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International spillover effects of U.S. tax reforms: Evidence from Germany

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Abstract

This paper explores the international transmission of U.S. tax shocks and provides evidence for the German economy. Using structural vector autoregressions, we find that after a U.S. tax cut, German GDP increases moderately. While higher U.S. demand stimulates German exports, a deterioration of price competitiveness lowers this positive growth impulse. The current account increases significantly. Surprisingly, German prices fall as domestic companies reduce unit labor costs. The resulting increase of the real interest rate dampens domestic demand. German tax policy shows an opposite reaction to U.S. tax policy. The latter result, however, is driven by the decade of the 1970s. We find that significant changes in the transmission channels arise by distinguishing between different types of U.S. tax reforms. In particular, in contrast to U.S. personal income tax reforms, changes in the corporate income tax cause a depreciation of the German real effective exchange rate.

JEL Codes: H20; E32; E62; F44

Keywords: Fiscal policy; tax policy; international spillovers; structural vector autoregressions

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1 Introduction

The Tax Cuts and Jobs Act (TCJA) in the United States (U.S.) not only led to discussions about its expansionary impact on the U.S. economy, but also about macroeconomic repercussions for the rest of the world.[1] Improving the understanding of the international transmission of U.S. fiscal policy is of particular interest, as it has presumably consequences for policy-making in other countries. Furthermore, elaborating specific transmission channels of spillover effects, contributes to studies in international macroeconomics as challenges remain regarding the choice of correct modeling and parameter assumptions (Enders et al., 2011). Moreover, tax authorities in other countries may decide to use own tax instruments, either to stabilize their economy in the wake of higher external demand or to improve their medium-term international competitiveness by cutting tax rates. Whether they have systematically reacted to U.S. tax changes in the past seems therefore of interest.

This paper provides a detailed analysis of the impact of past U.S. tax reforms on the German economy to shed light on potential spillover effects of the TCJA. For Germany, the effects of the recent U.S. tax reform are of interest because of its close trade ties and economic relations with the U.S. To this end, we first consider the general impact of U.S. tax reforms on German macroeconomic variables. In a second step, we study differences in spillover effects stemming from U.S. personal income tax (PIT) and corporate income tax (CIT) changes.

Our study further exploits historical experiences with regard to German tax legislation. The detailed analysis of the interplay between tax reforms in both countries is possible as we can draw on a historical account of legislated tax changes in Germany. It was set up by Hayo and Uhl (2014) and includes information on tax changes from official government documents. In contrast to alternative indicators for tax reforms that are based on tax revenue, we can examine different steps of the legislative process: from the draft of the tax bill to the actual implementation. Additionally, only discretionary decisions of policymakers are considered. Automatic stabilizers do not affect the validity of this indicator.

Studies regarding the spillover effects of U.S. tax shocks are quite scarce. So far, more research has been conducted considering the spillover effects of government spending shocks. Using a panel of OECD countries Auerbach and Gorodnichenko (2013) find sizable positive

[1] Using direct regressions and SVAR models, Mertens (2018) finds that the TCJA increases GDP growth in the U.S. by 1.2 and 0.4 percentage points in 2018 and 2019, on average. Other empirical approaches deliver similar results. Barro and Furman (2018) estimate GDP per capita to increase by 0.9% in the long run. Additionally, they provide a summary of further estimates. Lieberknecht and Wieland (2018) use a DSGE model and model explicitly the phasing out of some measures as well as the full expense of investments in the first years after the reform. They find a significantly higher short-term impact on GDP growth in the U.S. and an expansionary effect on euro area production.

government spending effects on foreign output.[2] They state that their evidence suggests that international fiscal policy coordination could be advantageous. Faccini et al. (2016) find that U.S. government spending shocks have sizable spillover effects. The transmission rather runs via a lower real interest rate channel in foreign countries than via an improved domestic trade balance. Fiscal spillovers within the euro area have been studied by, e.g., Beetsma et al. (2006) or Cwik and Wieland (2011), with different policy conclusions.

Regarding spillover effects originating from U.S. tax shocks, we are only aware of the study by Natoli and Metelli (2018). They use a global VAR framework and identify U.S. tax shocks by using the narrative method introduced by Mertens and Ravn (2013). While they also find positive spillover effects after U.S. tax cuts, especially their results regarding the price responses differ from our findings which might be the result of different model specification assumptions.

There is a large strand of literature on the theory of sequential interactions in tax competition, especially with respect to corporate taxation, see Keen and Konrad (2013) for a summary. However, the empirical identification of such interactions is challenging. The empirical evidence is, therefore, inconclusive, see Overesch and Rincke (2011) and Chirinko and Wilson (2017), among others.

We study the spillover effects of U.S. tax reforms on the German economy by using structural vector autoregressions (SVARs). These models allow us to separate unanticipated exogenous changes from endogenous movements in U.S. tax policy. Our empirical framework builds upon standard approaches of the U.S. tax multiplier literature.[3] In a first step, we analyze the effects of general U.S. tax reforms. To do so, we rely on estimates for the output elasticity of tax revenue determined by Mertens and Ravn (2014). To study the effects on the German economy, we add one German variable at a time to the otherwise identical VAR model of Mertens and Ravn (2014). In a second step, we exploit the consequences of U.S. tax

[2]Theory suggests that spillovers depend on the fiscal instrument involved, as well as the cyclical conditions and the monetary and exchange rate policy in both shock-emitting and shock-receiving economies. Blagrave et al. (2017) discuss the implications of macroeconomic and policy conditions in the transmission of fiscal spillovers.

[3]Ramey (2016) provides a comprehensive overview of the U.S. tax multiplier literature. In a nutshell, there exist two prominent methods: first, a number of studies relies on SVARs imposing short-run or sign restrictions, see, e.g., Blanchard and Perotti (2002) and Mountford and Uhlig (2009). The size of the tax multipliers varies considerably across these studies ranging from close to zero to very large. Second, Romer and Romer (2010) introduce the narrative method to identify the effects of tax reforms. They collect legislative tax changes and separate them into endogenous and exogenous tax changes based on the motivation stated by policy-makers (R&R series). They provide estimates for the tax multiplier of 2.5 to 3 after three years. Favero and Giavazzi (2012) embed the R&R series as an exogenous variable in a VAR model and find a quite low tax multiplier. In recent contributions, Mertens and Ravn (2013) and Mertens and Ravn (2014) combine both approaches with the "proxy SVAR". They obtain a high tax multiplier of 3 after 6 quarters.

reforms in more detail by distinguishing between personal income and corporate income tax changes. For that purpose, we use a modified variant of the model put forward by Mertens and Ravn (2013).

Using these models, we find that after general U.S. tax reforms characterized by tax cuts, German GDP increases only moderately. Moreover, we find that the German current account balance improves significantly, the international price competitiveness deteriorates (equivalent to an appreciation of the German real effective exchange rate), unit labor costs and prices fall. The reaction of the real effective exchange rate corroborates previous findings suggesting that the U.S. currency weakens after a positive fiscal stimulus.[4] For Germany, however, the deterioration of international price competitiveness vanishes by considering an estimation sample starting in the year 1980. To recap, German net exports provide a significant growth impulse for GDP and German prices fall.

In contrast to net exports, German domestic demand shows little reaction. In our view, this result could be due to the reaction of prices. After an expansionary U.S. tax reform, the German real interest rate increases due to a falling inflation rate. While the nominal interest rate barely reacts, we find that German consumer prices fall. This result is quite interesting as it contradicts the general impression that German prices should rise after an expansionary U.S. fiscal impulse.[5] Falling import prices and the significant reduction in unit labor costs can explain the slowdown in inflation rates. The dampened development of German labor costs might be the reaction of German companies with regard to the loss in German price competitiveness after the depreciation of the U.S. dollar. Our results suggest that German tax policy shows an opposite reaction after a U.S. tax reforms. Put differently, after U.S. tax cuts, German taxes increase significantly. This result, however, is driven by the decade of the 1970s.

After distinguishing between U.S. personal income and corporate income tax reforms, we find significant differences regarding the German reactions of the real effective exchange rate, domestic demand, and the current account. In general, the results for cuts in the average personal income tax rate are very similar to those estimated for general U.S. tax reforms.

The results significantly change after considering only cuts in the average corporate income tax rate. For this tax category, we find that the U.S. dollar appreciates and the German real effective exchange rate depreciates. Thus, the expansionary effects for German exports stemming from U.S. and world demand are strengthened by international price movements. In contrast, the depreciation of the German currency puts a drag on the development of

[4]See, e.g., Monacelli and Perotti (2010); Ravn et al. (2012); Enders et al. (2011), who find that after U.S. government spending shocks, the U.S. real exchange rate depreciates.

[5]For instance, the Bundesbank (2018), by running simulations determined with the NiGEM macroeconomic model, states that the recent U.S. tax reform delivers slightly negative effects on output for the euro area. The main reasons are that higher inflation and interest rates slow down production.

imports and domestic demand. The depreciation of the U.S. dollar could stem from the fact that international investors appreciate the increased investment incentives in the U.S. and, thus, need U.S. dollars to finance their new investment projects. All in all, the German current account balance improves much more after a cut in U.S. corporate taxes, compared to a reduction in personal income taxes of the same size.

Despite the depreciation of the German real exchange rate, we find that, in case of a cut in U.S. corporate taxes, the reduction in German consumer prices is stronger. This deflationary pressure is entirely due to a strong reduction in unit labor costs. In our opinion, German firms observe the improvement in U.S. business conditions and try to improve their competitiveness, either by putting more effort into enhancing productivity and/or by being reluctant with wages increases. The stronger reaction of German prices induces a higher real interest rate that, in turn, dampens private consumption and investment.

Regarding German tax policy, we find significant increases in German taxes after U.S. authorities decide to cut personal income and corporate income tax rates. However, this effect disappears when restricting the estimation sample by setting the starting date to the first quarter of 1980. The consideration of improving conditions in international tax competition by reducing taxes as a reaction to U.S. tax reforms seems to be minor over the whole estimation sample.

The paper is structured as follows. Section 2 describes our measure for legislated tax changes in Germany. In particular, we analyze the joint dynamics of the tax ratio and actual tax reforms. In Section 3, we outline our empirical framework. In Section 4, we present the main results for the spillover effects of general U.S. tax reforms as well as of personal income tax and corporate income tax reforms. We provide a number of robustness checks in Section 5. Section 6 concludes.

2 Description of German tax measures

2.1 Measuring tax policy changes

Evaluating changes in tax policy is far from easy as tax reforms are rarely limited to changes of statutory rates. Often they are quite complex and modify the tax base. Therefore, macroeconomic models most commonly rely on effective tax rates, e.g., following the methodologies by Mendoza et al. (1994) or Devereux and Griffith (1998). These approaches use data on actual tax revenue and relate them to data from the national accounts in order to approximate the tax base. Advantages are that effective tax rates are easy to calculate and cross-country comparisons are easier. However, they have the disadvantages that reforms have an delayed effect on revenue, announcement effects are hard to capture, and changes in effective tax

rates can also have other reasons. An alternative approach has been introduced by Romer and Romer (2010) (R&R) who use information from the legislative process.

To study German tax policy, we use the latter approach and extend the historical account of legislated tax changes which was set up by Hayo and Uhl (2014). This dataset includes information on tax changes from official government documents such as the *Finanzbericht*, the annual budgetary report of the Federal Ministry of Finance, and the draft bills. The revenue impact and the timing were extracted for a time-span from the first quarter of 1970 to the second quarter of 2010. We append all tax reforms which had been introduced in parliament between 2010 and 2017; see Appendix B for the supplemented reforms.[6]

For our quarterly time series of tax changes, we divide the expected revenue impact of the law on an annual basis after full implementation by nominal GDP as measured in the quarter during which the law was published. In case of temporary tax changes, we neutralize the initial tax change at the expiration date (phase-out). One-time revenue effects are directly compensated by an amount in the opposite direction in the following quarter. In the spirit of R&R, Hayo and Uhl (2014) use the narrative account of tax changes to construct an indicator for exogenous tax changes in Germany. This allows them to study the macroeconomic effects of these changes. In contrast to this, we analyze the spillover effects of U.S. tax laws on the German legislation. Therefore, we do not have to discriminate between exogenous or endogenous tax changes.

