Estimating Policy-Corrected Long-Term and Short-Term Tax Elasticities for the United States, Germany, and the United Kingdom

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MOTIVATION

- Fiscal policy developed as a cornerstone of Keynesian macroeconomics following the Great Depression in the early 1930s, but its popularity has fluctuated ever since.
  - 1950-1960
  - 1970s
- For instance, according to Uhl (2007), Germany did not make use of discretionary tax policy as a business-cycle stabilisation tool at all between 1980 and 2007 (Uhl, 2013).
  - 2007 financial crisis
- This re-emergence of fiscal policy was accompanied by a reassessment of its impact, especially in a low-interest-rate environment.
- For instance, IMF revised upwards its fiscal policy multiplier estimates, found to be 'near 0.5 in advanced economies during the three decades leading up to 2009', and states that 'our results indicate that multipliers have actually been in the 0.9 to 1.7 range since the Great Recession' (IMF, 2012).

MOTIVATION

- When calculating elasticities, empirical studies often disregard the revenue effect of discretionary policies, and instead they estimate ***"tax buoyancy"***.
- In contrast, tax elasticities isolate the revenue effect of changes in the tax base
- To compute the tax-to-output elasticity rather than tax buoyancy, two measures need to be taken into account:
  - adjust the revenues for the effect of discretionary policy changes and
  - the relationship between the relevant tax bases and income.
- Over the last decade, an increasing number of studies have tried to incorporate information on policy-induced changes in government revenues.

AIM & CONTRIBUTIONS OF THE STUDY

1. We present estimations of tax elasticities (tax to base & base to output) for three of the five largest economies in the world.
2. We use a newly constructed, much richer quarterly dataset - a larger sample size (elasticities for the most relevant tax categories at a quarterly frequency).
3. We correct for discretionary tax policies (if not the estimated elasticities are more accurately interpreted as estimates of tax buoyancy).
4. We adopt a different, arguably more intuitive approach to measuring short-term asymmetries based on the phase of the business cycle. In addition to 'booms' and 'recessions', we define a 'neutral' business cycle situation.

MAIN FINDINGS

1. In Germany and the UK, long-term tax-to-base elasticities are generally higher than short-term elasticities
2. Concerning base-to output elasticities, short-term elasticities are generally smaller than unity, whereas long-term elasticities are close to unity.
3. Tax-to-output elasticities in the short term are lower than long-term elasticities.
4. For tax-to-base elasticities, we find business cycle asymmetries across countries but not within countries.
5. For base-to-output elasticities, our results suggest few asymmetries across countries and more asymmetries across tax types.
6. Typically, the above conclusions do not hold for corporate income tax, which has the highest base-to-output elasticity.

Contributions

- To the best of our knowledge, our study is the first attempt that compares the tax-to-base and tax-to-output elasticities of the most relevant tax categories for the US, Germany, and the UK at
  - a quarterly frequency
  - correcting for discretionary tax policies at the level of detail found in this paper.
  - adopting a more intuitive approach to measuring short-term asymmetries based on the phase of the business cycle by defining a ‘neutral‘ business cycle situation.

In what follows:

1. Literature
2. Data and Proportional Adjustment
3. Estimation Methodology
4. Empirical Findings
5. Conclusion

Literature

Table 1: Overview of Previous Studies

Authors	Countries	Tax Type	Short-Run Elasticity	Long-Run Elasticity
Sobel and Holcombe (1996)	US	Personal Income	1.16	1.22
		Corporate Income	3.37	0.67
		Adjusted Gross Income	0.97	0.95
		Retail Sales	1.04	0.66
		Non-Food Retail	1.38	0.70
		Motor Fuel Usage	0.73	1.00
		Liquor Store Sales	–0.011(insignificant)	0.25
Creedy and Gemmell (2004)	UK	Personal Income	1.20–1.40	1.20–1.40
		Consumption Taxes	0.85–0.70	0.85–0.70
Bruce et al. (2006)*	US	Sales Tax	1.80 (above eq) 0.15 (below eq)	0.81
		Income Tax	2.66 (above eq) 0.217 (below eq)	1.83
Koester and Priesmeier (2012)	Germany	Profit-Related Taxes	0.43	0.77
		Wage Taxes	1.41	1.75
		VAT	0.90	0.79
Mourre and Princen (2019)	Germany	Personal Income	0.05 (insignificant)	1.78 (insignificant)
		Corporate Income	3.62 (insignificant)	1.95 (insignificant)
		Consumption taxes	0.49 (insignificant)	0.66
		SSC	0.37	0.75
	UK	Personal Income	3.42	1.11
		Corporate Income	4.72 (insignificant)	1.62 (insignificant)
		Consumption Taxes	1.72	1.11
		SSC	1.81	1.24
Boschi and d'Addona (2019)	Germany	Personal Income	0.93	2.99
		Corporate Income	0.15 (insignificant)	1.54
		Indirect Taxes	0.88	–0.50
		SSC	0.36	0.47
	UK	Personal Income	0.53	1.05
		Corporate Income	0.43	0.63
		Indirect Taxes	0.70	0.82
		SSC	0.74	1.53

Note: * indicates that elasticities are estimated as state averages and 'above' and 'below equilibrium' refers to relative position of the long-run relationship. 'Insignificant' refers to a p-value > 0.1.

Data and Proportional Adjustment

- In our analysis, we use personal income tax revenues, corporate income tax revenues, indirect tax revenues, and the social security contributions.
- Series are nominal and seasonally-adjusted.
- Data sources: Thomson Reuters Datastream & Bank for International Settlement.
- To obtain the discretionary tax policy changes, we employ the ***narrative approach***.
- Our narrative account covers the most important tax laws for our sample. Extensive analysis of the government records also allows us to differentiate between **temporary** and **permanent** policy changes.
- However, there is a ***drawback*** of of using narratively identified tax policy changes

Data and Proportional Adjustment

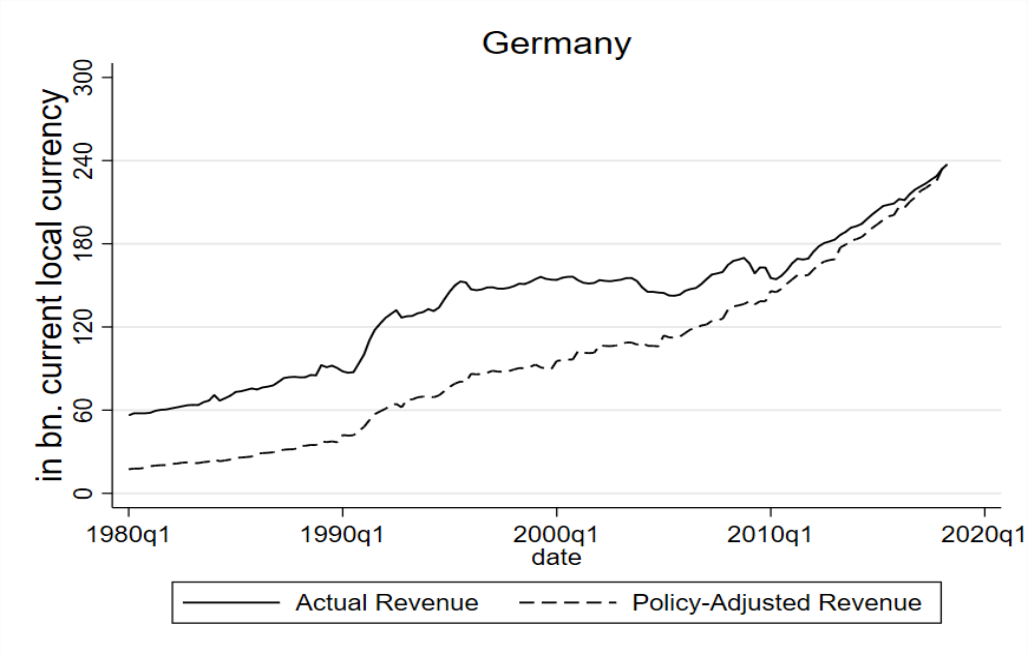
$$AR_{it} = R_{it} * \prod_{k=t+1}^{j} \left(\frac{R_{ik}}{R_{ik} - \Delta\tau_{ik}} \right) \forall\, t < j \qquad (1)$$

