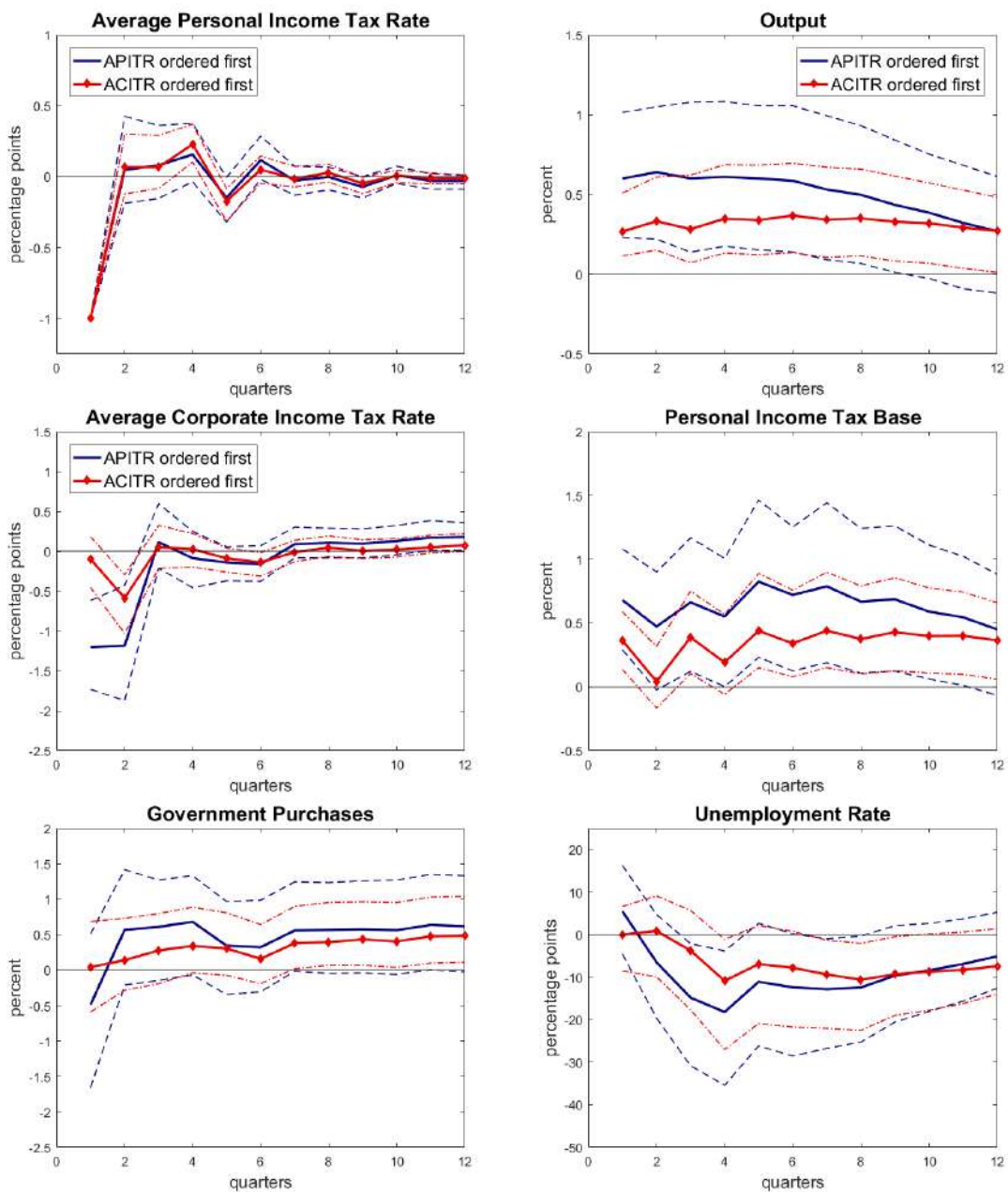


Figure 42: APITR cut with unemployment rate in the model

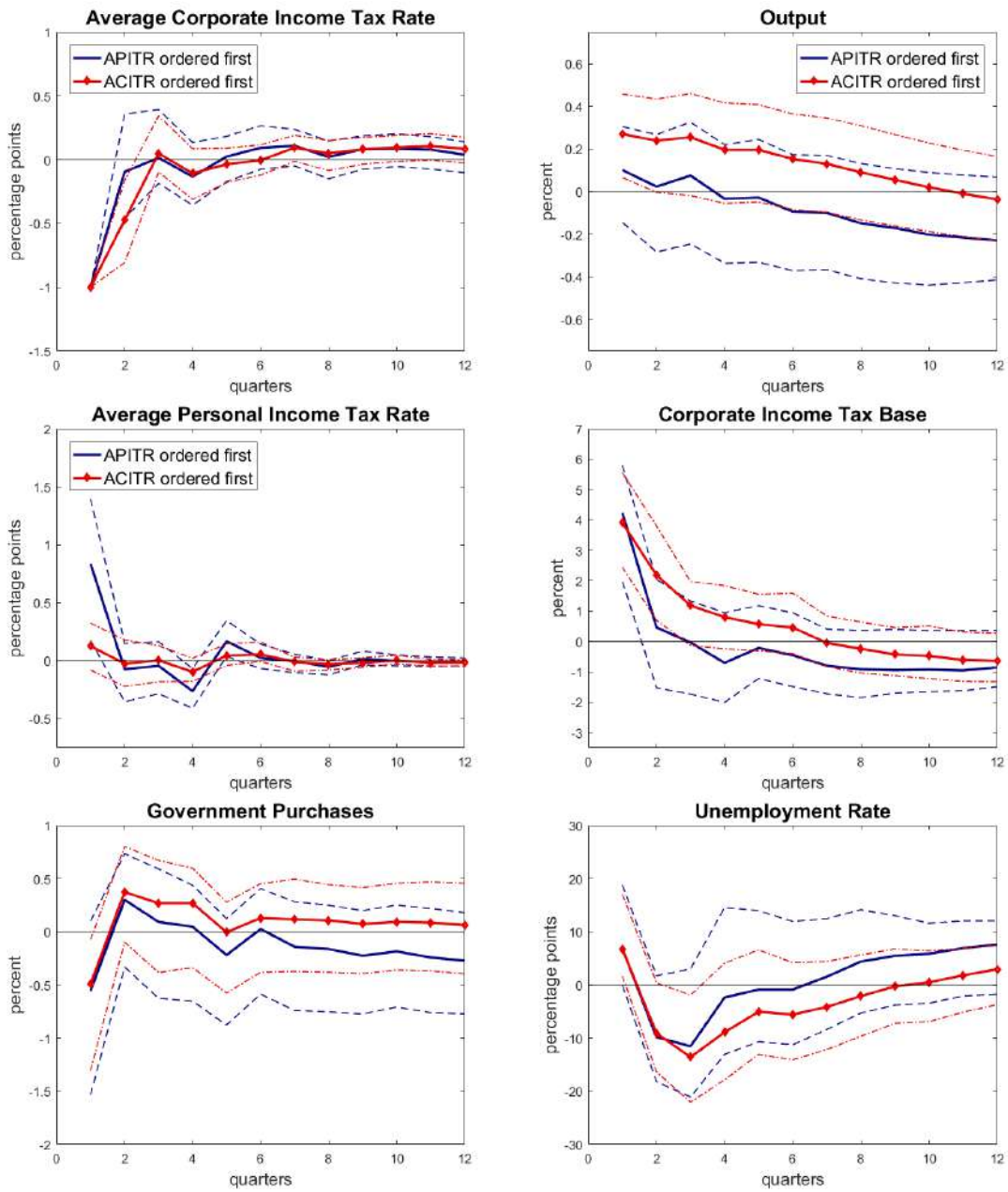


Figure 43: ACITR cut with unemployment rate in the model

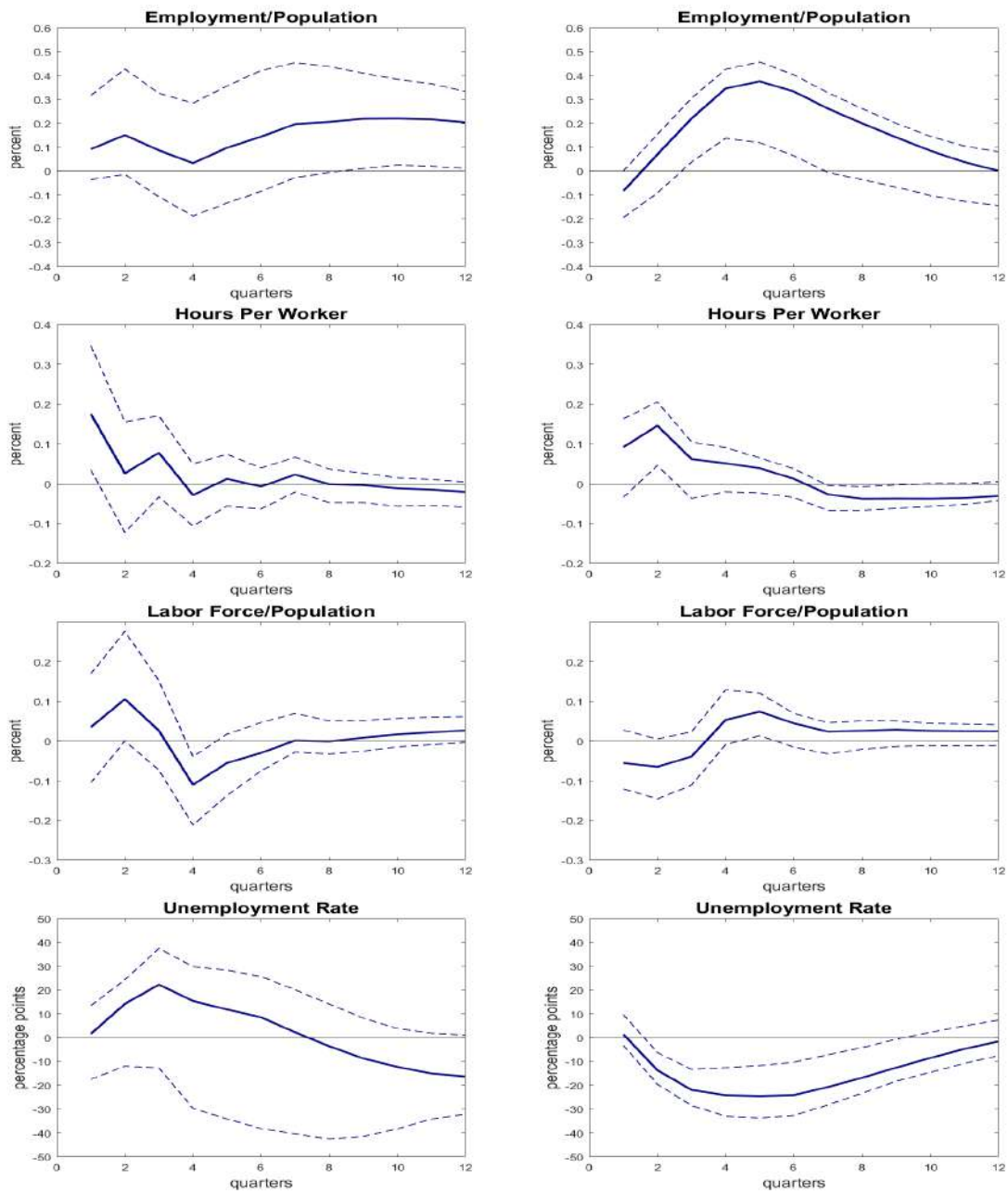


Figure 44: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include both CI tax changes and PI tax change in 2009