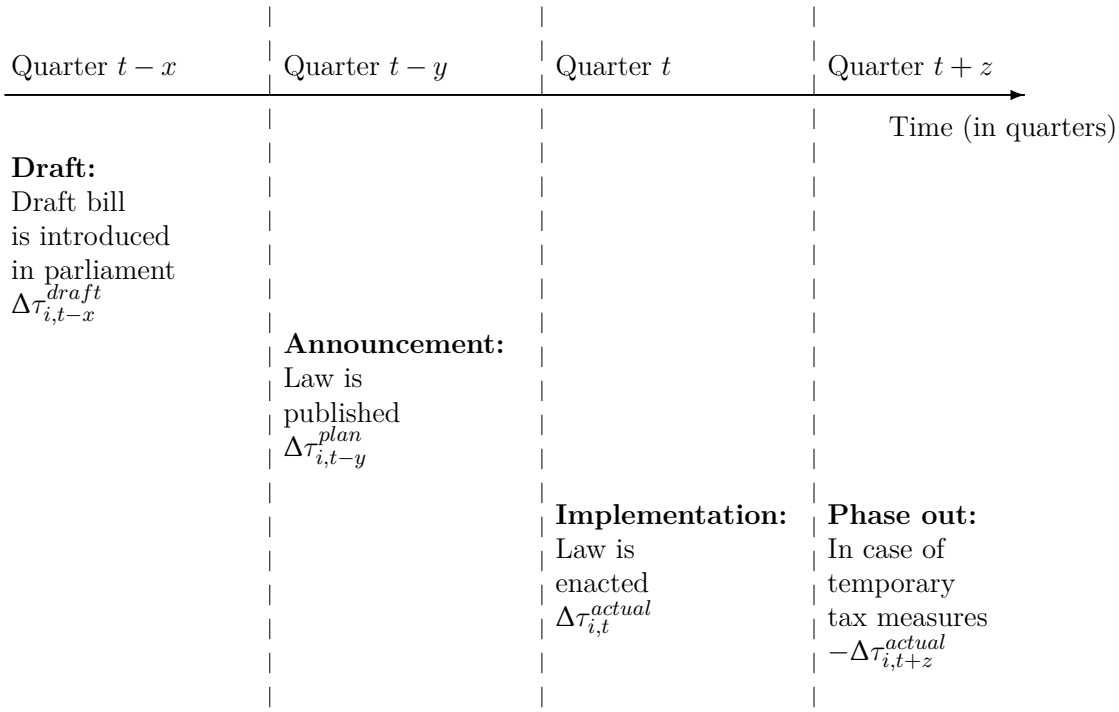
In comparison to conventional measures for tax changes such as changes of effective tax rates, the narrative approach allows us to consider the timing of the legislative process. There are three important dates that frame the legislative process: (i) the date of the draft bill (*draft*), (ii) the announcement date of the law (*announcement*), and (iii) the implementation date (*implementation*), see Figure 1. We include the respective dates as well as the tax revenue estimates at this time in our dataset. Please note that the revenue estimates of the draft bill could differ significantly from the tax measure ultimately put in place.

The legislative process starts with the introduction of a draft bill in parliament (draft date). The draft bill already includes a (first) forecast of the revenue effects as well as a justification for the intended changes. If several discussions in the lower chamber (*Bundestag*), parliamentary committees, and the higher chamber (*Bundesrat*) are successful, the law is eventually signed by the head of state and forwarded for publication (announcement date).[7] This publication comprises the date when the law becomes active (implementation date). A law typically includes several tax measures for which the implementation date can vary.

[6] A difference with regard to the U.S. is that the social insurance system is not part of the federal budget. Therefore, changes in social security contributions are not covered by this analysis.

[7] See Uhl (2013) for more details.

Figure 1: Timing of the legislative procedure in Germany



Notes: Measures are assigned to the quarter in which they are introduced/published/enacted if this happened before the middle of that quarter and to the next quarter otherwise.

To sum up, analyzing the official documents enables us to construct three time series which summarize the historical tax changes. Typically, a certain tax law consists of a multitude of distinct tax measures $\Delta\tau_{i,t}$. Our final time series at period t are therefore computed as follows:

$$\Delta\tau^{j}_{t} = \sum_{i=1}^{N^{j}_{t}} \Delta\tau^{j}_{i,t}, \tag{1}$$

where j defines the corresponding timing in the legislative process (draft, announcement, or implementation) and N^{j}_{t} the number of tax measures at period t.

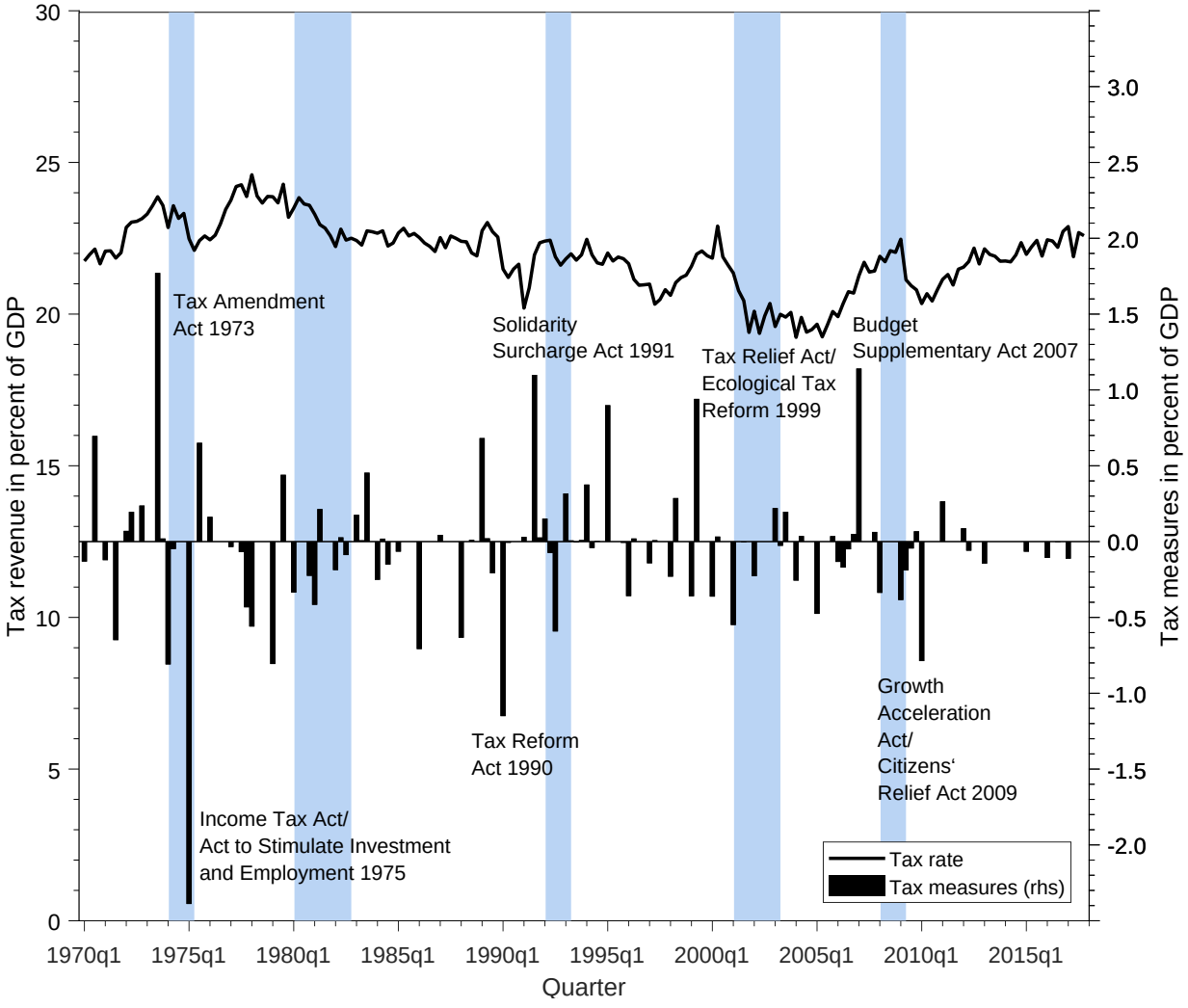
2.2 Time Series Properties

Figure 2 summarizes the time series of implemented legislated tax measures and compares it to the development of the tax ratio. In addition, shaded regions depict recessions as dated by the German Council of Economic Experts (2017). In recessions, the tax measures implemented by the German government are expansionary on average. After regressing the

quarterly series of the tax measures on a constant and a recession dummy, we obtain a highly significant recession dummy with the coefficient of -0.15 percent of nominal GDP.

For the tax ratio, the recession dummy is not significant. Nonetheless German tax revenue is sensitive with respect to the business cycle. Regressing the tax ratio on the cyclical component of German GDP, determined with the Hodrick-Prescott filter, yields a significant coefficient. It becomes even larger when we include time trends to control for long-term movements in the tax ratio.

Figure 2: Tax ratio and realized tax measures



Notes: This figure presents tax revenue in percent of nominal GDP (tax ratio) on the left scale. The right scale shows the legislated tax measures in percent of nominal GDP. Measures are assigned to the quarter in which they are enacted if implemented before the middle of that quarter and to the next quarter otherwise. We use seasonally and working day adjusted figures on GDP on West Germany until 1990-Q4, and on unified Germany thereafter. Shaded regions denote recessions as dated by the German Council of Economic Experts (GCEE): 1974q1-1975q2, 1980q1-1982q4, 1992q1-1993q2, 2001q1-2003q2, and 2008q1-2009q2.

The largest individual tax reforms by revenue impact were implemented in the 1970s. However, they also almost compensated each other. While the intention of the *Tax Amendment Act 1973* was to cool down the economy, the measures implemented in 1975 included a temporary investment surcharge to stimulate the business cycle. This reflects that in the 1970s the political motive of stabilizing the economy by implementing countercyclical policy measures was much more prevalent in Germany than today.

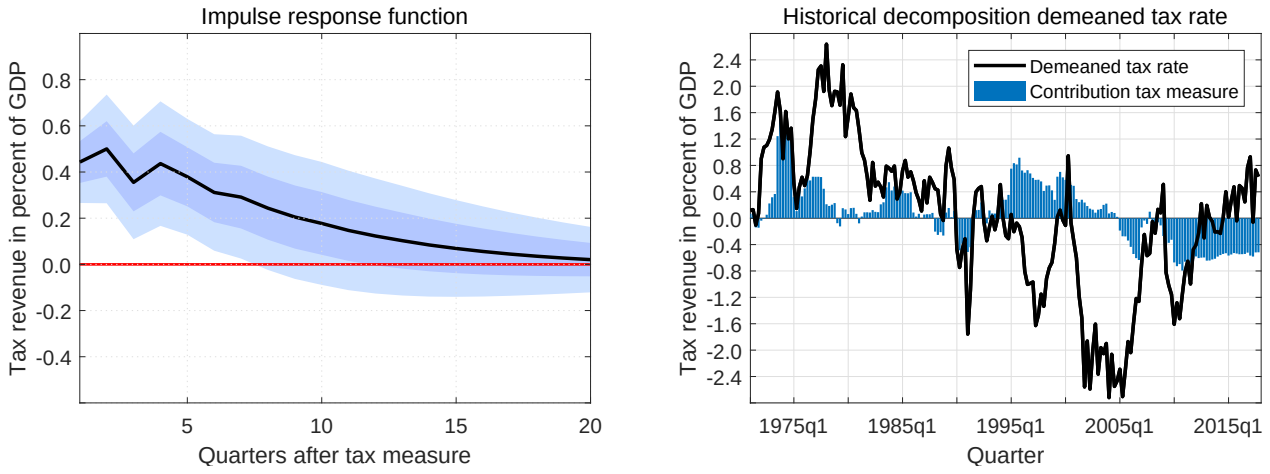
In addition, the measures implemented in 1975 contained structural reforms of the personal income tax. Such modifications of the income tax schedule are very frequent due to the progressive nature of the schedule and inflation (bracket creep). Also the large reform package in 1990 reshaped the income tax schedule and, additionally, lowered the corporate income tax rate. As a consequence of the German reunification a solidarity surcharge on income and corporate tax liabilities was introduced in 1991, and extended later in 1995.

