Online Appendix

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

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A Data Definitions and Sources

Table A1: U.S. variables used in SVARs of Sections 2.1 and 2.2: 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 Sections 2.1, 2.2 and D: 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; GDP 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

Variable	Description	Source
Import price index	Price index for imports of goods; quarterly; seasonally- and working day adjusted; period Q1 1970 to Q4 2017	Bundesbank
Exchange rate	Exchange rate between the U.S. dollar and the German currency (USD/EUR); quarterly; period Q1 1970 to Q4 2017	Bundesbank
German exports to U.S.	Nominal exports deflated using the export price index; quarterly; seasonally- and working day adjusted; period Q1 1971 to Q4 2017	Bundesbank
Bilateral trade balance	Difference between exports of goods from Germany to the U.S. and imports of goods from the U.S. to Germany divided by nominal German GDP; quarterly; seasonally- and working day adjusted; period Q1 1971 to Q4 2017	Bundesbank
Interest rate	Interbank rates for Germany: 3-month or 90-day rates and yields; quarterly; not seasonally adjusted; period Q1 1970 to Q4 2017	OECD
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. Source: Authors' calculations.

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 2.2, 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) analyse 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 2.2. 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.

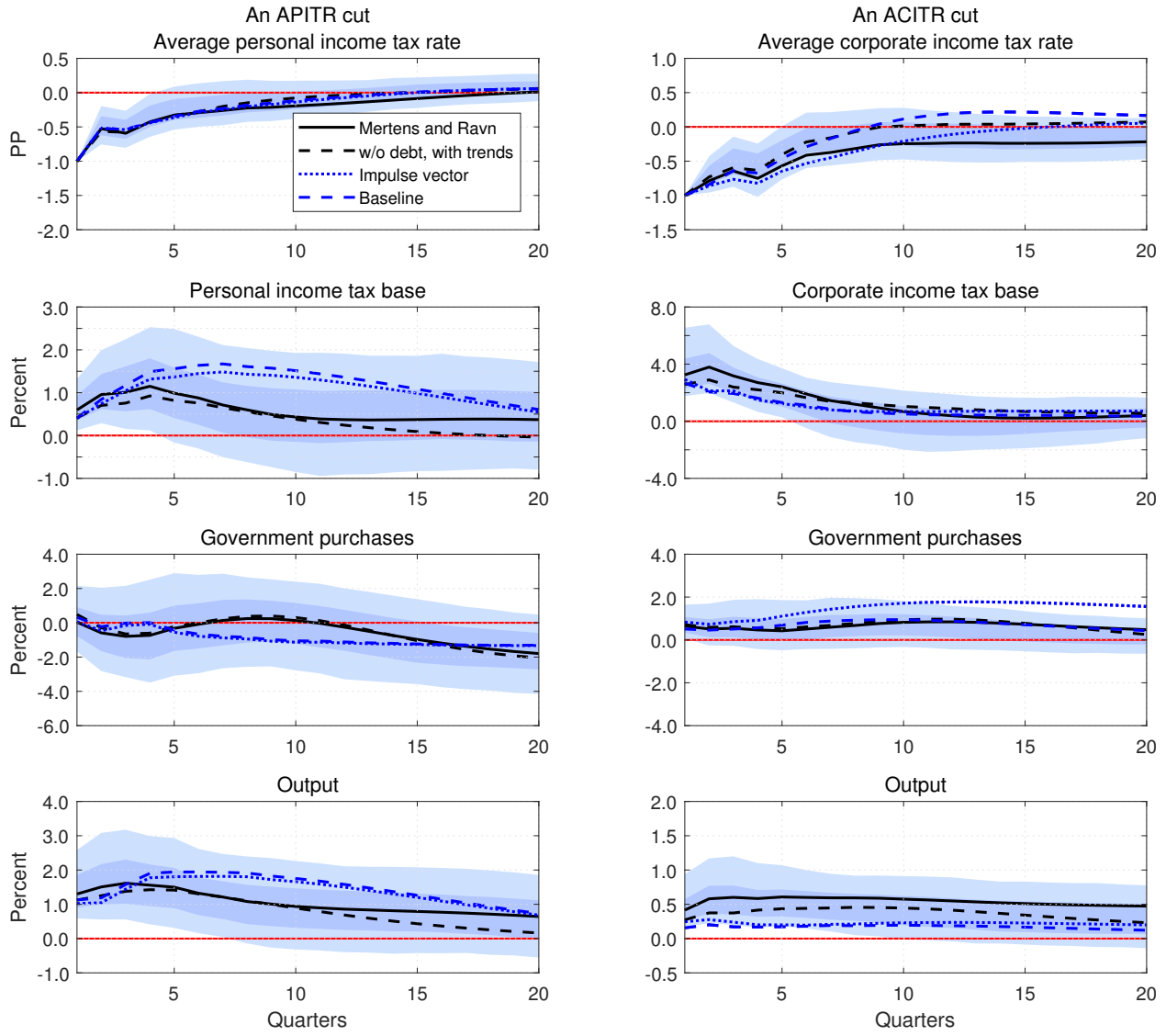
The blue dotted lines in Figure A1 exhibit the results of a robustness check for our identification procedure outlined in Section 2.2. So far, we identified the two structural tax shocks ϵ_t^{APITR} and ϵ_t^{ACITR} by relying on the impact coefficients provided by model 2, estimated with the sample for 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 (6). 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:

$$\begin{pmatrix} Z_t \\ X_t \end{pmatrix} = \tilde{\alpha}' d_t + \tilde{A}(L) \begin{pmatrix} Z_{t-1} \\ X_{t-1} \end{pmatrix} + D_0^{PI} \hat{\epsilon}_t^{APITR} + D_0^{CI} \hat{\epsilon}_t^{ACITR} + \tilde{u}_t, \tag{6}$$

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 2.2. The dotted blue lines show the results of the model defined by Equation (6) 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).

D Further results: bilateral trade linkages

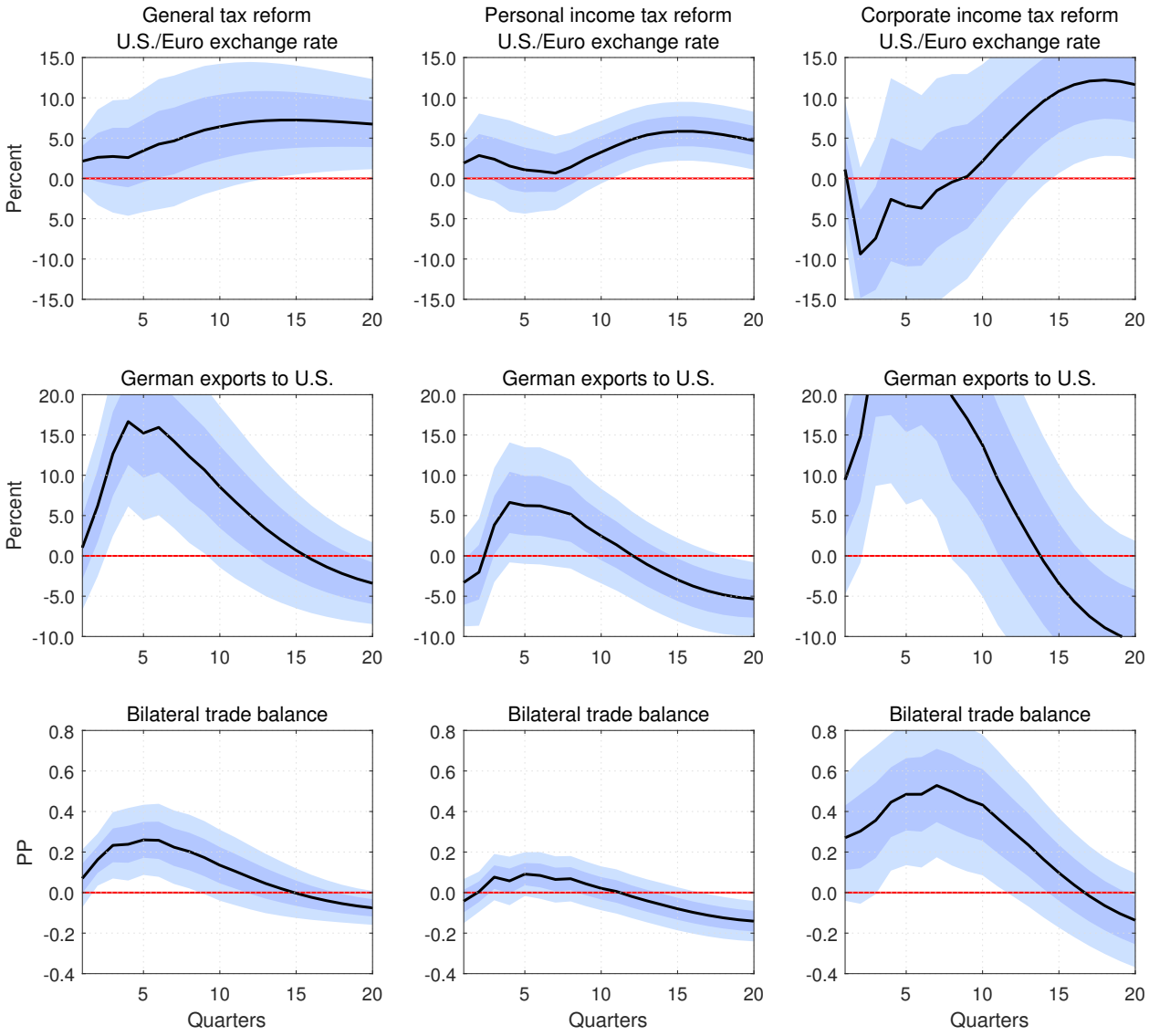
The results presented in Section 3 underline the importance of international trade for the transmission of U.S. tax shocks for the German economy. This section elaborates on this channel by using data on bilateral trade. Figure A2 summarizes these results for key variables characterizing the trade relations between Germany and the U.S.: the exchange rate, German exports to the U.S., and the bilateral trade balance. We present them separately for general tax shocks in the first column, personal income tax (PIT) reforms in the second column, and corporate income tax (CIT) reforms in the third column.

Reactions of the exchange rate between the U.S. dollar and the German currency are depicted in the three panels presented in the first line. Following general tax shocks, the U.S. dollar depreciates permanently against the German currency. This reaction happens almost immediately. In case of PIT shocks, the exchange rate reacts with a delay of about two years. After a CIT shock, the U.S. dollar even appreciates initially. This changes to the contrary over time.