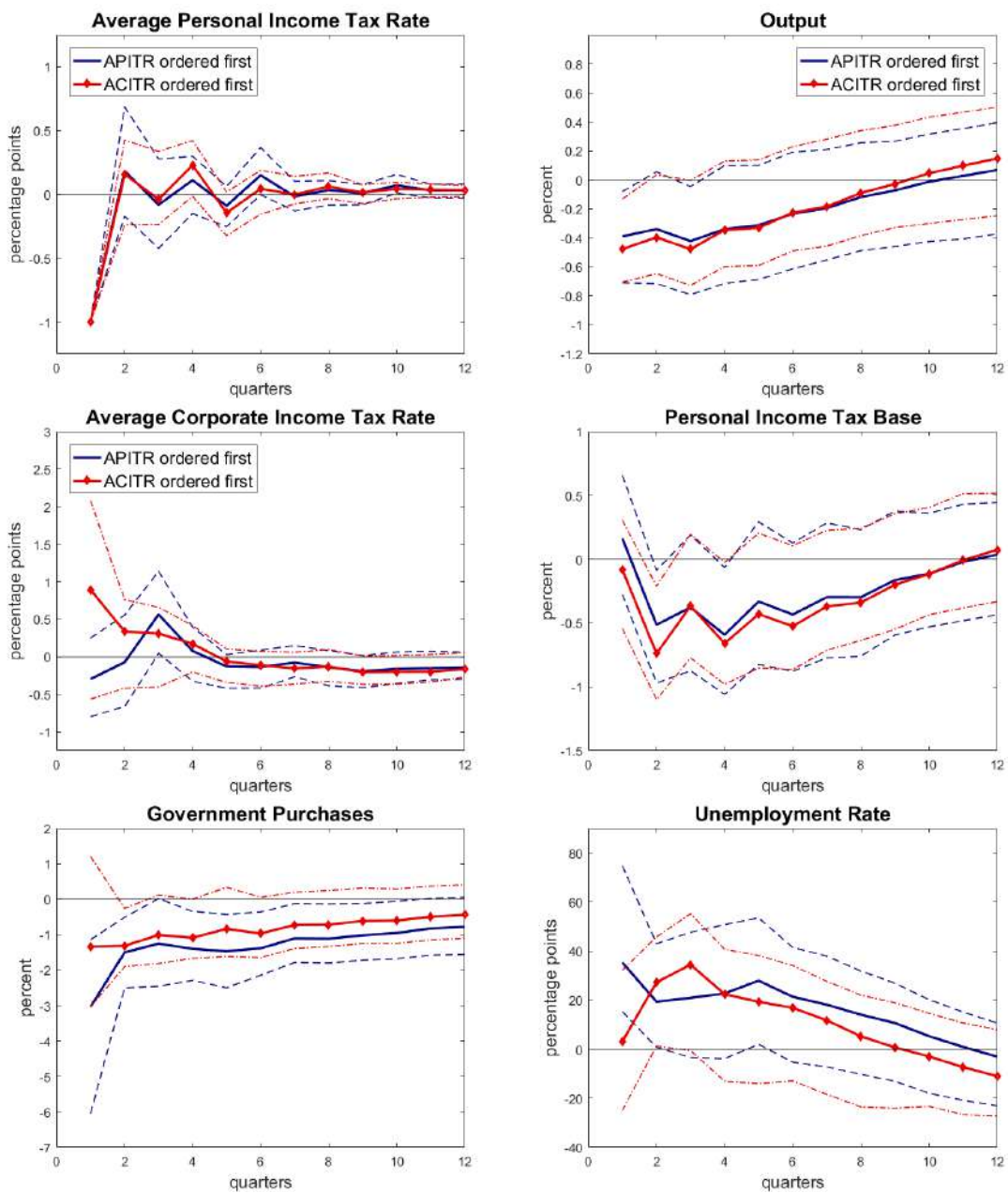


Figure 45: APITR cut with unemployment rate in the model

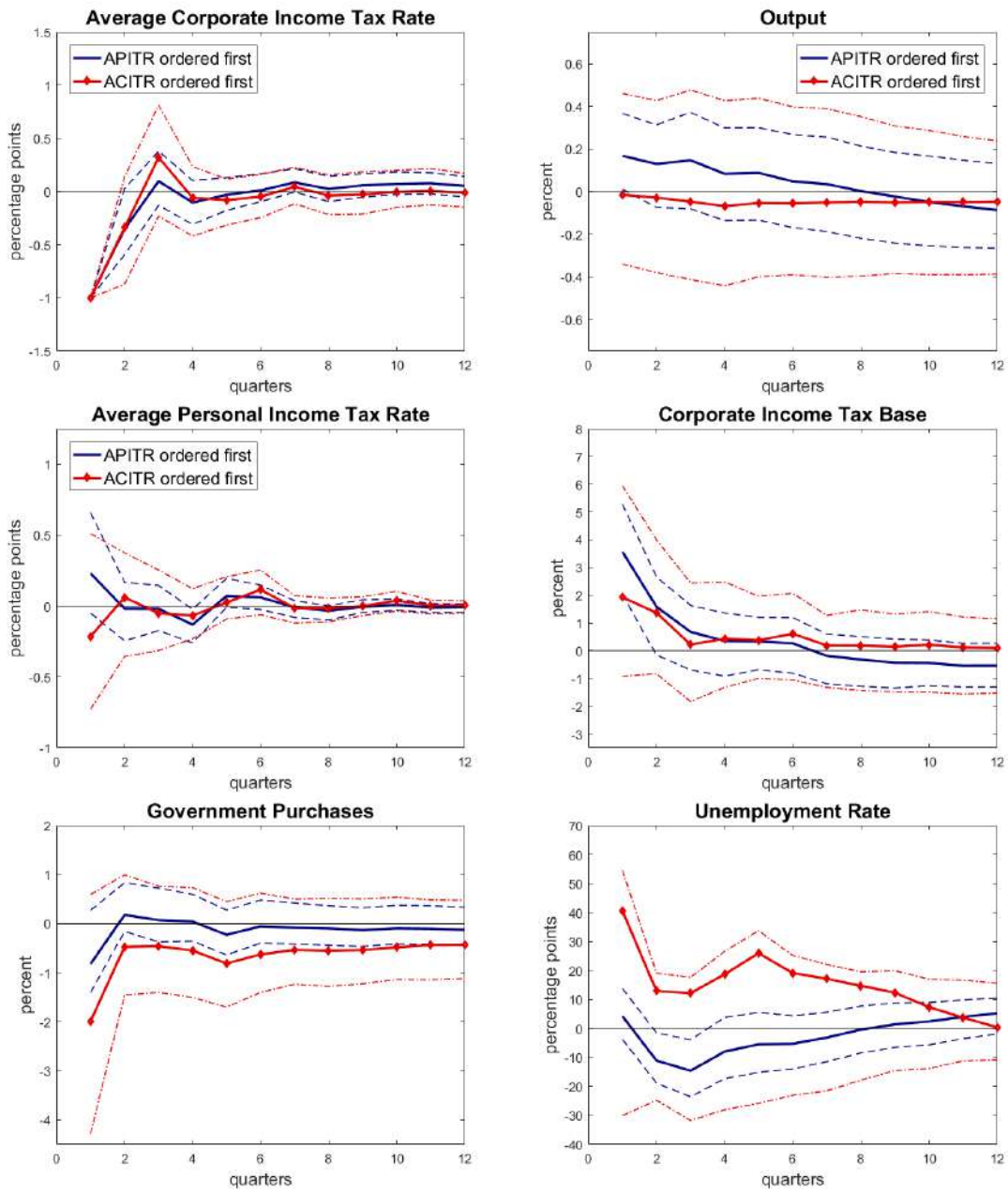


Figure 46: ACITR cut with unemployment rate in the model

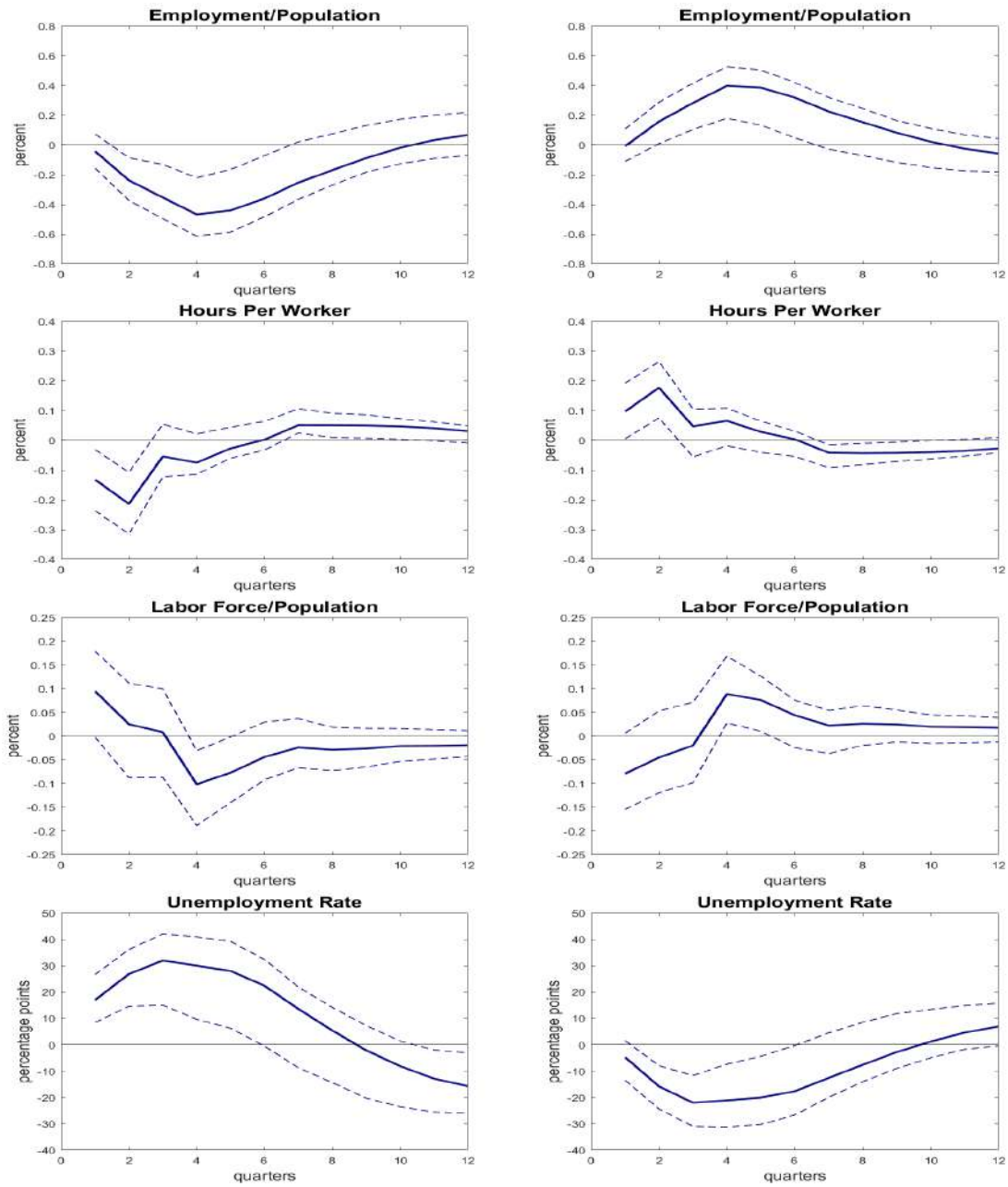


Figure 47: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include both CI tax changes and PI tax change in 2010