Several measures were implemented in 1999. On the one hand, the *Tax Relief Act* included a corporate tax reform and further reformed the income tax schedule. On the other hand, an ecological tax reform increased taxes on energy consumption. The *Budget Supplementary Act 2006* was intended to support the consolidation of the government budget. Most notably, it raised the value-added tax rate from 16 to 19 percent from 2007 onwards. The reforms in 2009 increased the allowances for contributions to health and long-term care insurance and again reformed the income tax schedule and the corporate tax code. After 2010, the revenue impact of the implemented tax measures was small. Nevertheless, we observe an increasing tax rate.

Figure 3 elaborates on this observation by analyzing the relation between the legislated tax changes and tax revenue. The impulse response function in the left panel shows a statistically significant positive reaction. However, tax revenue increases less than the underlying tax change. Following the implementation of a tax measure with an estimated revenue impact of one percent of GDP, the tax ratio increases by about 0.4 percentage points on impact. This observations could be due to measurement error as the quantitative impact is estimated in advance. Another plausible explanation is that macroeconomic responses dampen the expected revenue impact. Over time, the tax ratio declines and rebounds back to its pre-reform path after the 20 quarters. One reason for this rebound is that over time opposite tax measures are implemented.

The historical decomposition in the right panel highlights the contrast between the legislated tax measures and the development of the tax ratio. At the beginning of our sample in the 1970s and 1980s, tax reforms could explain the change of the tax ratio to a larger extent. At the end of the 1990s, it even pointed in the opposite direction. This is also the case at the end of our sample, where the increase of the tax ratio is not driven by tax reforms. One

Figure 3: The effects of German legislative tax changes on the tax ratio



Notes: This figure shows the results of a bivariate SVAR model. The model contains a measure defining the accumulated legislative tax changes in percent of GDP and the German tax revenue in percent of GDP (tax ratio). We use a Cholesky decomposition to identify exogenous changes originating from the legislative tax measures (ordered first). Both SVAR models include four lags. The estimation sample ranges from 1970q1 to 2017q4. The left panel shows the impulse response function of the German tax rate to a one-percentage point increase in the accumulated tax measure. Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004). The right panel displays the cumulative effects of the legislative tax changes on the tax rate. Data is described in Appendix B.

explanation is again the occurrence of bracket creep. Since 2010 the income tax schedule has only been adjusted partially to compensate for rising tax liabilities due to inflation.

3 Empirical model

We use structural vector autoregressions (SVARs) to determine the macroeconomic effects of U.S. tax reforms. These models allow us to separate autonomous changes in U.S. tax policy from endogenous movements in U.S. tax revenue, e.g., caused by business cycle fluctuations. These policy decisions could be made due to ideological reasons, the desire to keep the budget deficit under control or to foster long-run GDP growth. In this section, we introduce two recent approaches of the U.S. tax multiplier literature. First, we use smaller SVAR models to study the impact of general tax reforms. In a second step, we extend this framework and differentiate between personal and corporate income tax changes.

3.1 Model for general U.S. tax reforms

To study the macroeconomic effects of U.S. tax policy in general, we rely to a great extent on the framework proposed by Mertens and Ravn (2014) and Blanchard and Perotti (2002). Specifically, we use the same set of U.S. variables. In contrast to Mertens and Ravn (2014), we do not apply the "proxy SVAR" approach, that integrates narrative identification in the standard SVAR framework, since their used narrative time series of legislative tax changes ends in the year 2006. We instead rely on short run restrictions as we wish to use all information until the year 2017.[8]

Mertens and Ravn (2014) and Blanchard and Perotti (2002) estimate their SVAR model with the variables total tax revenue, T_t, government spending, G_t, and GDP, Y_t. All variables are seasonally adjusted and expressed in log real per capita terms.[9] The three variables are summarized in the vector Z_t. The reduced form VAR model takes then the form:

$$Z_t = \alpha' d_t + A(L) Z_{t-1} + u_t, \tag{2}$$

where $A(L)$ denotes a lag polynomial and d_t defines all deterministic trends with coefficients α. In our analysis, d_t includes a constant, a linear trend, a quadratic trend and a dummy for the second quarter of the year 1975. We include four lags to allow for delayed effects of up to one year.

To estimate the effects of unanticipated U.S. tax shocks on the German economy, we follow the approach outlined by Kilian and Park (2009) and add one German variable, X_t, at a time to the U.S. model (2). We assume, however, that the German variable does not affect the U.S. variables (subset VAR specification). This specification guarantees that the dynamics across U.S. variables do not change when we analyze different German variables.[10] Our extended reduced form VAR model looks as follows:

$$\begin{pmatrix} Z_t \\ X_t \end{pmatrix} = \tilde{\alpha}' d_t + \tilde{A}(L) \begin{pmatrix} Z_{t-1} \\ X_{t-1} \end{pmatrix} + \underbrace{\tilde{u}_t}_{A^{-1} B \epsilon_t}, \tag{3}$$

where $\tilde{u}_t$ defines the reduced form residuals and ϵ_t the structural shocks. By assumption the elements of ϵ_t are normally distributed with $E[\epsilon_t] = 0$ and $E[\epsilon_t \epsilon_t'] = I$. We estimate the VAR

[8] The structural tax shocks of our baseline SVAR have a correlation coefficient of 0.97 with the tax shock series determined with the "proxy SVAR" of Mertens and Ravn (2014). The considered time period ranges from the first quarter 1971 to the fourth quarter 2006.

[9] All fiscal data are at the level of the federal level. Government spending includes government consumption and investment. Tax revenue contains federal current tax receipts and contributions for government social insurance minus corporate income taxes from Federal Reserve Banks. A more detailed description of the data is provided in Appendix A.

[10] Our baseline results do not change by relaxing that assumption.

model (3) by seemingly unrelated regressions (SUR) using quarterly data over the period from the first quarter 1970 to the fourth quarter 2017. The availability of the German data determines the starting date of our sample.

To identify ϵ_t, we need to determine the contemporaneous impact matrices A and B. To do so, we use the information contained in the covariance matrix of $\tilde{u}_t$ and impose several short-run restrictions on A and B. First, we assume that shocks that can be assigned to German developments, ϵ_t^X, have no contemporaneous impact on U.S. variables. Second, we adapt the assumptions of Blanchard and Perotti (2002) and impose the restriction that government spending does not react to U.S. output fluctuations, ϵ_t^Y, and U.S. tax changes, ϵ_t^T, due to decision and recognition lags in fiscal policy. Our final identification assumption regards the output elasticity of tax revenue denoted by θ. Here we impose an outside elasticity. The identification assumptions to determine the structural shocks from reduced-form residuals can be summarized as follows:

$$\underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 \\ A_{21} & 1 & -\theta & 0 \\ A_{31} & A_{32} & 1 & 0 \\ A_{41} & A_{42} & A_{43} & 1 \end{bmatrix}}_{A} \underbrace{\begin{pmatrix} \tilde{u}_t^G \\ \tilde{u}_t^T \\ \tilde{u}_t^Y \\ \tilde{u}_t^X \end{pmatrix}}_{\tilde{u}_t} = \underbrace{\begin{bmatrix} \sigma_G & 0 & 0 & 0 \\ 0 & \sigma_T & 0 & 0 \\ 0 & 0 & \sigma_Y & 0 \\ 0 & 0 & 0 & \sigma_X \end{bmatrix}}_{B} \underbrace{\begin{pmatrix} \epsilon_t^G \\ \epsilon_t^T \\ \epsilon_t^Y \\ \epsilon_t^X \end{pmatrix}}_{\epsilon_t}. \tag{4}$$

Caldara and Kamps (2017) and Mertens and Ravn (2014) show that the cyclical elasticity of taxes plays a crucial role for the size of the U.S. tax multiplier. Specifically, the higher θ, the higher the effects of U.S. tax policy on U.S. output. In our baseline calculations, we use the estimate delivered by Mertens and Ravn (2014). According to their results, tax revenue increases by 3.13 percent when output rises by one percent. In the literature on U.S. tax multipliers, this value is at the higher end of the range. With 2.08 Blanchard and Perotti (2002) obtain a significantly lower value of θ. Finally, Caldara and Kamps (2017) deliver an estimate of 2.43 using non-policy instruments in a "proxy SVAR" framework. In Section 4.1 we show how our results depend on the choice of θ.

3.2 Model for U.S. personal and corporate income tax changes

We analyze the effects of U.S. tax reforms in more detail by distinguishing between two types of taxes. Mertens and Ravn (2013) use a "proxy SVAR" framework to study the macroeconomic effects of personal income and corporate income tax shocks on the U.S. economy. To do so, they basically split total tax revenue into four components, namely the average tax rates for personal and corporate income, $APITR_t$ and $ACITR_t$ and the personal

and corporate income tax bases, B_t^{PI} and B_t^{CI}. The latter two variables are expressed in real per capita terms.

$APITR_t$ is determined as the sum of personal current taxes and contributions for government social insurance divided by personal taxable income, B_t^{PI}. $ACITR_t$ corresponds to taxes on corporate profits in relation to corporate profits, B_t^{CI}. The final tax shocks are those unexpected changes in $APITR_t$ and $ACITR_t$ which have the highest correlation with the instrument series. As instruments Mertens and Ravn (2013) use personal income tax and corporate income tax reform from the narrative series of Romer and Romer (2010). These narrative instruments do not contain pre-announced tax reforms and are available for the years 1950 to 2006.

In order to be as close as possible to the SVAR framework regarding general tax reforms, introduced in the previous section, we make two adjustments to the VAR specification by Mertens and Ravn (2013). First, we do not include federal government debt in our analysis. And second, our VAR model contains a linear trend, a quadratic trend and a dummy for the second quarter of the year 1975.[11]

The vector Z_t contains six variables: $APITR_t$, $ACITR_t$, the logarithms of B_t^{PI} and B_t^{CI}, G_t and Y_t. Otherwise, the specification and sample length of this reduced form VAR model is the same as described in model (3).

To identify the impulse response functions with respect to the two structural tax shocks ϵ_t^{APITR} and ϵ_t^{ACITR}, we again face the problem of our shorter estimation sample which, in addition, proceeds until the end of 2017. To address this issue, we again rely on short-run restrictions. Specifically, given our estimated reduced form VAR, we are interested in the contemporaneous impact coefficients of the macroeconomic variables with respect to the two tax shocks. In our baseline calculations, we rely on the impact coefficients provided by the modified "proxy SVAR" of Mertens and Ravn (2013).

In detail, we use our VAR-specification and our choice of U.S. variables, Z_t, to estimate a "proxy SVAR" which otherwise is in line with Mertens and Ravn (2013).[12] The sample period is 1950 to 2006. This SVAR model delivers the impact coefficients in two impulse vectors. These vectors include the initial responses for all variables in Z_t with respect to the two tax shocks. The impact coefficients for the German variable are then estimated with this information set via short run restrictions.[13]

[11]The structural shocks for personal and corporate income tax changes of our SVAR have correlation coefficients of 0.81 and 0.78, respectively, with the corresponding shock series delivered by the "proxy SVAR" of Mertens and Ravn (2013). The considered time period ranges from the first quarter 1971 to the fourth quarter 2006.

[12]To this end, we modify the replication files of Mertens and Ravn (2013) which are available under the link: https://www.aeaweb.org/articles?id=10.1257/aer.103.4.1212. Appendix C shows that this "proxy SVAR" essentially yields the same results as provided by Mertens and Ravn (2013).