The second line shows effects on German exports of goods to the U.S. following a tax shock. To adjust for price changes, nominal exports have been deflated using the export price index for all countries. Due to data availability, estimations start in the first quarter of 1971. The impulse response functions show a statistically significant increase of exports to the U.S. after taxes have been reduced. These reactions happen almost on impact. After one year, exports are about 15% higher in models including all tax reforms, the reaction is weaker for PIT reforms and stronger for CIT reforms. In all three cases, the positive reaction reverses into its opposite over time.

The effects on exports also become apparent in the responses of the bilateral trade balance as shown in the third line. This measure is defined as the difference between exports of goods from Germany to the U.S. and imports of goods from the U.S. to Germany divided by nominal German GDP. All panels show an increase in the trade balance after a tax cut. Analogous to the reaction of the German exports to the U.S., the effect is particularly pronounced after a CIT shock where the trade balance increases by up to 0.6 percentage points after about two years.

Figure A2: Effects of U.S. tax shocks on bilateral trade with Germany



Notes: The figure shows the responses of variables in percent (in percentage points in case of the bilateral trade balance) over 20 quarters. The panels on the left-hand side depict effects after a general tax reform, the middle panels show the results after a personal income tax reform and the right-hand side after a corporate income tax reform. Full lines are point estimates. 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).