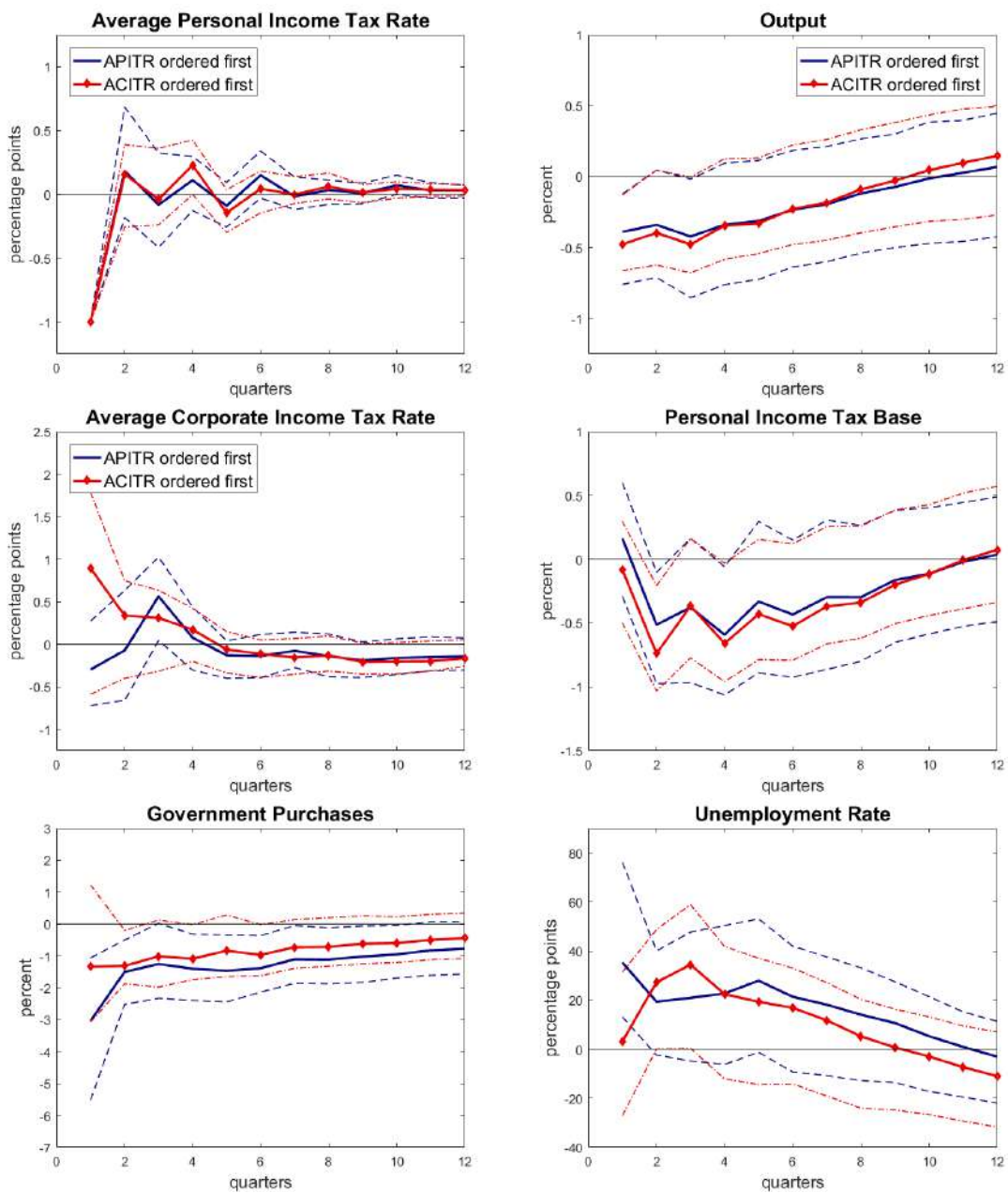


Figure 48: APITR cut with unemployment rate in the model

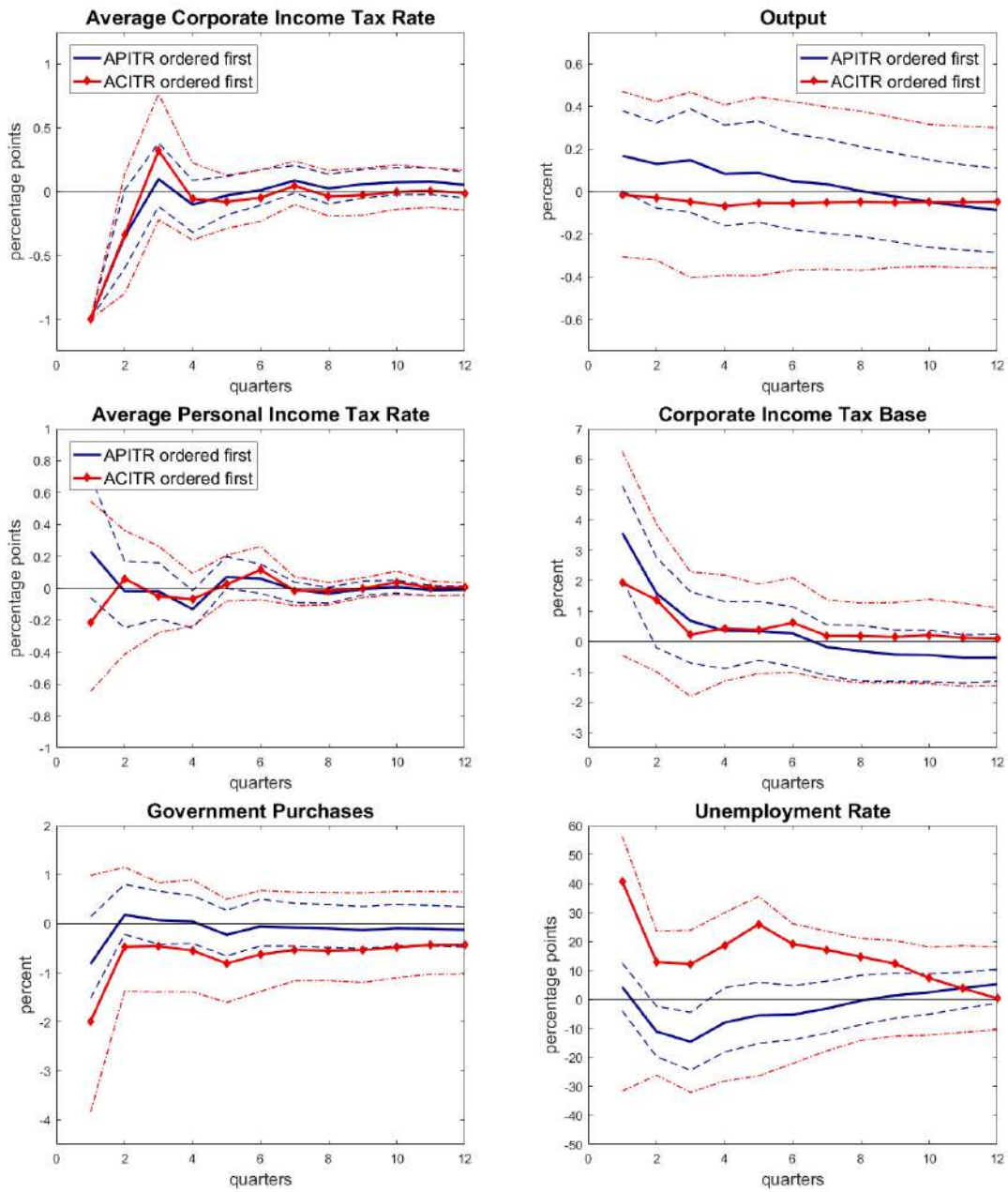


Figure 49: ACITR cut with unemployment rate in the model

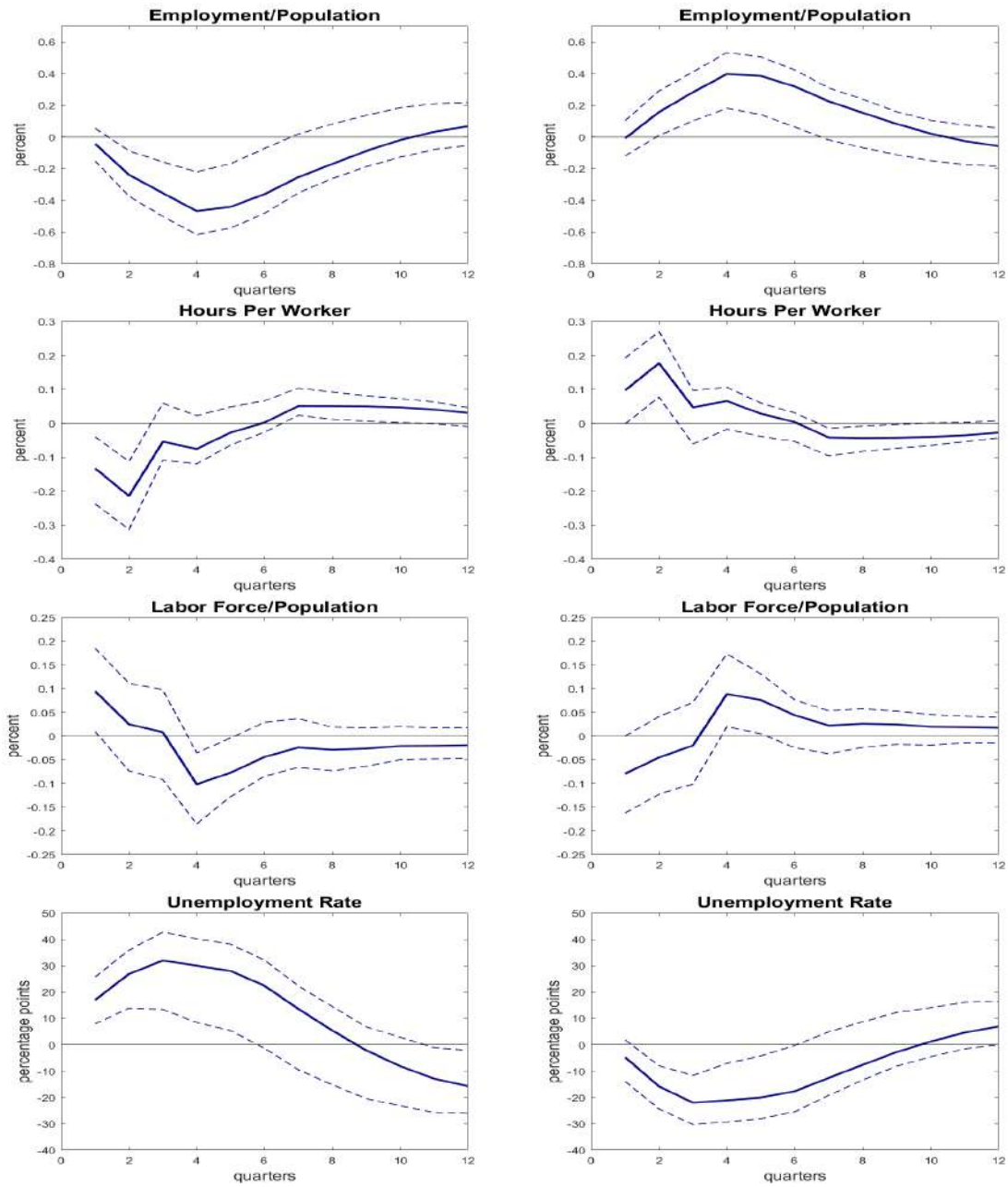


Figure 50: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include both CI tax changes and PI tax change in 2012