[13]For the exact derivation of the impact coefficients, including scaling matrix and ordering of the tax

4 The spillover effects of U.S. tax reforms

In this section, we summarize the results regarding the effects of U.S. tax policy changes on the German economy. We start by presenting the outcomes of smaller SVARs to analyze the effects of changes in U.S. tax revenue in general. We proceed by analyzing the effects of U.S. tax reforms in more detail and distinguish between personal income and corporate income tax reforms. Finally, we describe how the German government adjusts its tax policy as a direct or indirect consequence of U.S. policy changes.

4.1 Effects of general tax reforms on the German economy

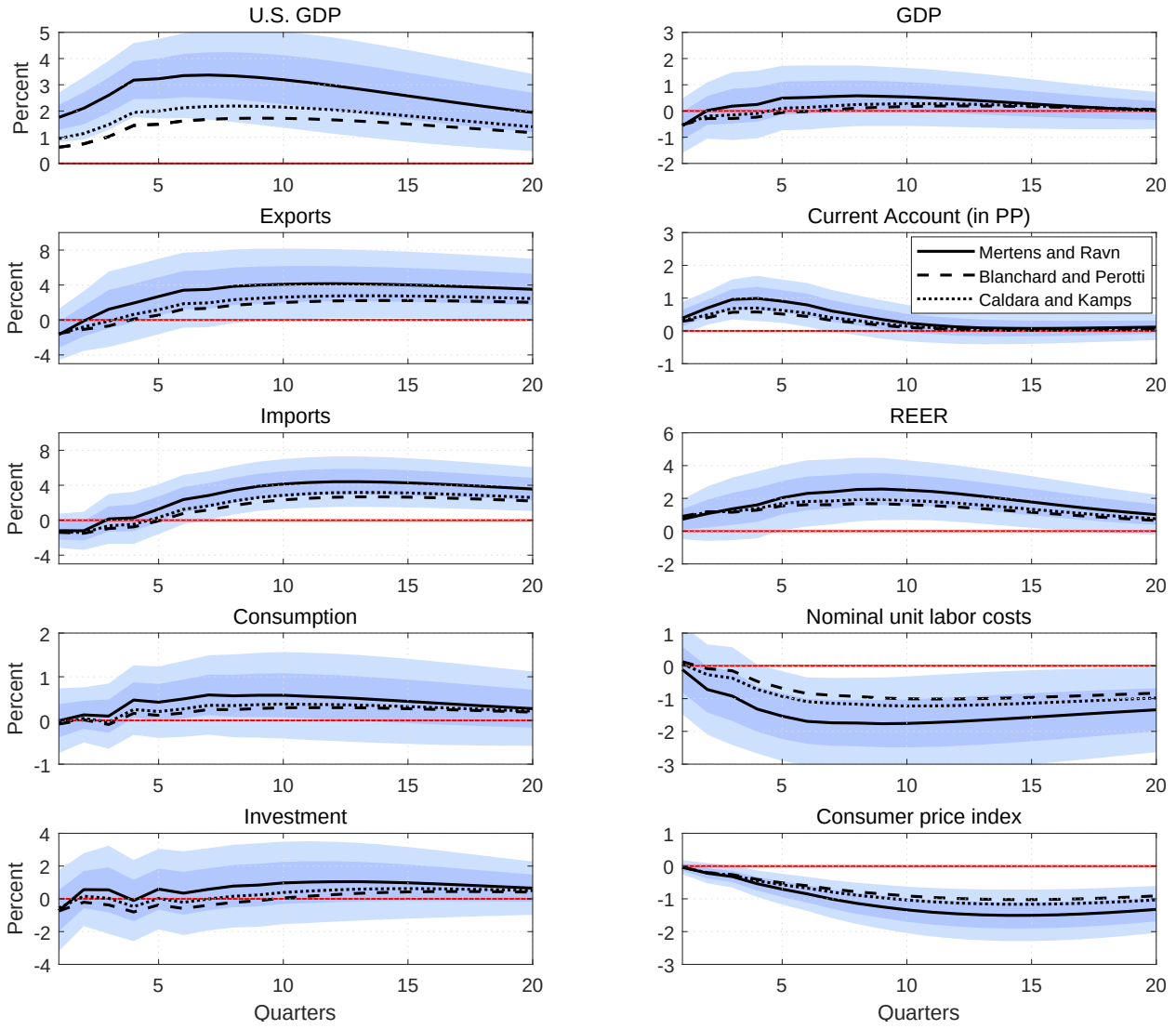
Figure 4 displays the reaction of U.S. GDP and several German macroeconomic variables after an U.S. tax cut that lowers tax revenue by one percent of GDP. To put that number into perspective, Mertens (2018) assumes that the tax cuts of the TCJA amount to an initial impulse of -1.1 percent of GDP in the first quarter 2018. Consequently, we can interpret the impulse response functions of Figure 4 as plausible outcomes of the recent U.S. tax reform.

The solid lines define our baseline results. They are based upon a cyclical elasticity of taxes of 3.13 as proposed by Mertens and Ravn (2014). Additionally, we show the impulse responses for cases in which θ is set to 2.08 (dashed lines), in line with Blanchard and Perotti (2002), and to 2.43 (dotted lines), as estimated by Caldara and Kamps (2017). As aforementioned, the size of θ plays a crucial role for the size of the U.S. tax multiplier. This is reflected in the reaction of U.S. GDP. Our results resemble the findings of Caldara and Kamps (2017), i.e. the higher θ, the higher the expansionary effect on U.S. GDP of an U.S. tax cut. In our baseline calculations, we find that after one year the level of U.S. GDP has increased by more than three percent. Afterwards, the expansionary effect disappears somewhat over time. After four years, however, U.S. GDP is still two percent higher compared to the scenario without initial tax cut. Overall, the reactions of the macroeconomic variables determined with the identification approach of Mertens and Ravn (2014) are more pronounced compared to the results with the proposed elasticities of Blanchard and Perotti (2002) and Caldara and Kamps (2017).

Our baseline results show that U.S. tax reforms affect the German economy primarily via two channels: first, the larger U.S. domestic demand stimulates German export (demand channel). Second, changes in U.S. tax policy lead to movements on the foreign exchange market (price channel). In our analysis, we find that the U.S. dollar depreciates significantly with respect to the German currency. In total, this depreciation leads to a deterioration of German price competitiveness by more than two percent, measured by the real effective

variables, the reader is referred to Mertens and Ravn (2013).

Figure 4: Effects on U.S. GDP and spillover effects on the German economy



Notes: The figure shows the responses of macroeconomic variables in percent (in percentage points in case of the current account) over 20 quarters following an exogenous U.S. tax cut corresponding to one percent of U.S. GDP. Apart from the upper left panel that depicts the response of U.S. GDP, all other panels refer to German variables. Full lines are point estimates using the cyclical elasticity of taxes delivered by Mertens and Ravn (2014). Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004). Dashed lines are point estimates using the elasticity provided by Blanchard and Perotti (2002), dotted lines refer to the Caldara and Kamps (2017) identification.

exchange rate. Furthermore, in line with this observation, we find that the German terms of trade improve and German import prices fall.

As a consequence, the reaction of German exports depends on two opposite effects. A positive demand effect stemming from the growing U.S. economy and a negative price effect

that makes German export goods more expensive. Figure 4 shows that after an initial contraction of German exports, the demand effect becomes more important over time which is consistent with the development of U.S. GDP. We see a significant positive reaction of German exports after one and a half year. The peak is reached after two years with a magnitude of four percent. This positive export development, however, seems to be the only significant driver in the reaction of German GDP. German investment and private consumption show no significant reaction. Overall, for German GDP we find a positive, but insignificant reaction.

An increase in the real interest rate could be one explanation for the weak development of German domestic demand. Surprisingly perhaps, the German price level (consumer price index) shows a significant negative reaction following a U.S. tax cut. This reaction builds up steadily and after three years the German price level is 1.5 percent lower compared to the situation without U.S. tax shock.[14] The reduction in German prices is accompanied by a decline in German import prices and a reduction in wage costs. Wage costs are measured by nominal unit labor costs. Besides changes in total wages (including social contributions and taxes) per working hour, this measure takes into account improvements in labor productivity. The decline in unit labor costs has the same size as the reduction in consumer prices. It might be the outcome of the reactions of German companies with regard to the loss in German price competitiveness.

We find that the current account increases by up to one percentage point after one year. At the beginning, this reaction is primarily driven by the improvement in the German terms of trade. Over time, the stronger reaction of German exports compared to German imports gets more important for the development of the current account. After roughly two years, the increase in imports is the same as for exports, such that the positive current account reaction vanishes.

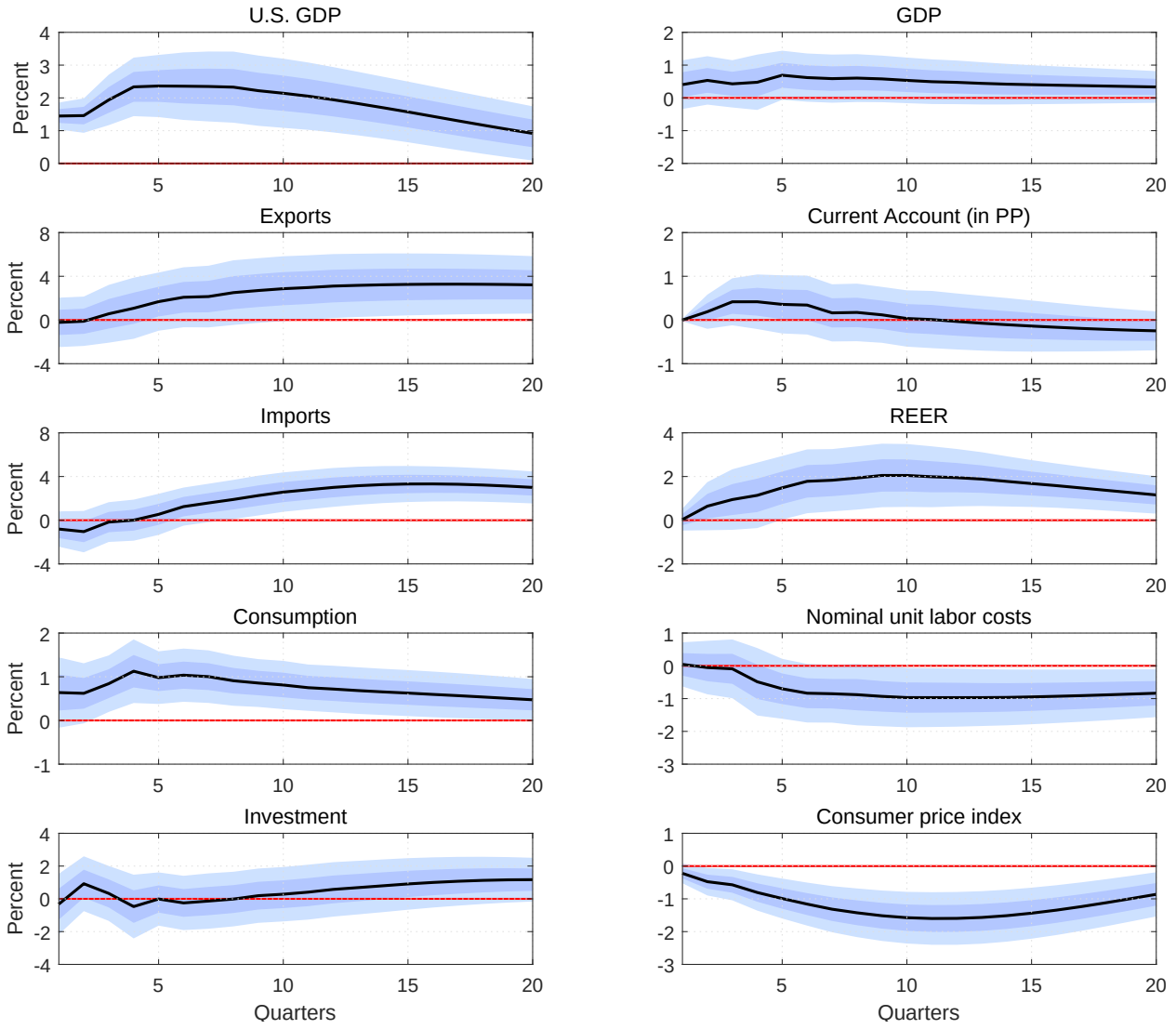
4.2 Effects of personal income and corporate income tax reforms

So far, we have seen that after general U.S. tax cuts, in Germany GDP increases modestly, the current account rises significantly, the international price competitiveness deteriorates, unit labor costs and prices fall. In the following section, we analyze whether these results change by distinguishing between U.S. personal income and corporate income tax reforms.