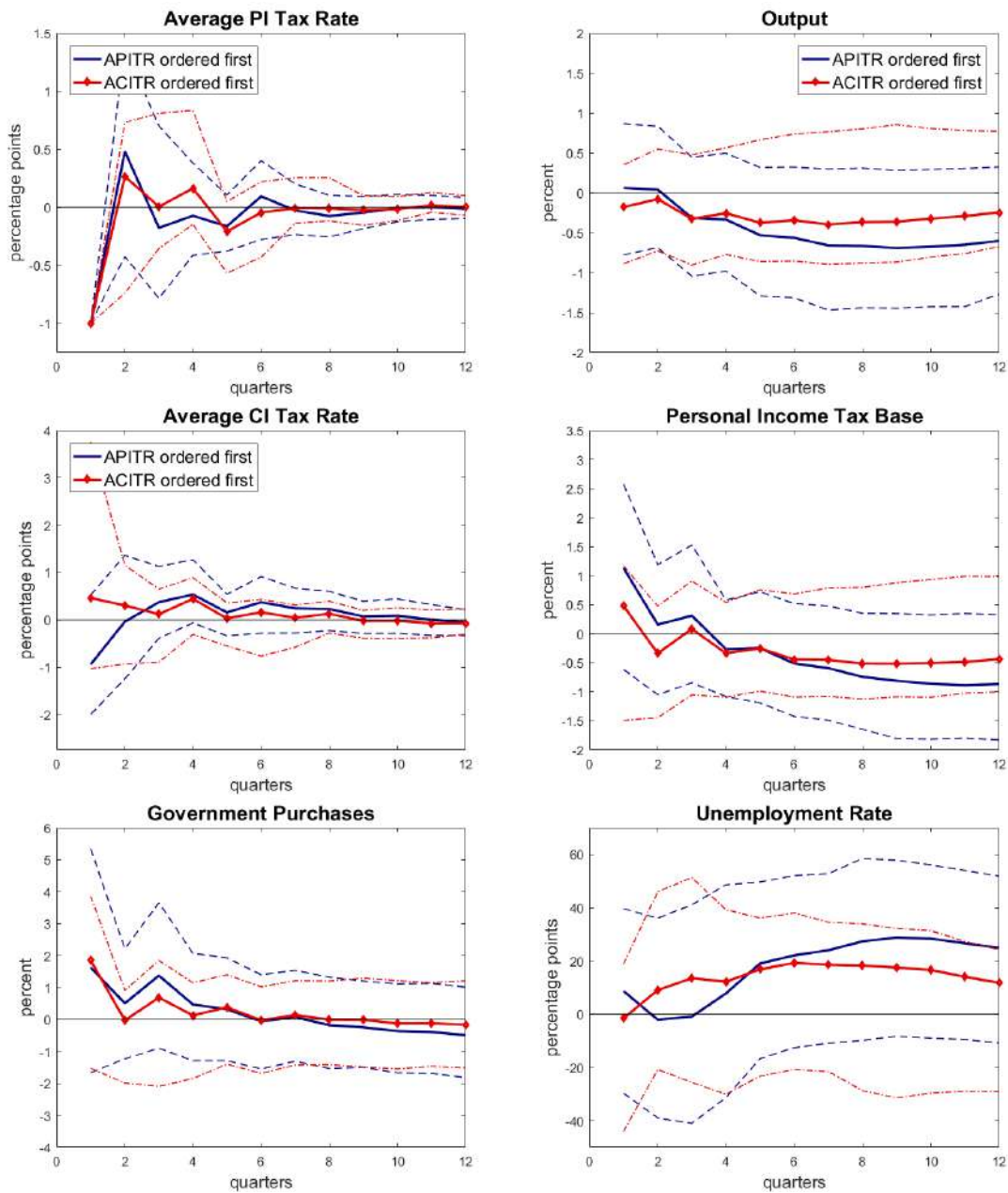


Figure 51: APITR cut with unemployment rate in the model

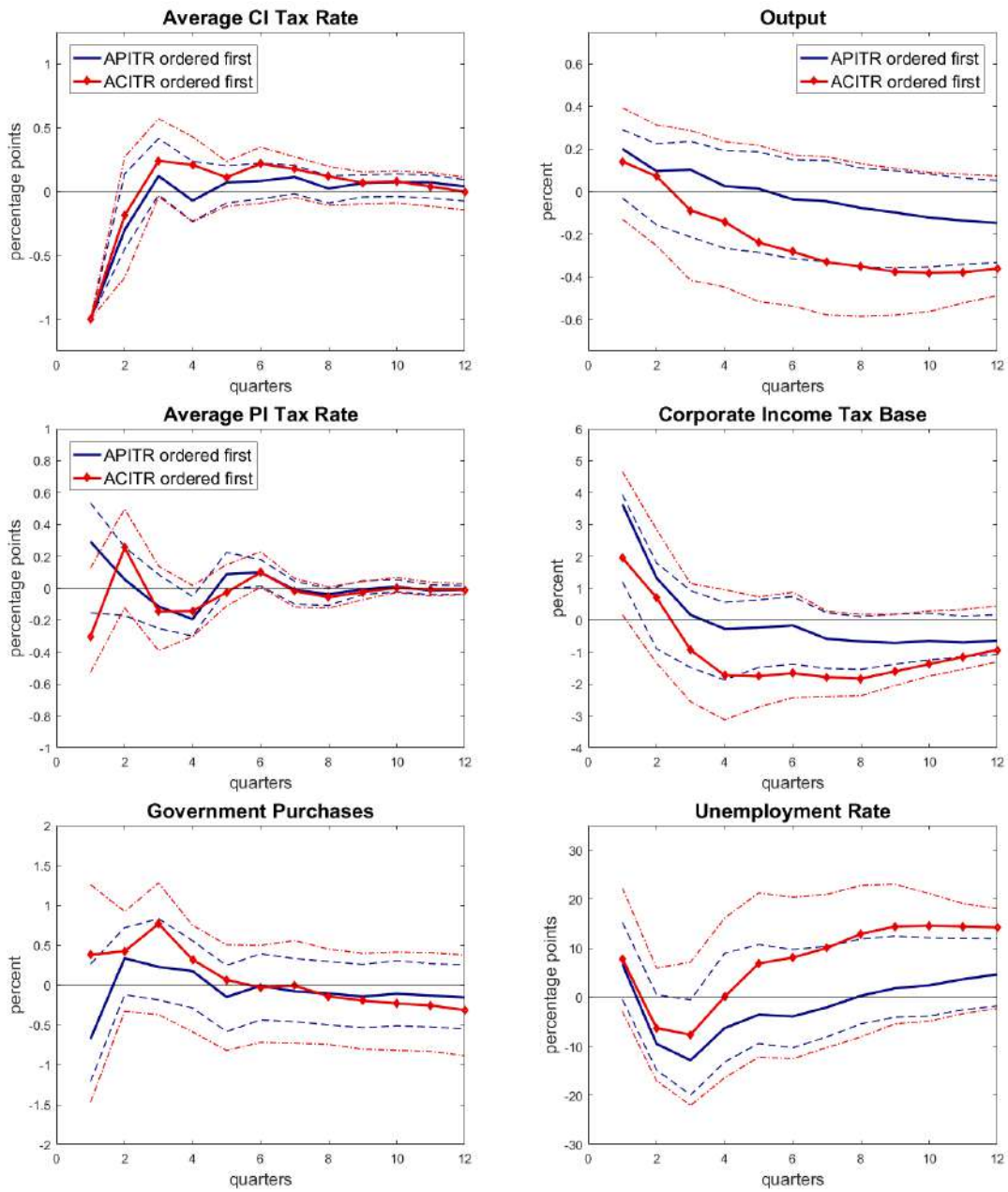


Figure 52: ACITR cut with unemployment rate in the model

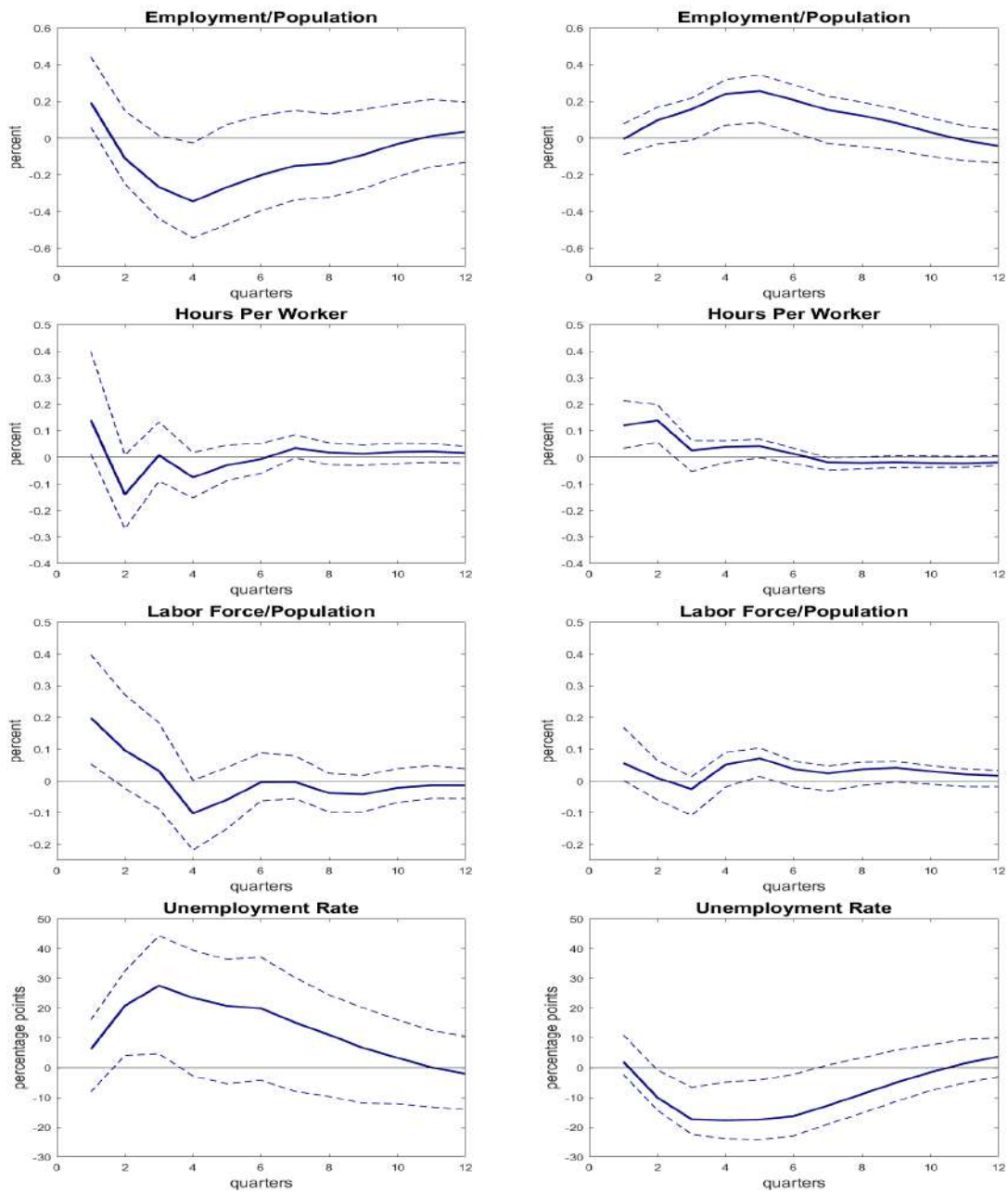


Figure 53: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include both CI tax changes and PI tax change in 2016

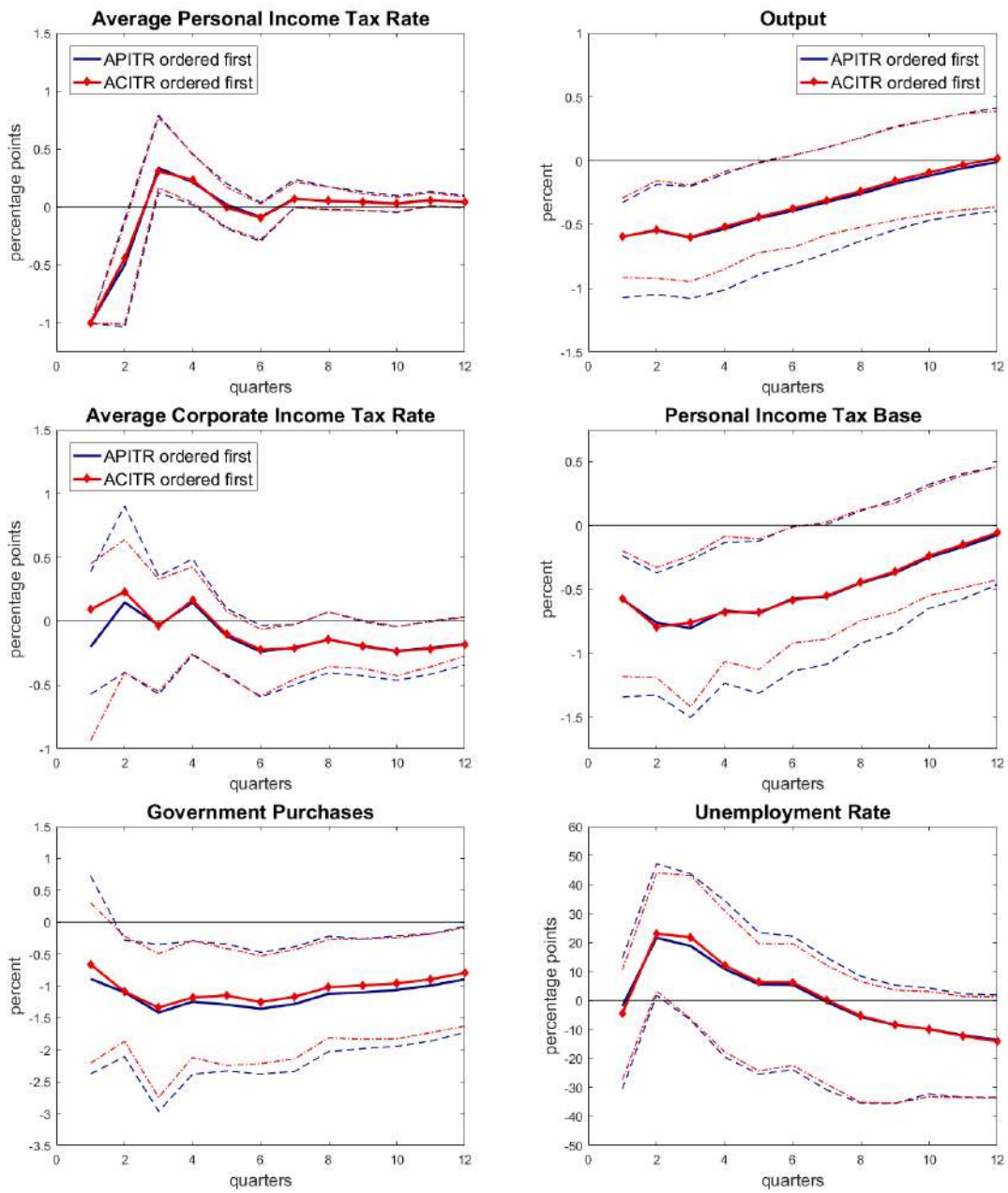


Figure 54: APITR cut with unemployment rate in the model

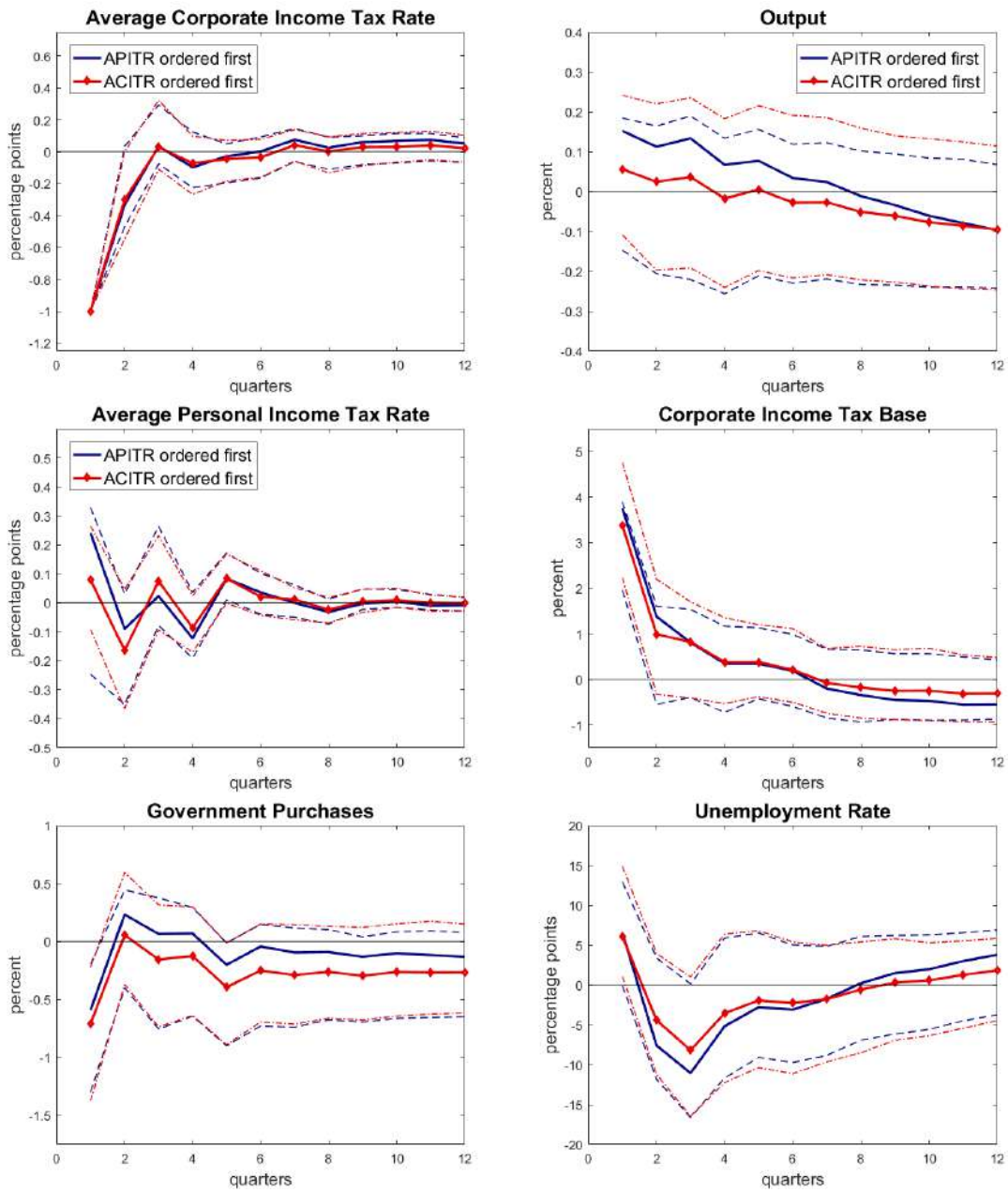


Figure 55: ACITR cut with unemployment rate in the model

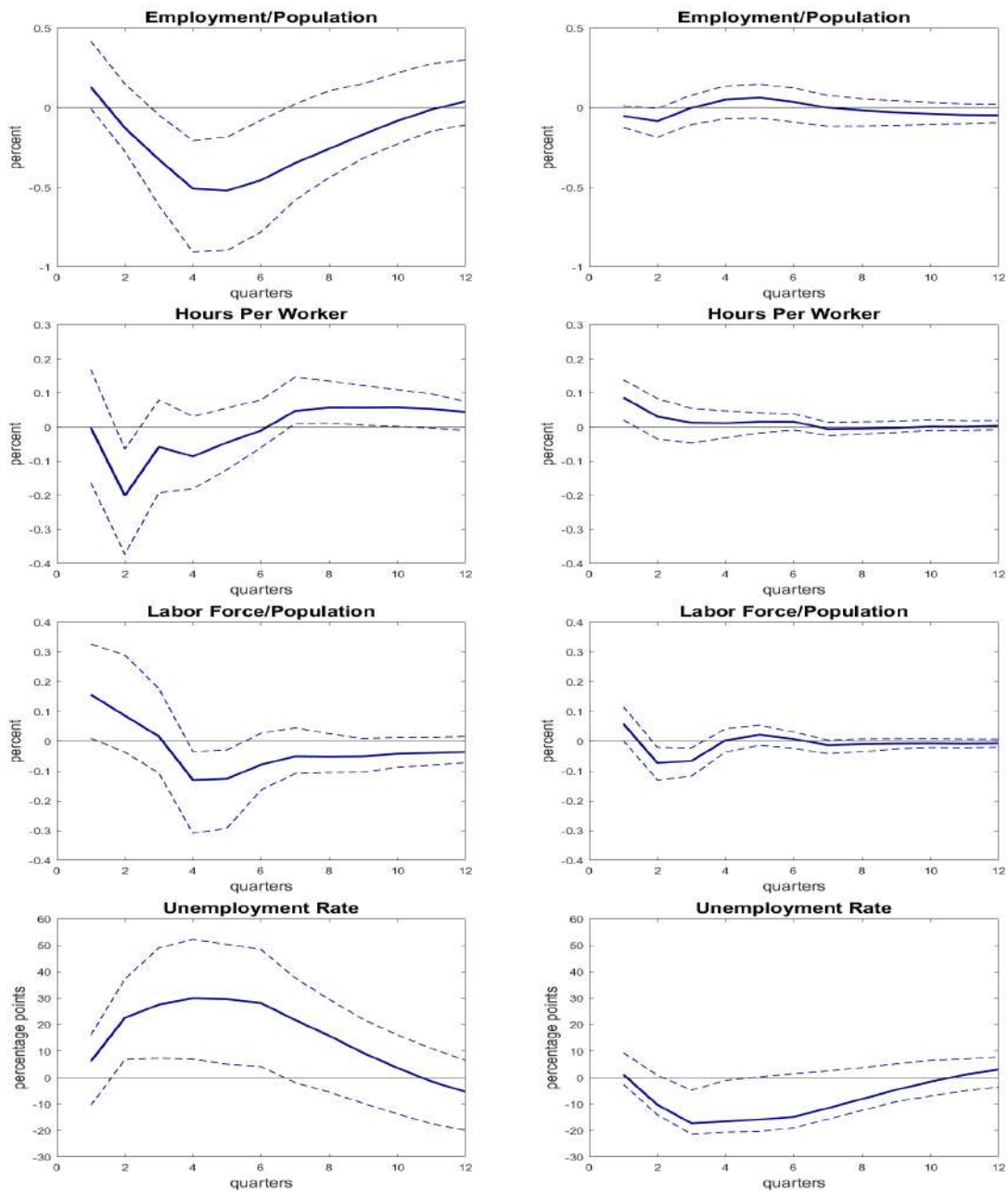


Figure 56: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include CI tax changes one by one