To simplify the comparison between the outcomes of both types of U.S. tax reforms, we rescale the corresponding tax rate cuts, $APITR_t$ and $ACITR_t$. In our baseline estimations,

[14] For short-term and long-term German interest rates, we find insignificant declines after one year. Regarding the spread between U.S. and German interest rates, however, our results show a significant increase after two years. Results are available upon request.

Figure 5: Effects of U.S. personal income tax reform



Notes: The figure shows the responses of macroeconomic variables in percent (in percentage points in case of the current account) over 20 quarters following an exogenous cut in the U.S. personal income tax rate, $APITR_t$, corresponding to one percent of U.S. GDP. Apart from the upper left panel which depicts the response of U.S. GDP, all other panels refer to German variables. Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004).

we study cuts in $APITR_t$ and $ACITR_t$ that amount to one percent of GDP without considering interactions with the U.S. economy, i.e. reactions of B_t^{PI} and B_t^{CI}. This initial impulse, therefore, does not correspond to the drop in tax revenue of one percent of GDP in the previous section. The reason is that cuts in $ACITR_t$ do not reduce total corporate tax revenue as B_t^{CI} increases strongly due to the stimulated U.S. economy. At the end, both

effects – (i) the cut in $ACITR_t$ and (ii) the increase in B_t^{CI} – almost cancel out each other. It turns out that the effects of the general tax reform of the previous sections are almost entirely driven by adjustments of the $APITR_t$.

A cut of $ACITR_t$ that amounts to one percent of GDP translates into a reduction in the average tax rate by 11.3 percentage points.[15] To put that number into perspective, according to Mertens (2018), the measures of the business tax reform of the TCJA are equivalent to a cut in $ACITR_t$ of 7.4 percentage points (0.7 percent of GDP). For $APITR_t$ we consider a cut in the tax rate of 1.25 percentage points. The corresponding number of the recent U.S. tax reform amounts to 0.8 percentage points (0.6 percent of GDP).

Figure 5 presents the results for a cut in $APITR_t$. They are very similar to those discussed for general U.S. tax reforms in the previous section. There are some differences regarding the size of the impulse responses for several variables. But please note, that the initial cut of $APITR_t$ does not take into account the following increase in B_t^{PI}.[16] Put differently, to compare our results with those of the previous section we need to increase the initial tax cut of $APITR_t$. It, therefore, seems more instructive to discuss the qualitative differences and potential changes in the significance levels of our results.

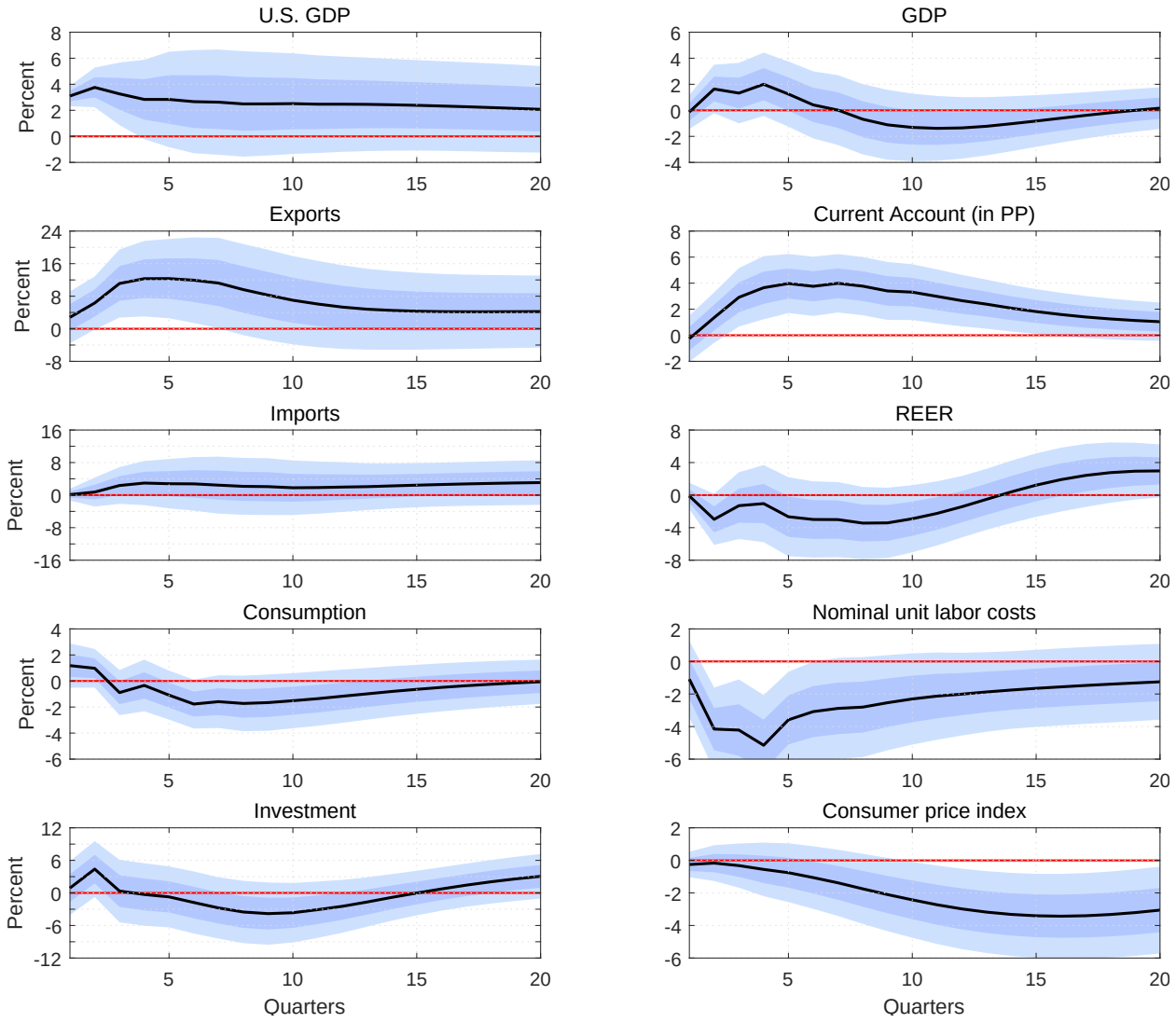
In contrast to the results of general U.S. tax reforms, for private consumption, we find a sizable positive reaction. This stronger reaction of consumption is associated with a stronger expansion of domestic demand. This contributes to two further findings: the reaction of German GDP is almost significant at a 5 percent significance level and the expansionary effect on the German current account is less pronounced. To sum up, compared to the effects of a general U.S. tax reform, we find a stronger reaction of German domestic demand, but not of investment.

Regarding German domestic demand, we obtain a completely different picture after a cut in $ACITR_t$. The dynamic reactions are summarized in Figure 6. Our results suggest that after a reduction in U.S. corporate income taxes, private consumption and investment decline in Germany. Even though these reductions are not significant at a 5 percent significance level, the qualitative nature of these impulse response looks much different compared to a cut in $APITR_t$. Additionally, we find a much stronger positive reaction of the German current account which is mainly due to an improvement in German price competitiveness. This improvement is caused by an appreciation of the U.S. dollar with respect to the Ger-

[15] To determine this number, we compute the long-term average of the ratio between nominal GDP and corporate income since 1970. Please note, that this ratio is not stable over time. It fluctuates between 8 and 16 and is strongly countercyclical. Using the ratio of the fourth quarter 2017 with 9.2 would yield an initial corporate income tax cut of 0.8 percent of GDP for the TCJA.

[16] Figure A1 in Appendix C shows that in our baseline SVAR a cut in $APITR_t$ by one percentage point leads to a contemporaneous rise of B_t^{PI} per capita of roughly 0.5 percent.

Figure 6: Effects of U.S. corporate income tax reform



Notes: The figure shows the responses of macroeconomic variables in percent (in percentage points in case of the current account) over 20 quarters following an exogenous cut in the U.S. corporate income tax rate, $ACITR_t$, corresponding to one percent of U.S. GDP. Apart from the upper left panel which depicts the response of U.S. GDP, all other panels refer to German variables. Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004).

man currency. This could be the result that international investors appreciate the increased investment incentives in the U.S. and, thus, need U.S. dollars to finance their new investment projects. As a consequence, the demand and price channel foster German exports. Furthermore, the real depreciation of the German currency strains German import demand as foreign goods are more expensive.

Our results show that after a cut in $ACITR_t$ German prices decline more strongly compared to a reduction in $APITR_t$. This deflationary pressure on German consumer prices cannot be explained by falling import prices. It is now entirely due to a strong reduction in unit labor costs. A possible explanation might be that German firms see the improvement in business conditions in the U.S. and try to improve their competitiveness by putting more efforts in increasing productivity and/or rising wages to a lesser extent. This negative price development has negative effects on private consumption and investment as German real interest rates rise.

4.3 Effects on German tax legislation

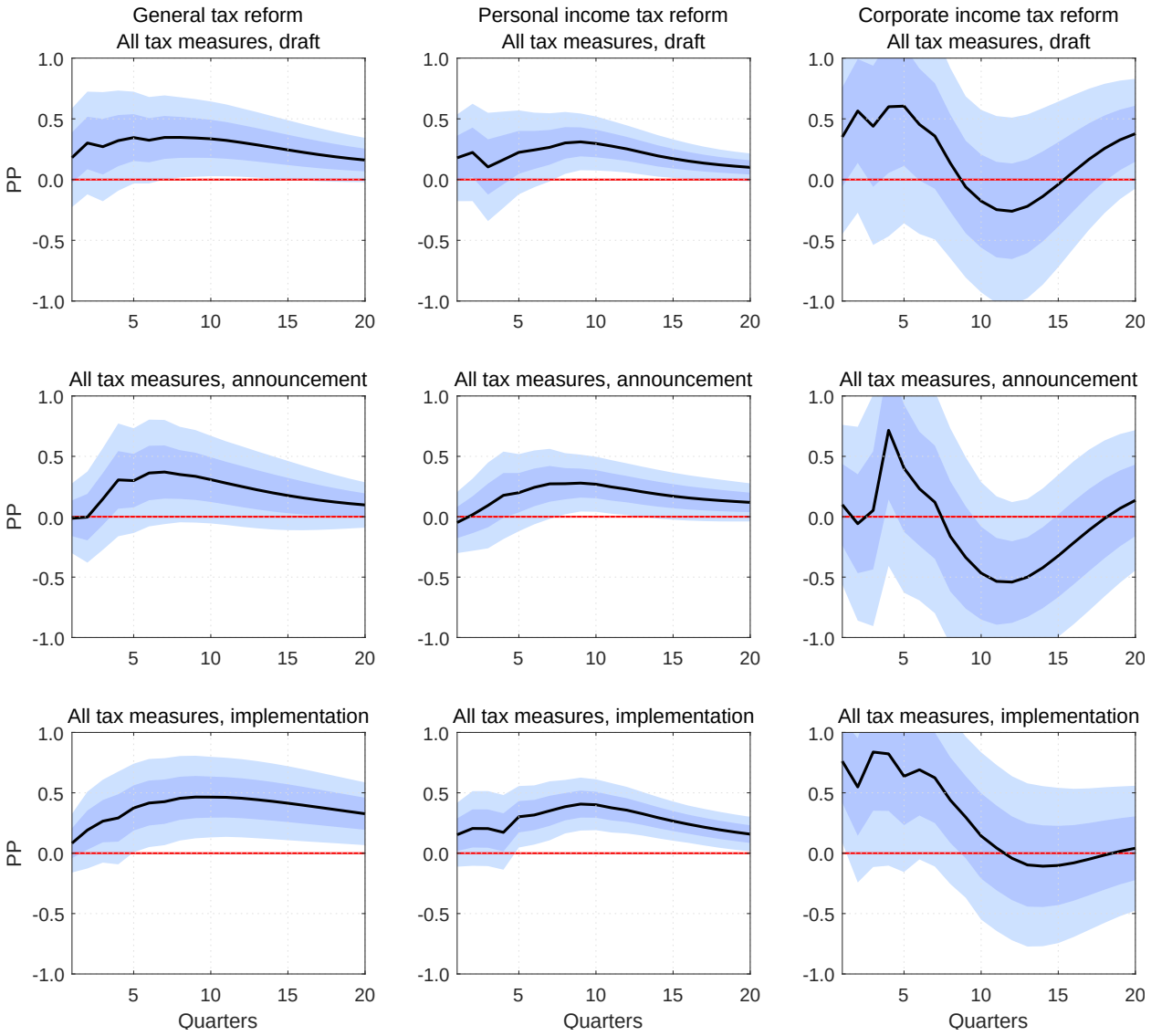
In this section, we study the interplay between U.S. and German tax reforms. For German tax legislation, we can examine three different steps of the legislative process: (i) the draft of the tax bill, (ii) the announcement and (iii) the actual implementation. Regarding the single steps, the corresponding time period and quantitative size of the single tax measure can vary to a large degree.