Include CI tax change in 2009 and all PI tax changes

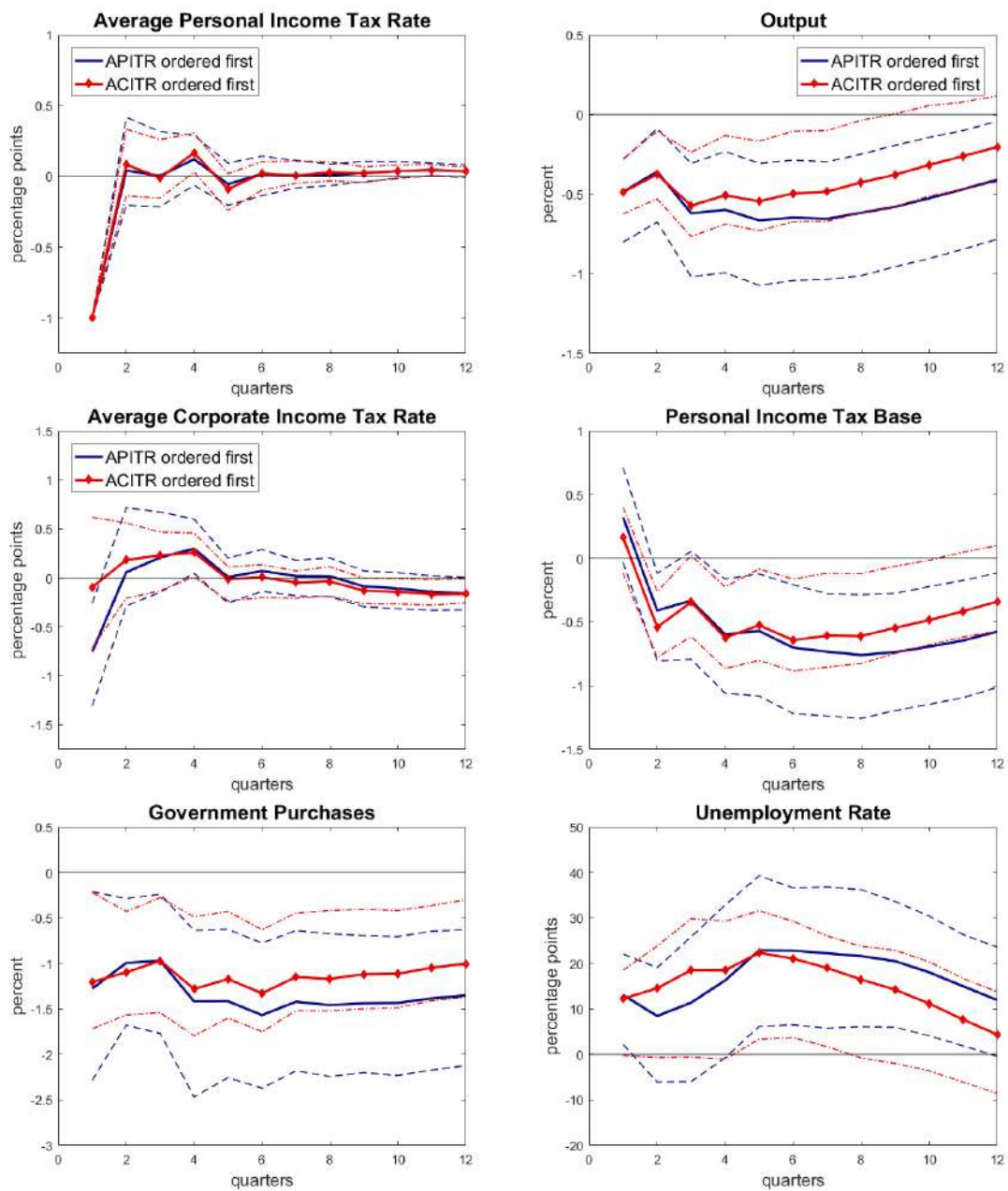


Figure 57: APITR cut with unemployment rate in the model

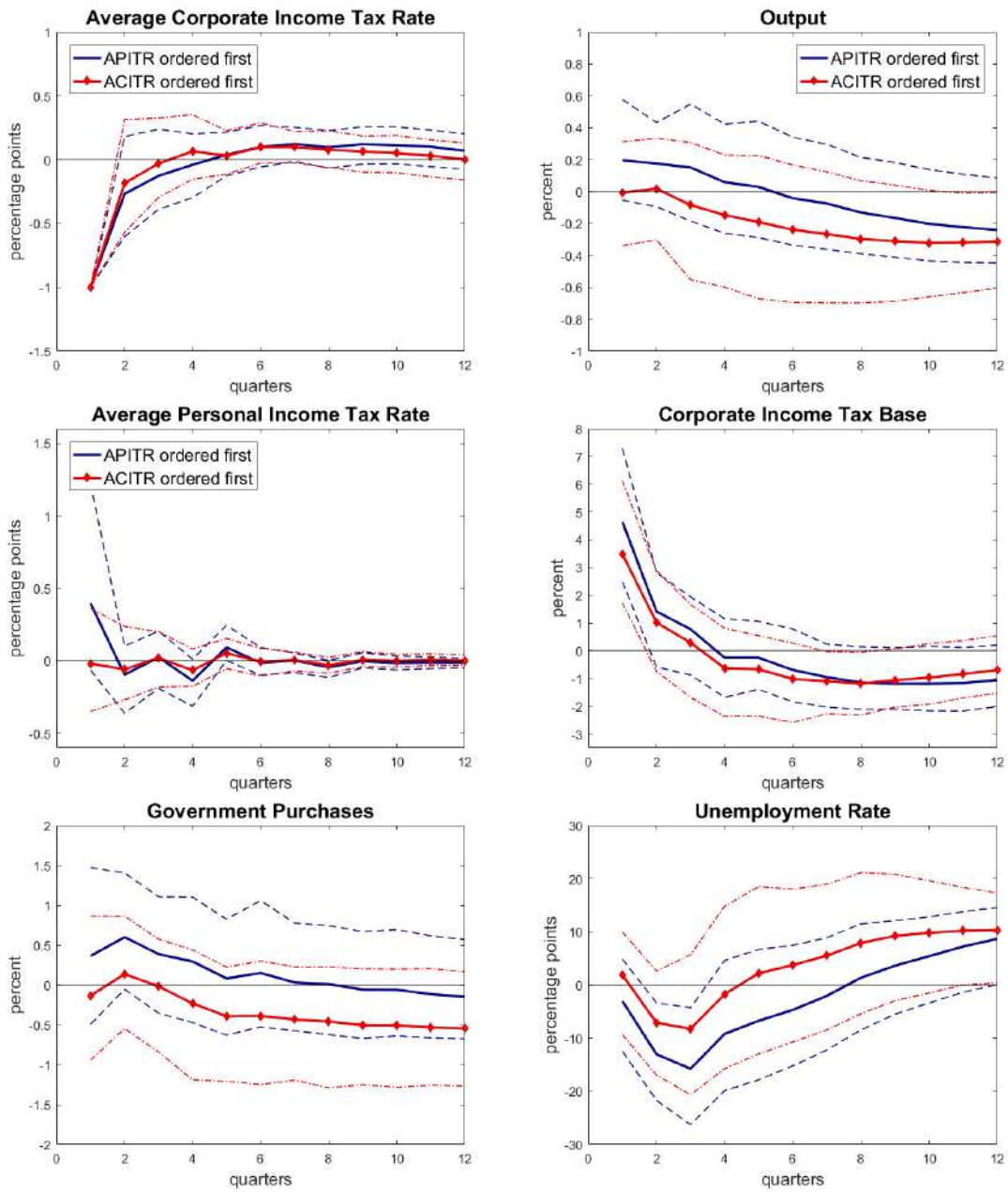


Figure 58: ACITR cut with unemployment rate in the model

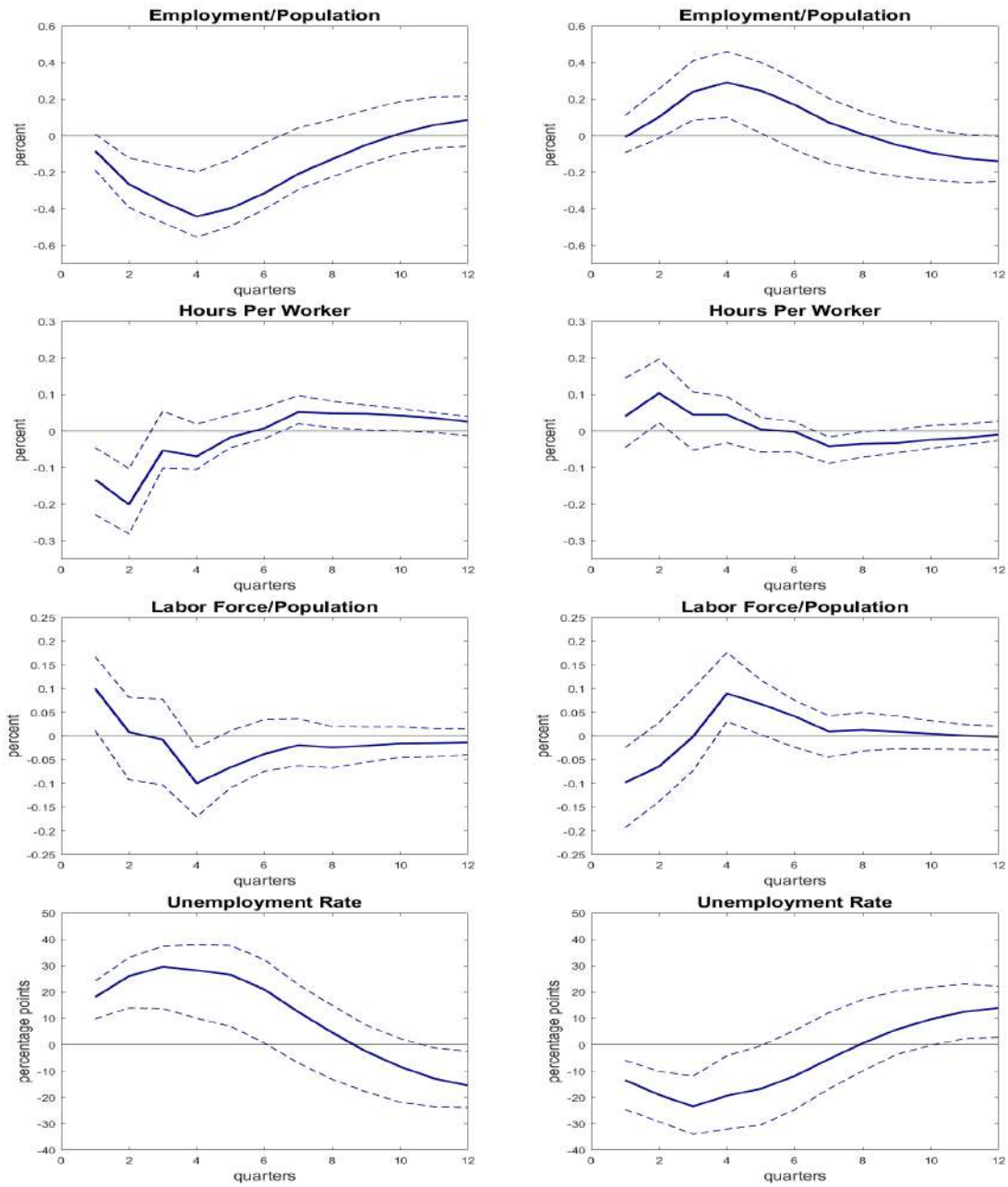


Figure 59: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include CI tax change in 2009 and PI tax changes in 2009 and 2010