Figure 7 depicts the outcomes for the different proxies for tax measures. The left-hand panels depict responses of tax measures after a general U.S. tax reform, the panels in the middle show the results after a personal income tax reform, and the right-hand side after a corporate income tax reform. Regarding general U.S. tax reforms, we consider a tax cut that lowers tax revenue by one percent of GDP. For the personal income and corporate income tax reforms, we study cuts in $APITR_t$ and $ACITR_t$ that amount to one percent of GDP without considering interactions with the U.S. economy.

For all tax measures, our estimations yield a robust and uniform result for the estimation sample starting in 1970: German tax policy shows an opposite reaction after a U.S. tax reforms. Put differently, after U.S. tax cuts German taxes increase significantly. After a general U.S. tax reform with a tax cut amounting to one percent in GDP, our results suggest that German taxes are eventually lifted by 0.3 percent (0.5 percent) of GDP after one (two) years. This reaction of German tax authorities is presumably not a direct reaction to U.S. tax policy. It is more likely that it is caused by indirect business cycle related effects.

Moreover, this opposite behavior of German tax policy could be a further explanation for the moderate expansion of German GDP and domestic demand after an initial U.S. tax cut, as shown in the previous section. Regarding the size of the German tax multiplier, Hayo and Uhl (2014) find that a one percentage point increase in the German tax-to-GDP ratio causes an output reduction of 2.4 percent. Consequently, in our baseline sample, GDP growth in Germany would have been higher without this opposite German tax policy.

Figure 7: Effects of a U.S. tax reform on German tax legislation



Notes: The figure shows the responses of German tax legislation in percentage points over 20 quarters following an exogenous U.S. tax cut corresponding to one percent of U.S. GDP. The panels on the left-hand side depict effects on all tax measures after a general tax reform, the middle panels show the results after a personal income tax reform and on the right-hand side the effects with regard to a corporate income tax reform are shown. The upper, middle and lower panels provide estimates for the three time series of tax measures which correspond to different stages of the legislative process, see Section 2. Full lines are point estimates using the elasticity identified by Mertens and Ravn (2014). Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004).

5 Robustness Checks

To check the robustness of our baseline results, we perform three further analyses. First, with the first quarter of 1974, we choose a later starting date for our estimation sample. This date is also used by Hayo and Uhl (2014). They rely on Perotti (2005) who identifies a structural break around 1974 which can be explained by the end of the Bretton Woods exchange rate system.[17] Analyzing the size of fiscal multipliers for the German economy, Tenhofen et al. (2010) and Baum and Koester (2011) use similar starting dates. Second, we further restrict our estimation sample by setting the starting date to the first quarter of 1980. This is driven by the observation that the motivation to conduct countercyclical fiscal policy in Germany was considerably stronger during the 1970s than afterwards. Third, we allow the vector of German variables, X_t, to include more variables. So far, in our baseline calculations, we have analyzed only one German variable at a time.

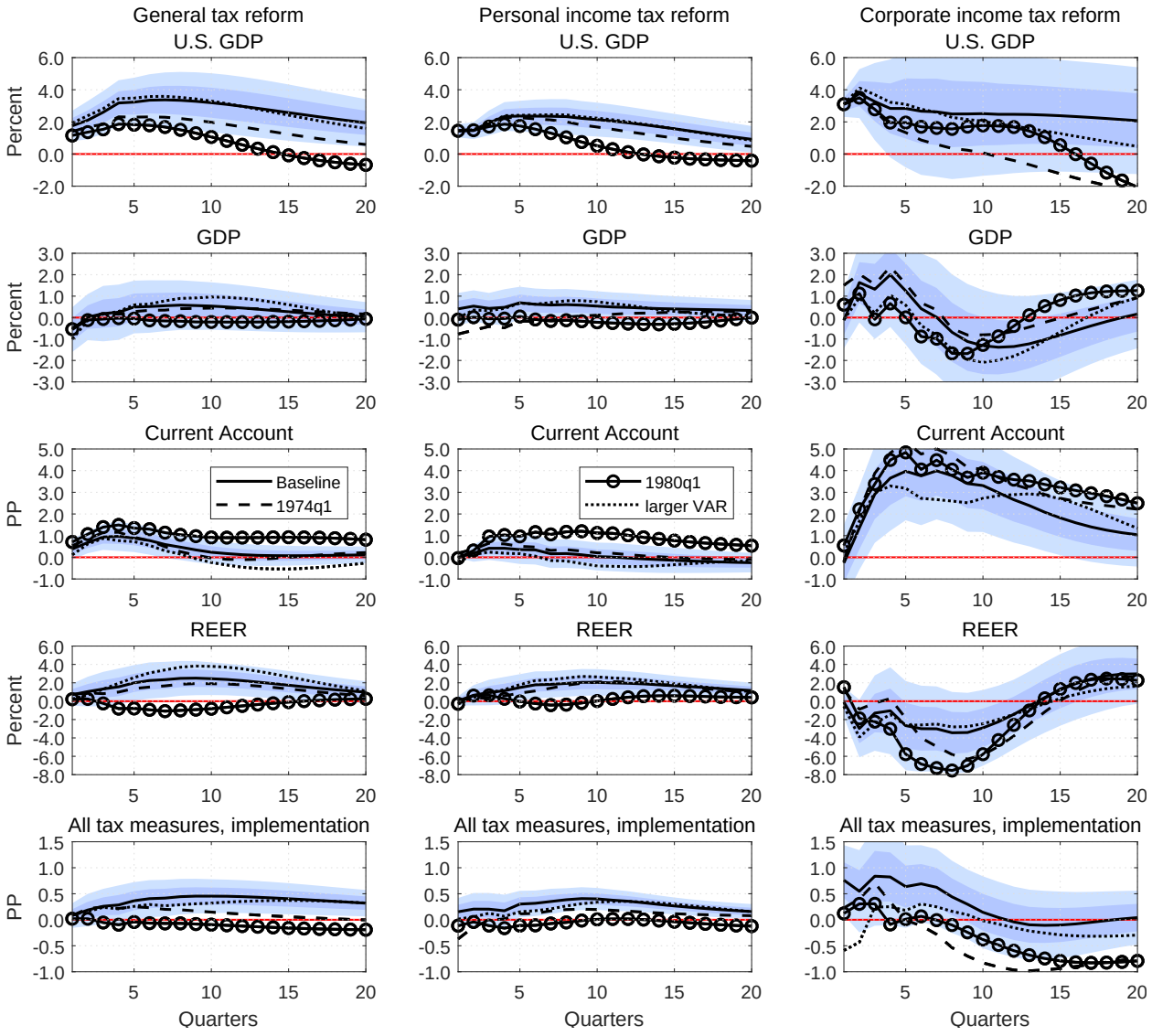
Figure 8 summarizes the results for five variables, namely U.S. GDP and the German variables GDP, the current account, the real effective exchange rate and implemented tax measures. The solid lines and confidence bands refer to the baseline results. The dashed and dotted lines are point estimates for the estimation sample starting in 1974 and the larger SVAR specification, respectively. The lines with circles reflect the results for the even shorter estimation sample starting in the first quarter of 1980. The initial responses corresponds to an exogenous U.S. tax cut of one percent of U.S. GDP.

Regarding the estimations starting in 1974, we find that the reaction of U.S. GDP gets smaller. Mertens and Ravn (2014) and Perotti (2005) find a similar result. The decline in the positive U.S. GDP response is especially pronounced after a cut in U.S. corporate income taxes. In contrast, the reaction after a decline in the average U.S. personal income tax rate is negligible. For the other variables, we find very similar results compared to our baseline calculations. Exceptions are the insignificant negative response of German GDP in the case of a U.S. personal income tax reform and, to some extent, the effects of U.S. tax reforms on German tax reforms.

When further restricting the estimation sample, the reaction of U.S. GDP becomes even less pronounced. The corresponding effect on production in Germany is no longer statistically significantly different from zero. The same is true for the response of the real effective exchange rate and the implemented tax measures. After 1980, German tax policy seems to have become more passive.

[17] The effects of exchange rate regimes on fiscal multipliers are discussed, e.g., by Born et al. (2013).

Figure 8: Robustness Checks



Notes: The figure shows the responses of variables in percent (in percentage points in case of the current account and the tax measures) over 20 quarters following an exogenous U.S. tax cut corresponding to one percent of U.S. GDP. Apart from the upper left panel which depicts the response of U.S. GDP, all other panels refer to German variables. Full lines are point estimates in our baseline scenario. Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004). Dashed lines are point estimates for the shorter sample period starting in the first quarter of 1974, lines with circles are point estimates for the estimation period starting in the first quarter of 1980, dotted lines are point estimates for a larger SVAR specification.

Including more German variables simultaneously in our SVAR model, yields slightly different reactions of the German variables for the variants of general U.S. tax reforms and U.S. personal income tax reforms.[18] However, our main statements remain unchanged. After U.S. tax cuts, German GDP increases only moderately, the German current account increases significantly, the German real effective exchange rate appreciates and German authorities increase taxes. In the case of U.S. corporate income tax reforms, we find a weaker response of German GDP and a different reaction of German tax measures which, however, is insignificant. The other results regarding the large improvement of the German current account and the depreciation of the German real effective exchange rate are still valid.

6 Conclusion

This study adds to the empirical literature on international spillover effects of fiscal policy. Specifically, we study the transmission of U.S. tax shocks and provide evidence for the German economy. Our results show that German GDP increases only moderately in response to general U.S. tax cuts. This finding can be explained by several factors: First, higher demand in the U.S. exerts a significant growth impulse on GDP via the export channel. Second, this positive effect outweighs the negative effects stemming from the price channel. We observe an appreciation of the real effective exchange rate. In line with this, the German terms of trade improve and import prices fall. Unit labor costs decline by almost the same amount as consumer prices. Third, as the nominal interest rate barely reacts, the decline in consumer prices leads to a higher real interest rate which, in turn, depresses German domestic demand.

German tax policy either reacts with opposite measures or remains passive. We cannot observe an objective to improve medium-term international competitiveness by cutting taxes in response to U.S. tax reforms. The fact that the significant, restrictive effect on tax measures disappears when starting the estimations in 1980 points to the circumstance that German tax policy was used as a stabilizing instrument more intensively at the beginning of our sample.