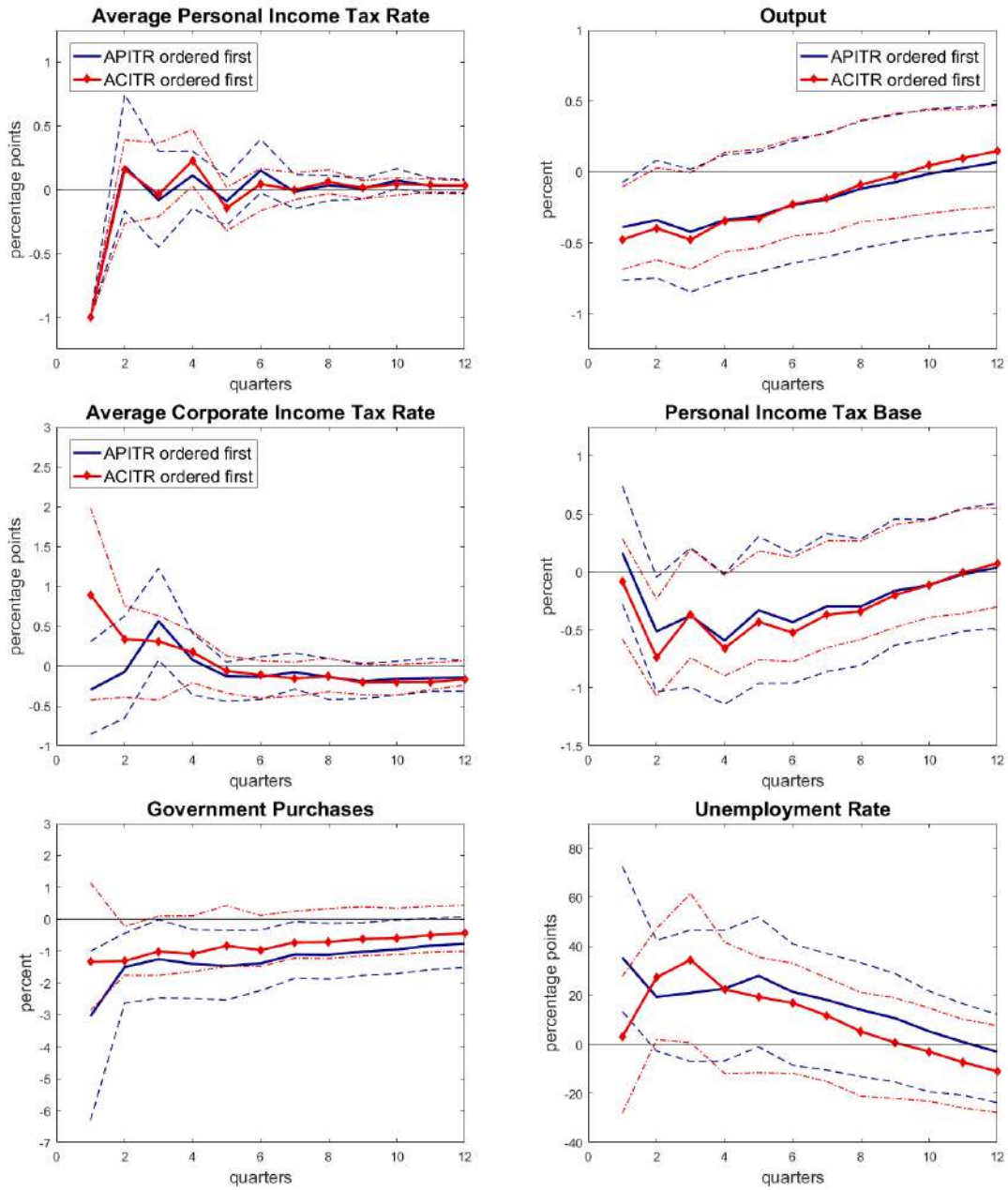


Figure 60: APITR cut with unemployment rate in the model

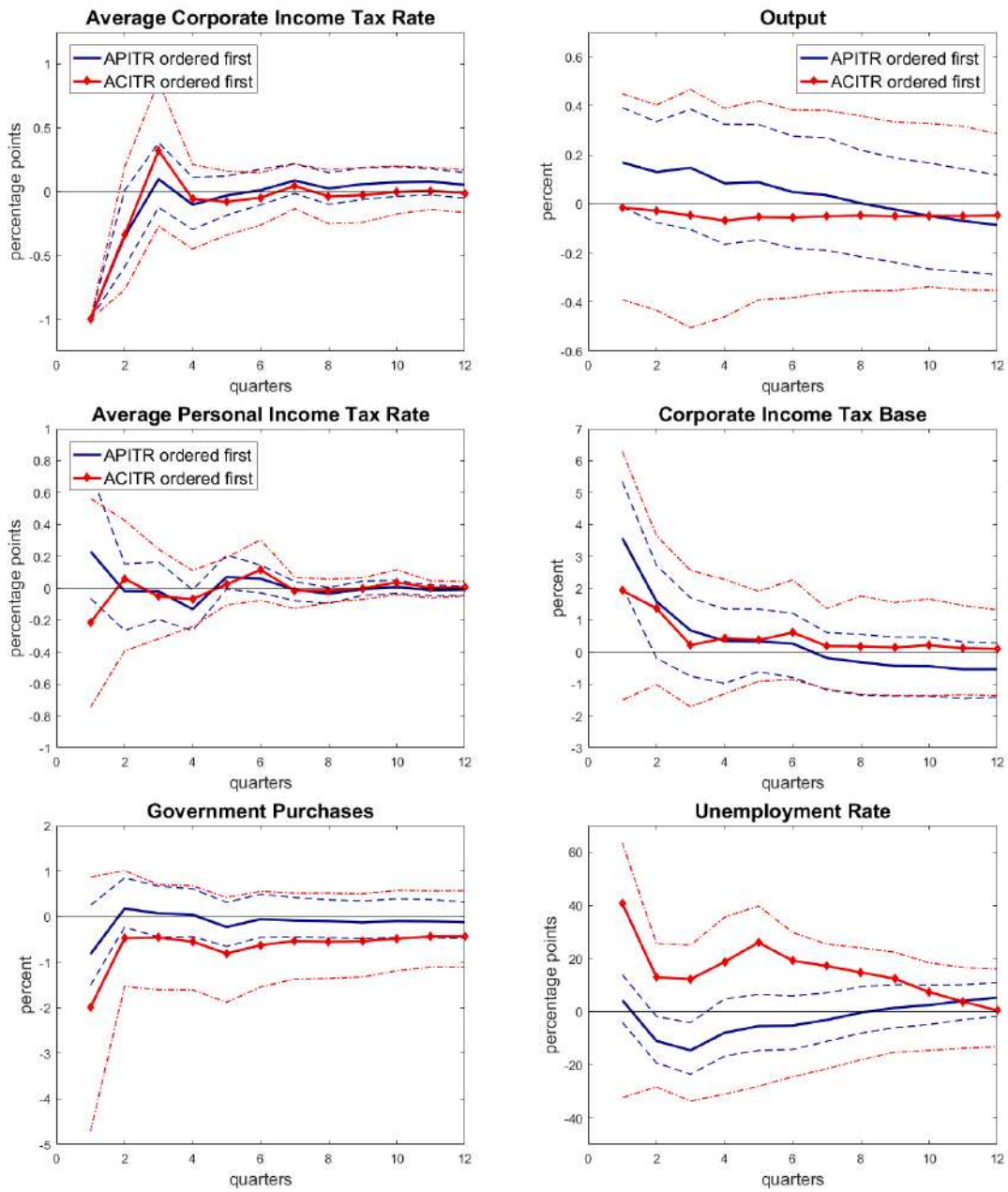


Figure 61: ACITR cut with unemployment rate in the model

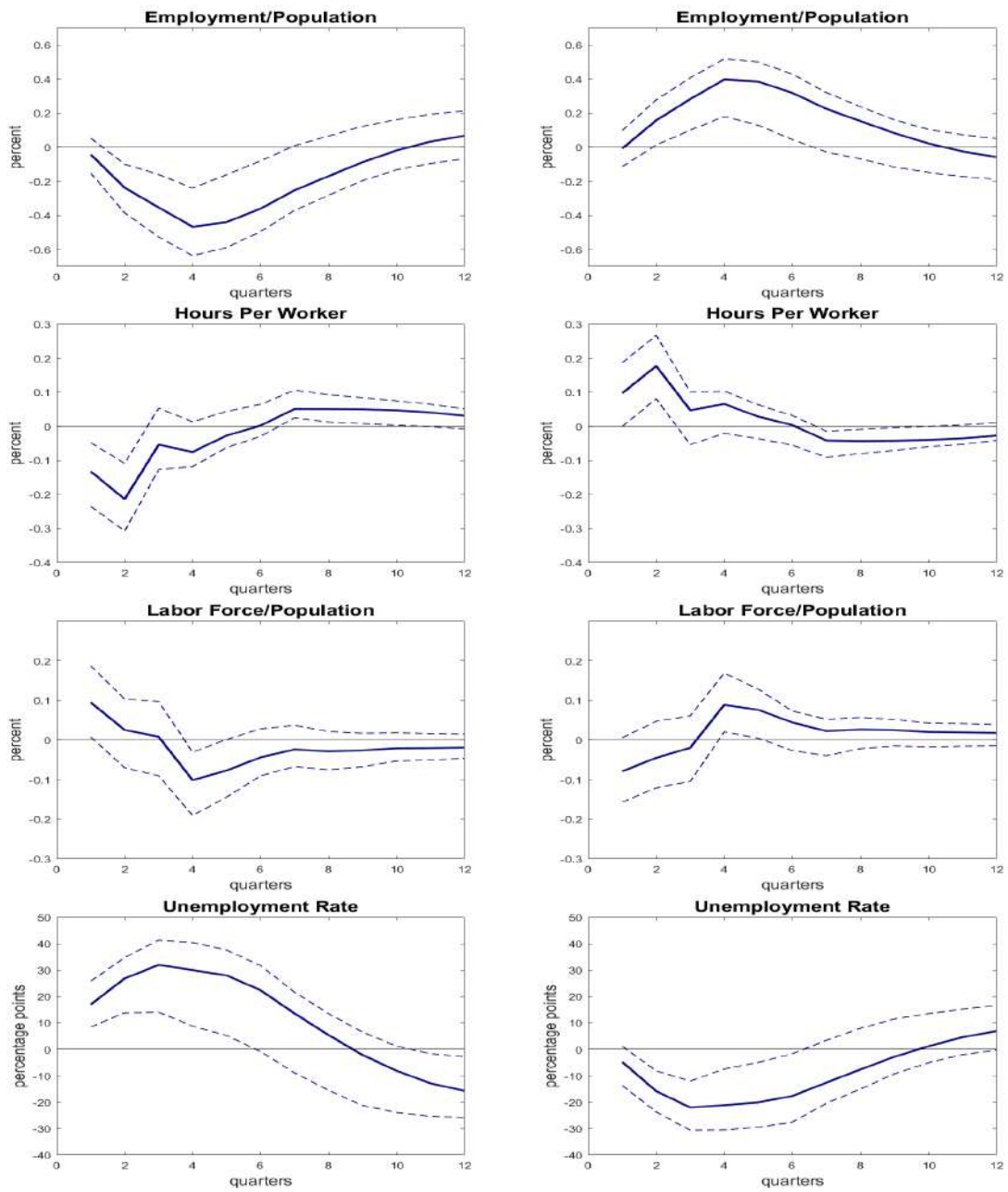


Figure 62: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include CI tax change in 2010 and all PI tax changes