We extend our analysis by distinguishing between different types of tax reforms. While the results with respect to cuts in the average personal income tax rate are very similar to

[18] Looking at these results, one might wonder why the impulse response function of U.S. GDP for the larger SVAR is differs from the baseline model. At least the subset specification should guarantee that German variables do not affect U.S. GDP. But note, that the estimation sample for the larger SVAR model starts later as we have only data for the German current account balance since the first quarter of 1971. Using the same samples for both models, yields identical impulse response functions for U.S. GDP.

those for general U.S. tax reforms, we find significantly different responses following corporate income tax changes. In this case, the U.S. dollar appreciates and the German real effective exchange rate depreciates. Accordingly, the expansive effects via the export channel are supported by international price movements. The German current account balance improves to a larger extent. Also the deflationary pressure is higher.

The recent large tax reform in the U.S., the TCJA, includes both, cuts in the average personal income tax as well as cuts in the corporate income tax. Our findings suggest that this should trigger positive spillover effects on German GDP. Apart from that, the reform package includes several provisions that affect the taxation of multinationals. While our approach can shed light on potential spillover effects of the TCJA and its transmission, the estimates are based on historical experiences. Therefore, the effects of reform components that deviate strongly from past reforms, such as the provisions on international taxation, are hard to capture. Additionally, the approach rests on the assumption that the reform was unexpected and exogenous. Our analysis abstracts from non-linearities as well as asymmetric effects of tax cuts and tax increases. Moreover, we do not consider state-dependent effects. To investigate whether model specifications that address these issues lead to different conclusions would be worthwhile. This opens an important avenue for future research.

References

Auerbach, A. J. and Y. Gorodnichenko (2013): "Output Spillovers from Fiscal Policy," *American Economic Review*, 103, 141–46.

Barro, R. and J. Furman (2018): "The Macroeconomic Effects of the 2017 Tax Reform," *Brookings Papers on Economic Activity*.

Baum, A. and G. B. Koester (2011): "The impact of fiscal policy on economic activity over the business cycle - evidence from a threshold VAR analysis," Discussion Paper Series 1: Economic Studies 2011,03, Deutsche Bundesbank.

Beetsma, R., M. Giuliodori, and F. Klaassen (2006): "Trade spill-overs of fiscal policy in the European Union: a panel analysis," *Economic Policy*, 21, 640–687.

Blagrave, P., G. Ho, K. Koloskova, and M. E. Vesperoni (2017): *Fiscal Spillovers: The Importance of Macroeconomic and Policy Conditions in Transmission*, International Monetary Fund.

Blanchard, O. and R. Perotti (2002): "An empirical characterization of the dynamic effects of changes in government spending and taxes on output," *The Quarterly Journal of Economics*, 117, 1329–1368.

Born, B., F. Juessen, and G. J. Müller (2013): "Exchange rate regimes and fiscal multipliers," *Journal of Economic Dynamics and Control*, 37, 446–465.

Bundesbank (2018): *Monthly Report - February 2018*, Deutsche Bundesbank.

Caldara, D. and C. Kamps (2017): "The analytics of SVARs: a unified framework to measure fiscal multipliers," *The Review of Economic Studies*, 84, 1015–1040.

Chirinko, R. S. and D. J. Wilson (2017): "Tax competition among U.S. states: Racing to the bottom or riding on a seesaw?" *Journal of Public Economics*, 155, 147 – 163.

Cwik, T. and V. Wieland (2011): "Keynesian government spending multipliers and spillovers in the euro area," *Economic Policy*, 26, 493–549.

Devereux, M. P. and R. Griffith (1998): "Taxes and the Location of Production: Evidence from a Panel of US Multinationals," *Journal of Public Economics*, 68, 335–367.

Enders, Z., G. J. Müller, and A. Scholl (2011): "How do fiscal and technology shocks affect real exchange rates?: New evidence for the United States," *Journal of International Economics*, 83, 53–69.

Faccini, R., H. Mumtaz, and P. Surico (2016): "International fiscal spillovers," *Journal of International Economics*, 99, 31–45.

Favero, C. and F. Giavazzi (2012): "Measuring tax multipliers: The narrative method in fiscal VARs," *American Economic Journal: Economic Policy*, 4, 69–94.

German Council of Economic Experts (2017): *Towards a Forward-Looking Economic Policy. Annual Report 2017/18*.

Gonçalves, S. and L. Kilian (2004): "Bootstrapping Autoregressions with Conditional Heteroskedasticity of Unknown Form," *Journal of Econometrics*, 123, 89–120.

Hayo, B. and M. Uhl (2014): "The macroeconomic effects of legislated tax changes in Germany," *Oxford Economic Papers*, 66, 397–418.

Keen, M. and K. A. Konrad (2013): "The Theory of International Tax Competition and Coordination," in *Handbook of Public Economics*, ed. by A. J. Auerbach, R. Chetty, M. Feldstein, and E. Saez, Elsevier, vol. 5 of *Handbook of Public Economics*, 257–328.

Kilian, L. and C. Park (2009): "The Impact of Oil Price Shocks on the U.S. Stock Market," *International Economic Review*, 50, 1267–1287.

Lieberknecht, P. and V. Wieland (2018): "On the Macroeconomic and Fiscal Effects of the Tax Cuts and Jobs Act," Working Paper 10/2018, German Council of Economic Experts.

Mendoza, E. G., A. Razin, and L. L. Tesar (1994): "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption," *Journal of Monetary Economics*, 34, 297–323.

Mertens, K. (2018): "The Near Term Growth Impact of the Tax Cuts and Jobs Act," Working paper, Federal Reserve Bank of Dallas.

Mertens, K. and M. O. Ravn (2013): "The dynamic effects of personal and corporate income tax changes in the United States," *American Economic Review*, 103, 1212–47.

——— (2014): "A reconciliation of SVAR and narrative estimates of tax multipliers," *Journal of Monetary Economics*, 68, S1–S19.

Monacelli, T. and R. Perotti (2010): "Fiscal policy, the real exchange rate and traded goods," *The Economic Journal*, 120, 437–461.

Mountford, A. and H. Uhlig (2009): "What are the effects of fiscal policy shocks?" *Journal of Applied Econometrics*, 24, 960–992.

Natoli, F. and L. Metelli (2018): "The international transmission of US fiscal shocks," MPRA Paper 84207, University Library of Munich, Germany.

Overesch, M. and J. Rincke (2011): "What Drives Corporate Tax Rates Down? A Reassessment of Globalization, Tax Competition, and Dynamic Adjustment to Shocks*," *The Scandinavian Journal of Economics*, 113, 579–602.

Perotti, R. (2005): "Estimating the effects of fiscal policy in OECD countries," Tech. rep., CEPR Discussion Paper No. 4842.

Ramey, V. A. (2016): "Macroeconomic shocks and their propagation," in *Handbook of Macroeconomics*, Elsevier, vol. 2, 71–162.

Ravn, M. O., S. Schmitt-Grohé, and M. Uribe (2012): "Consumption, government spending, and the real exchange rate," *Journal of Monetary Economics*, 59, 215–234.

Romer, C. D. and D. H. Romer (2010): "The macroeconomic effects of tax changes: estimates based on a new measure of fiscal shocks," *American Economic Review*, 100, 763–801.

Tenhofen, J., G. B. Wolff, and K. H. Heppke-Falk (2010): "The macroeconomic effects of exogenous fiscal policy shocks in Germany: a disaggregated SVAR analysis," *Jahrbücher für Nationalökonomie und Statistik*, 230, 328–355.

Uhl, M. (2013): "A History of Tax Legislation in the Federal Republic of Germany," MAGKS Joint Discussion Paper Series in Economics 11-2013.

A Data Definitions and Sources

Table A1: U.S. variables used in SVARs of Sections 3.1 and 3.2 : description and sources

Variable	Description	Source
Gross domestic product	real gross domestic product (GDP); billions of chained 2009 dollars; quarterly; seasonally adjusted; period Q1 1970 to Q4 2017, National Income and Product Accounts (NIPA) Tables 1.1.5 and 1.1.9	BEA
Population aged 16 and above	civilian noninstitutional population; thousand persons; quarterly; not seasonally adjusted	Federal Reserve Bank of St. Louis
GDP per capita	real gross domestic product divided by population aged 16 and above; seasonally adjusted; period Q1 1970 to Q4 2017	own calculations
Government spending per capita	real federal government consumption expenditures and gross investment (billions of chained 2009 dollars) deflated by the GDP deflator and divided by population aged 16 and above; seasonally adjusted; period Q1 1970 to Q4 2017, NIPA Tables 3.9.5 and 1.1.9	BEA
Tax revenue per capita	federal current tax receipts and contributions for government social insurance less corporate income taxes from Federal Reserve Banks; seasonally adjusted; period Q1 1970 to Q4 2017, NIPA Tables 3.2 and 1.1.9	BEA
Personal income tax base per capita	personal income less government transfers plus contributions for government social insurance deflated by the GDP deflator and divided by population aged 16 and above; seasonally adjusted; period Q1 1970 to Q4 2017, NIPA Tables 2.1, 3.2 and 1.1.9	BEA
Average personal income tax (APITR)	sum of federal personal current taxes and contributions for government social insurance divided by the personal income tax base; seasonally adjusted; period Q1 1970 to Q4 2017, NIPA Tables 3.2 and 1.1.9	BEA
Corporate income tax base per capita	corporate profits less Federal Reserve Bank Profits deflated by the GDP deflator and divided by population aged 16 and above; seasonally adjusted; period Q1 1970 to Q4 2017, NIPA Tables 1.12, 6.16 and 1.1.9	BEA
Average corporate income tax (ACITR)	federal taxes on corporate income excluding Federal Reserve banks divided by corporate profits (excluding Fed profits); seasonally adjusted; period Q1 1970 to Q4 2017, NIPA Tables 3.2 and 1.1.9	BEA

Notes: All series were downloaded from the cited sources in August 2018 at the most recent vintage available at that time.

Table A2: German variables used in SVARs of Section 3.2: description and sources

Variable	Description	Source
Population in working age	Population aged between 16 and 74; thousand persons; quarterly; seasonally adjusted; post-1991 data (referring to reunited Germany) are extended backwards by using the growth rates of the pre-1991 data that refer to Western Germany only; Fachserie 18 Reihe 1.3 (Table 2.1.7) and Reihe S. 28 (Table 2.1.6)	Federal Statistical Office (DESTATIS)
Gross domestic product per capita	real gross domestic product (GDP) divided by population in working age; GPD data are chained volume (base year=2010); post-1991 data are extended backwards by using the growth rates of the pre-1991 data; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017, Fachserie 18 Reihe 1.3 (Table 2.3.2) and Reihe S. 28 (Table 2.3.2)	DESTATIS
Exports per capita	real exports divided by population in working age; export data are chained volume (base year=2010); post-1991 data are extended backwards by using the growth rates of the pre-1991 data; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017, Fachserie 18 Reihe 1.3 (Table 2.3.2) and Reihe S. 28 (Table 2.3.2)	DESTATIS
Imports per capita	real imports divided by population in working age; import data are chained volume (base year=2010); imports post-1991 data are extended backwards by using the growth rates of the pre-1991 data; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017, Fachserie 18 Reihe 1.3 (Table 2.3.2) and Reihe S. 28 (Table 2.3.2)	DESTATIS
Consumption per capita	real private consumption divided by population in working age; consumption data are chained volume (base year=2010); post-1991 data are extended backwards by using the growth rates of the pre-1991 data; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017, Fachserie 18 Reihe 1.3 (Table 2.3.2) and Reihe S. 28 (Table 2.3.2)	DESTATIS
Investment per capita	gross fixed capital formation divided by population in working age; investment data are chained volume (base year=2010); post-1991 data are extended backwards by using the growth rates of the pre-1991 data; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017, Fachserie 18 Reihe 1.3 (Table 2.3.2) and Reihe S. 28 (Table 2.3.2)	DESTATIS
Nominal unit labor costs	nominal total wage costs (incl. all social contributions and taxes) per working hour divided by real hourly productivity (real GDP per working hour); post-1991 data (referring to reunited Germany) are extended backwards by using the growth rates of the pre-1991 data that refer to Western Germany only; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017, Fachserie 18 Reihe 1.3 (Table 2.1.9) and Reihe S. 28 (Table 2.1.8)	DESTATIS
Current account	nominal current account in percent of GDP; quarterly; seasonally- and working day adjusted; period Q1 1971 to Q4 2017	Bundesbank
CPI	German consumer price index; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017	Bundesbank
REER	real effective exchange rate based on CPI data; quarterly growth rates of this series have a correlation coefficient of 0.94 with the growth rates of the indicator of German price competitiveness which is available since Q1 1972; quarterly; not seasonally adjusted; period Q1 1970 to Q4 2017	IMF

Notes: All series were downloaded from the cited sources in August 2018 at the most recent vintage available at that time.