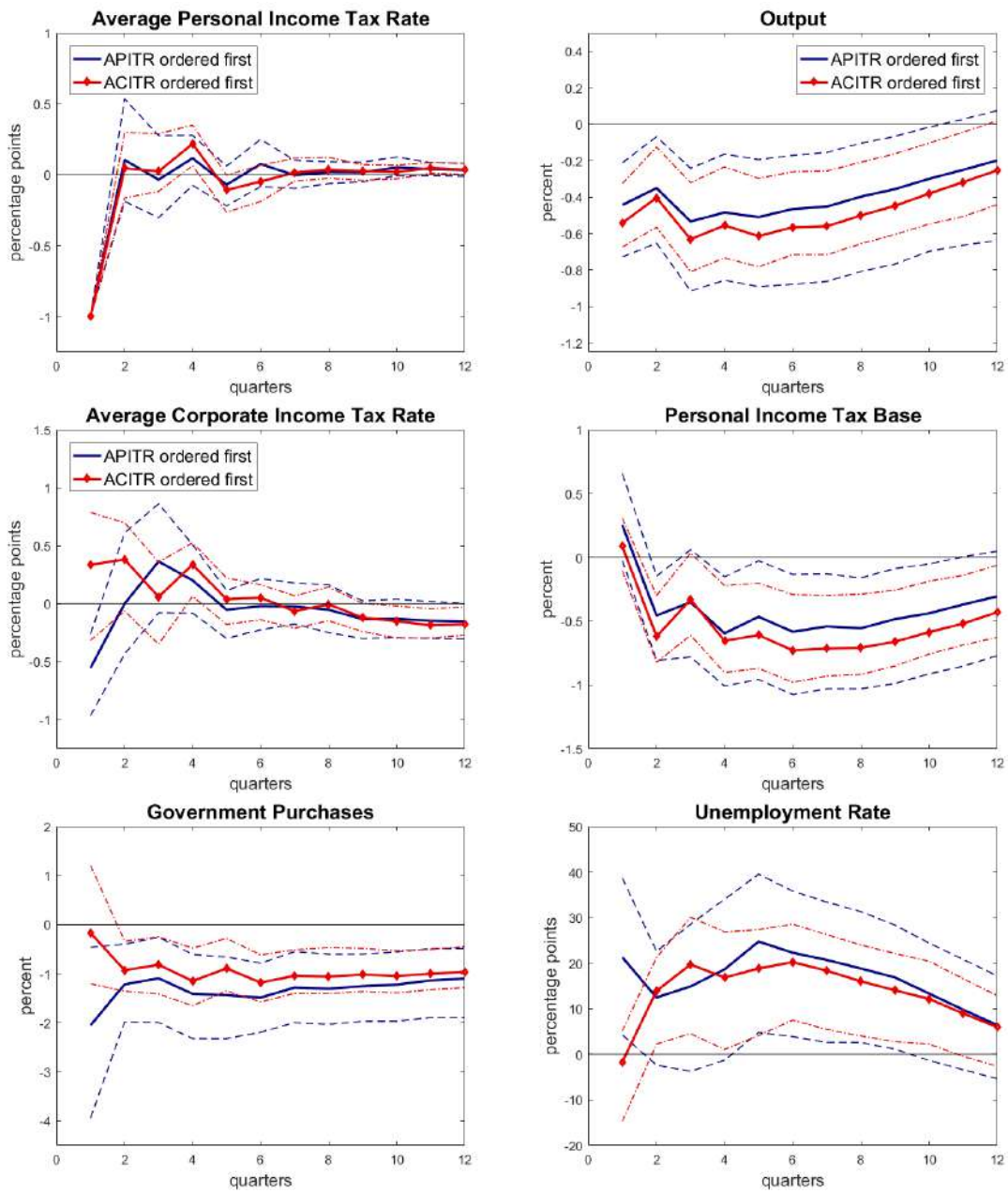


Figure 63: APITR cut with unemployment rate in the model

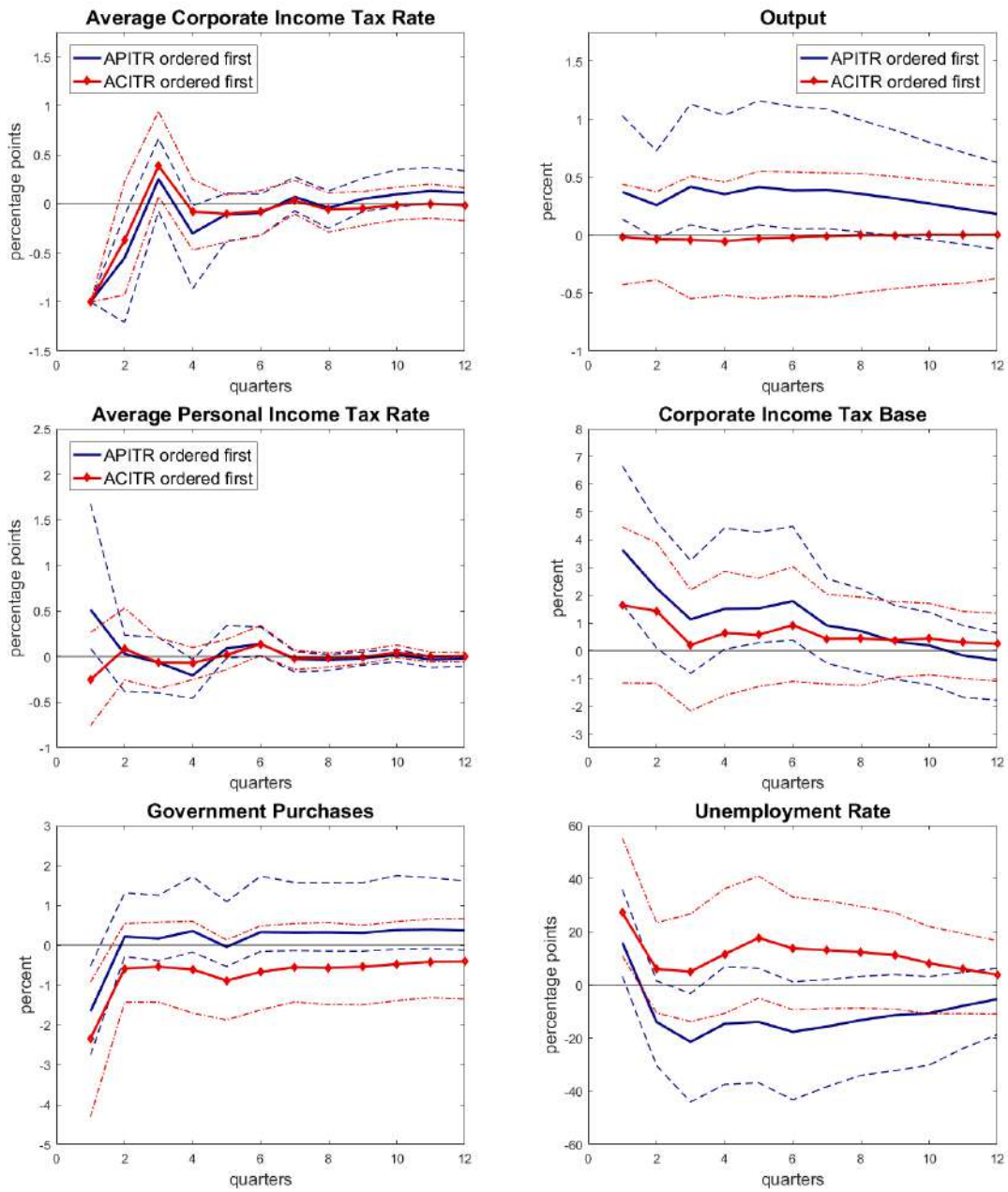


Figure 64: ACITR cut with unemployment rate in the model

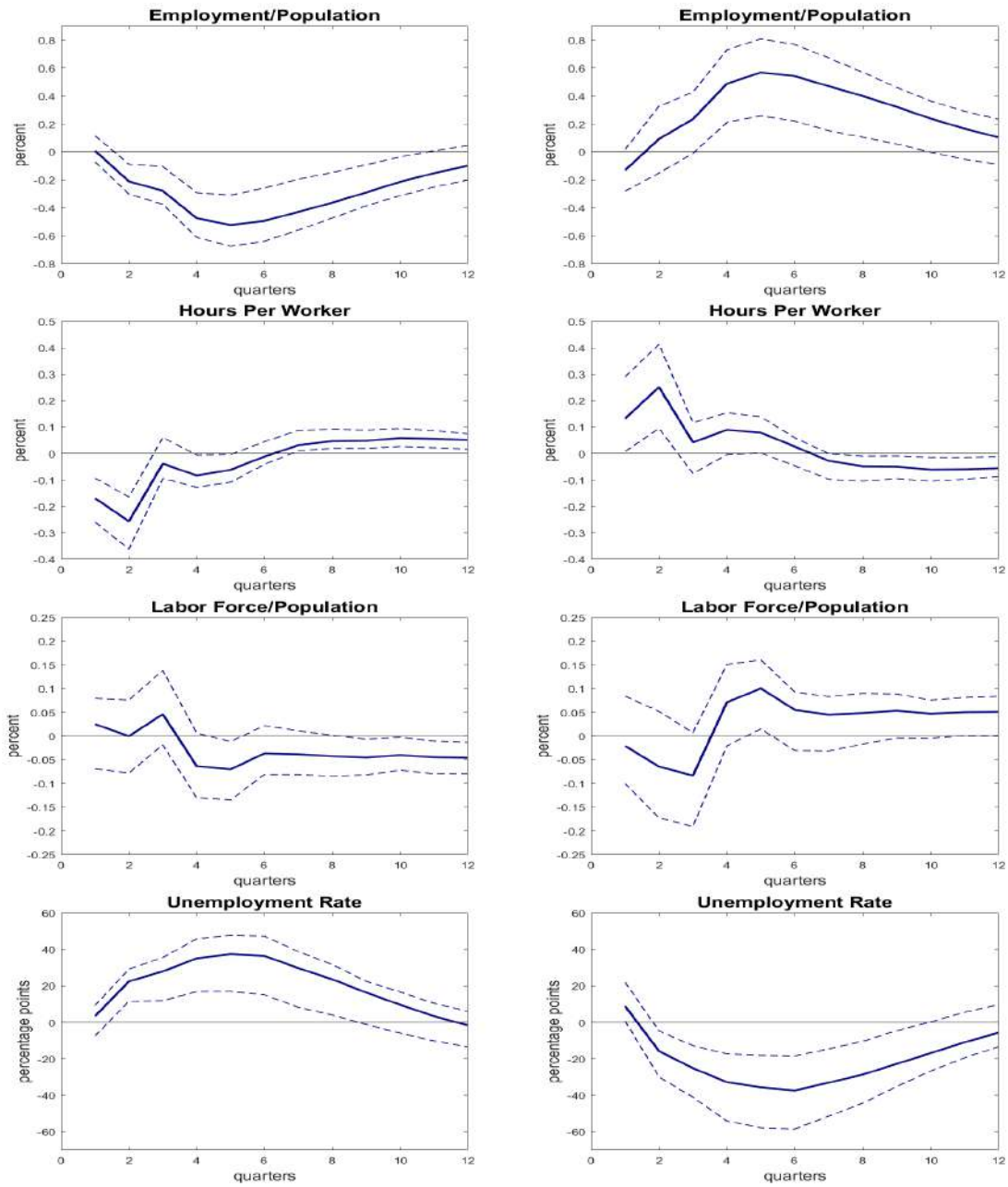


Figure 65: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

Include CI tax change in 2010 and PI tax changes in 2009 and 2010

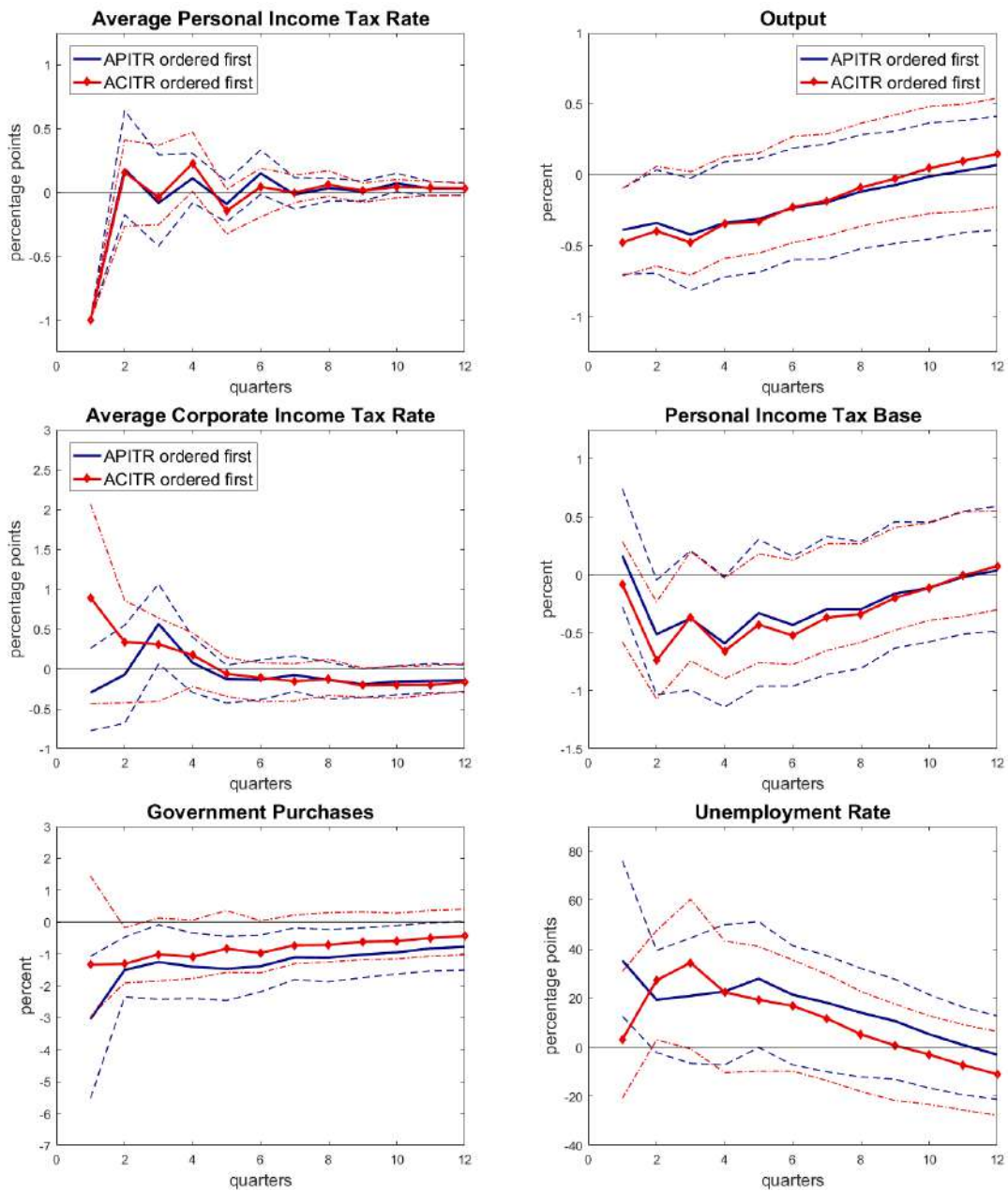


Figure 66: APITR cut with unemployment rate in the model

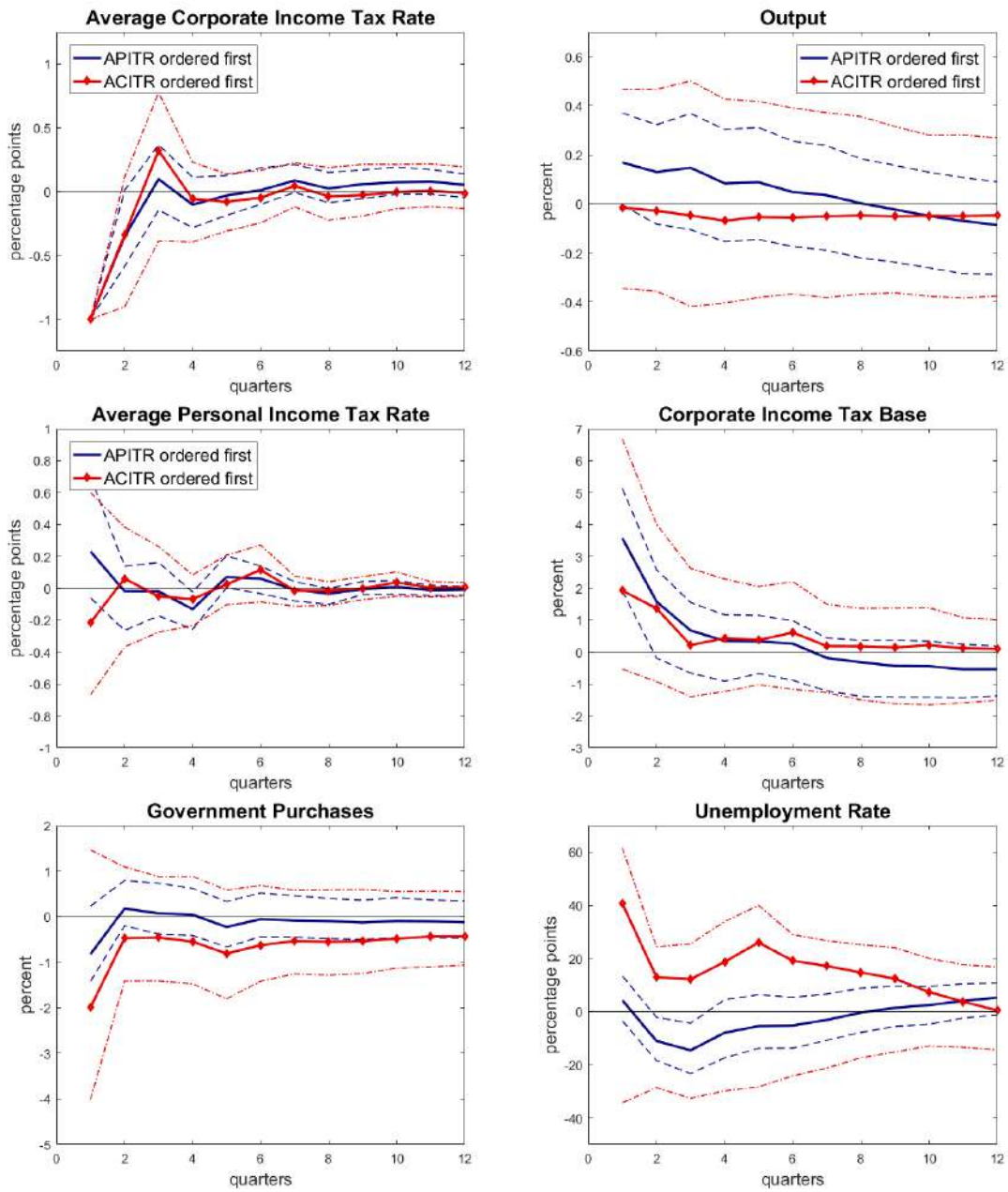


Figure 67: ACITR cut with unemployment rate in the model

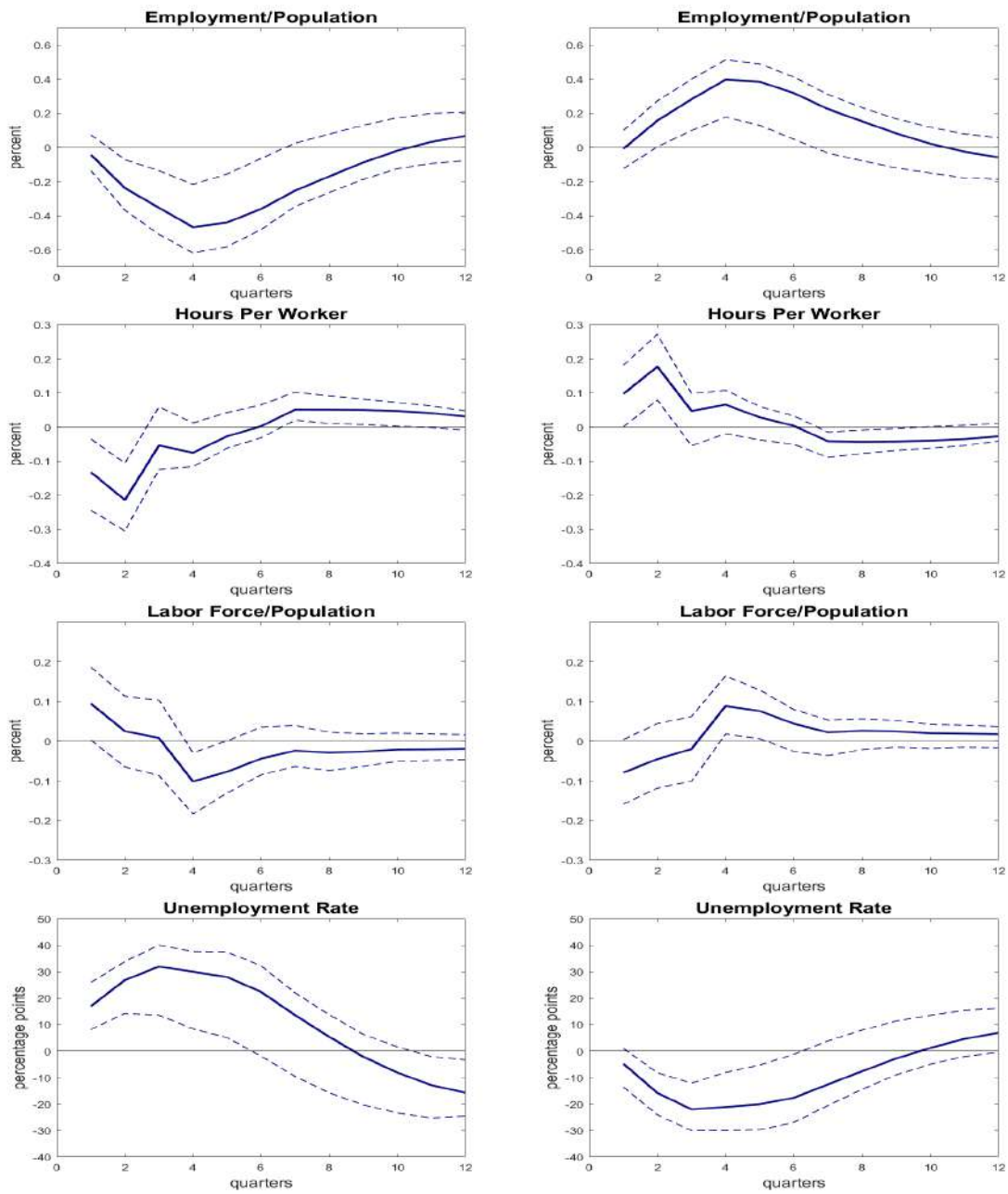


Figure 68: Labor market responses to tax cuts. Left panel: APITR cut, right panel: ACITR cut

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