B Important tax reforms after 2010

All German tax reforms until the second quarter of 2010 are summarized in detail by Uhl (2013). He also categorizes the single tax reforms into categories of motivation provided by the German government: countercyclical, macroeconomic shock, spending driven and consolidation. We append all tax reforms that have been introduced in parliament between the third quarter of 2010 and the final quarter of 2017. The results are shown in Table A3.

Table A3: Important tax legislations and their revenue impacts, extension of Uhl (2013)

No.	Title	Motivation	Draft	Announcement	Implementation	Impact
1	Law on the Implementation of Amendments to the EU Mutual Assistance Directive and other Measures against Base Erosion and Profit Shifting	S	09/2016	12/2016	01/2017 01/2018	-2,315 million € (-0.07%) -3,630 million € (-0.11%)
2	Act Increasing the Minimum Exempted Income, the Child Allowance, the Child Benefit and the Child Supplement	S	03/2015	07/2015	01/2015 01/2016 07/2016	-2,000 million € (-0.07%) -3,345 million € (-0.11%) -75 million € (-0.002%)
3	Law to Offset Bracket Creep	S	12/2011	02/2013	01/2013	-2,570 million € (-0.09%)
4	Act Amending the Energy and the Electricity Duty Act as well as the Aviation Tax Act	S	08/2012	12/2012	04/2012 01/2013	50 million € (0.002%) -2,340 million € (-0.08%)
5	Budget Supplementary Act 2011	C	09/2010	12/2010	01/2011	1,920 million € (0.07%)
6	Nuclear Fuel Duty Act	C	09/2010	12/2010	01/2011	2,300 million € (0.09%)

Notes: Original titles in German: (1) *Gesetz zur Umsetzung der Änderungen der EU-Amtshilferichtlinie und von weiteren Maßnahmen gegen Gewinnkürzungen und -verlagerungen*, (2) *Gesetz zur Anhebung des Grundfreibetrags, des Kinderfreibetrags, des Kindergeldes und des Kinderzuschlags*, (3) *Gesetz zum Abbau der kalten Progression*, (4) *Gesetz zur Änderung des Energiesteuer- und des Stromsteuergesetzes sowie zur Änderung des Luftverkehrsteuergesetzes*, (5) *Haushaltsbegleitgesetz 2011*, (6) *Kernbrennstoffsteuergesetz*. Impact is the estimated implemented revenue effect of the tax law in million euro on an annual basis after full implementation (in percent of GDP). Tax measures are assigned to one of the following categories of motivation: CC = countercyclical, MS = macroeconomic shock, SD = spending driven, S = structural, C = consolidation.

C Comparison of model specifications for U.S. personal and corporate income tax changes

In this appendix, we compare the results from our baseline SVAR specification, as presented in Section 3.2, with the results provided by Mertens and Ravn (2013). Differences could arise due to two reasons: first, we make two adjustments to the VAR specification proposed by Mertens and Ravn (2013). In our analysis, we do not consider federal government debt and our model contains a linear trend, a quadratic trend and a dummy for the second quarter of the year 1975. Second, we use a different sample period. We study the quarterly period between the years 1970 and 2017 whereas Mertens and Ravn (2013) analyze the time frame between the years 1950 and 2006.

To explore the consequences of the differences in the model specification, we first replicate the results of Mertens and Ravn (2013) (model 1). The results are shown as solid black lines in Figure A1. Additionally, we show the confidence bands as shaded areas. In a second step, we determine the results for the "proxy SVAR" of Mertens and Ravn (2013) for the same sample with the following two adjustments (model 2): no federal debt and including trends and a dummy for the second quarter of the year 1975. The dashed black lines show the results. For a cut in the average U.S. personal income tax rate (left column), we almost find no differences comparing the results of model 1 and model 2. For the reduction in the corporate income tax rate (right column), some minor deviations occur in the responses of the tax rate and GDP. Overall, the different specification assumptions yield almost identical results.

Regarding the issue of different sample sizes, we depict the impulse response functions of our baseline approach in Figure A1, as introduced in Section 3.2. Our sample ranges from the first quarter 1970 to the fourth quarter 2017. Otherwise, the model specification is the same as in model 2. For the personal income tax shock, we find larger positive responses of GDP and the personal income tax base after one year. In contrast, in case of a corporate income tax reform, we find smaller positive reactions of GDP and corporate income tax base. Nonetheless, the main statements of Mertens and Ravn (2013) are not affected.

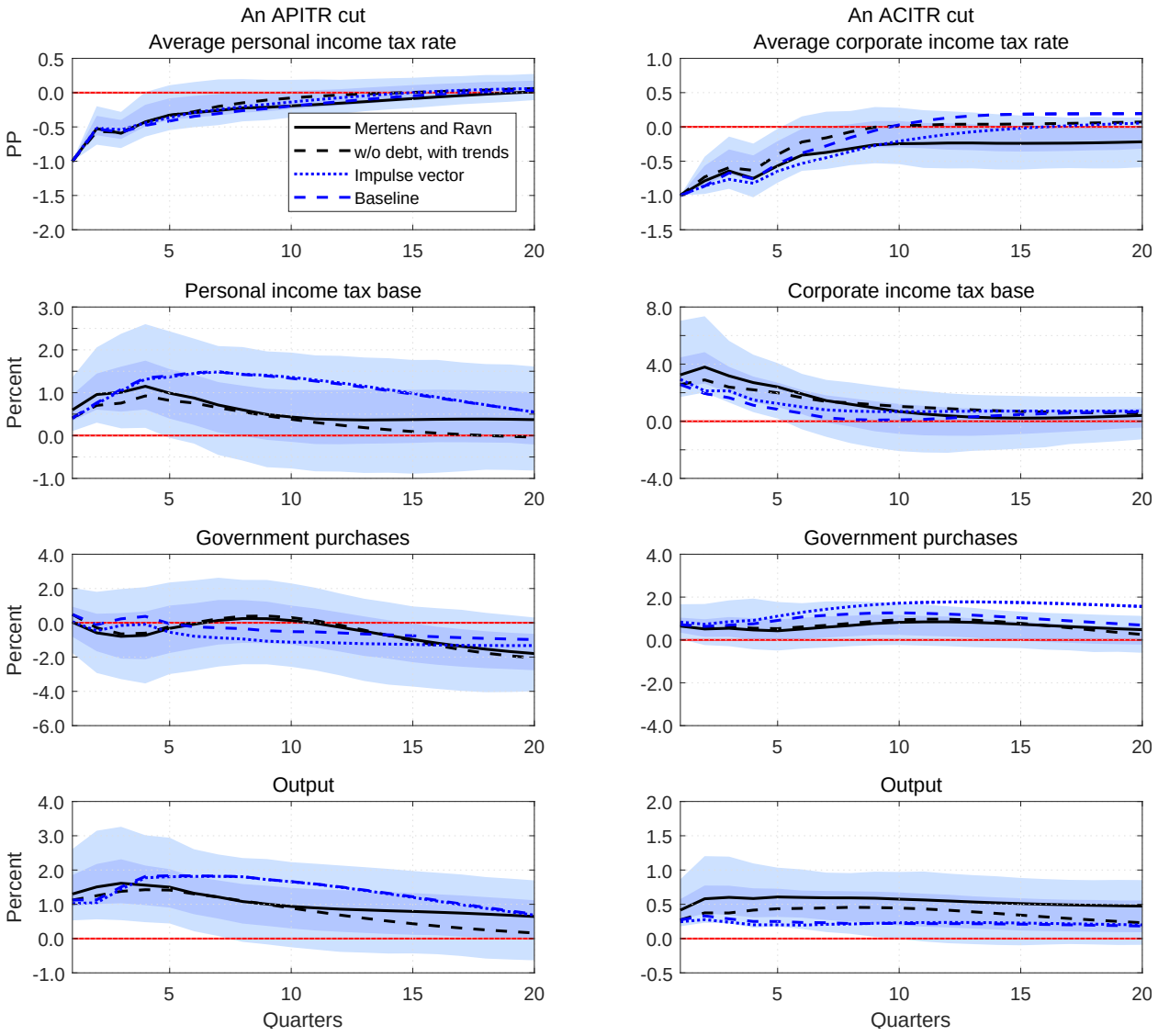
The blue dotted lines in Figure A1 exhibit the results of a robustness check for our identification procedure outlined in Section 3.2. So far, we identified the two structural tax shocks ϵ_t^{APITR} and ϵ_t^{ACITR} by relying on the impact coefficients provided by model 2, estimated with the sample for the years 1950 to 2006. Alternatively, we could use the structural shocks $\hat{\epsilon}_t^{APITR}$ and $\hat{\epsilon}_t^{ACITR}$ determined from model 2 directly in the reduced form VAR estimation of our baseline model (5). Specifically, we can use the contemporaneous values of both tax shocks as exogenous variables. To estimate the model for our baseline

sample, we assume that the values of $\hat{\epsilon}_t^{APITR}$ and $\hat{\epsilon}_t^{ACITR}$ adopt the value of 0 beginning with the first quarter of 2007. The extended reduced form model is defined as follows:

$$\begin{pmatrix} Z_t \\ X_t \end{pmatrix} = \tilde{\alpha}' d_t + \tilde{A}(L) \begin{pmatrix} Z_{t-1} \\ X_{t-1} \end{pmatrix} + D_0^{PI} \hat{\epsilon}_t^{APITR} + D_0^{CI} \hat{\epsilon}_t^{ACITR} + \tilde{u}_t, \tag{5}$$

where D_0^{PI} and D_0^{CI} define the impact vectors of the two tax shocks $\hat{\epsilon}_t^{APITR}$ and $\hat{\epsilon}_t^{ACITR}$ determined with model 2. These impact vectors, in turn, can be used as starting values to determine the impulse response functions for the macroeconomic variables in the initial period. The blue dotted and dashed lines in Figure A1 show that this approach yields similar results compared to our baseline calculations.

Figure A1: Comparison of model specifications



Notes: The figure shows the responses of variables in percent (in percentage points in case of the tax rates) over 20 quarters following an exogenous cut in the U.S. personal income (left column) and corporate income tax rate (right column) corresponding to one percentage point of the respective average tax rate. The solid lines and confidence bands are a replication of the results of Mertens and Ravn (2013) (model 1). The dashed black lines show the impulse response functions for the "proxy SVAR" of Mertens and Ravn (2013) with two modifications (model 2): we do not include federal government debt and the used model contains a linear trend, a quadratic trend and a dummy for the second quarter of the year 1975. The dashed blue lines present the outcomes of our baseline approach introduced in Section 3.2. The dotted blue lines show the results of the model defined by Equation (5) in which the baseline model is extended by the determined tax shocks of model 2 to determine the impulse vectors for impulse response functions. In contrast to models 1 and 2 (estimation sample: 1950q1 to 2006q4), the estimation sample is 1970q1 to 2017q4. Otherwise, the model specification is the same as in model 2. Dark and light blue shaded areas: 68-percent and 95-percent-confidence bands, respectively, are constructed using a recursive design wild bootstrap, see Gonçalves and Kilian (2004).