- i stands for the tax type
- AR_{it} are the adjusted revenues at time t,
- R_{ik} are the unadjusted revenues, and $\Delta\tau_{ik}$ are the discretionary tax changes

- Past tax revenues are corrected for discretionary policy changes under the assumption that the relative revenue effects are proportional over the full period.

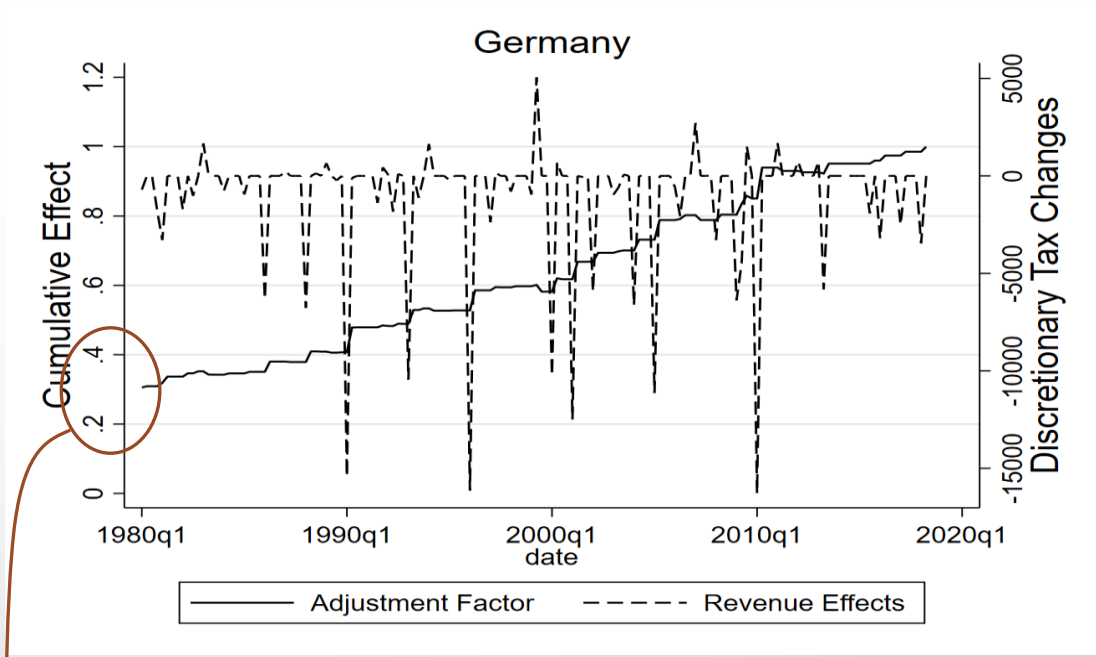
Data and Proportional Adjustment

Figure 1: Actual and Policy-Adjusted Personal Income Tax Revenues



Shows how income tax changes shifts the adjusted series

Figure 2: Cumulative Effect of Discretionary Changes, Personal Income Tax Revenues



Accumulates the effect of discretionary tax changes on revenues.

As of 1980, collected German income tax revenues would have been almost 70% lower if the legislation of 2018Q2 had already been in place.

ESTIMATION METHODOLOGY

We estimate the **long-run elasticities** using

$$ln(AR)_{i,c.t} = \alpha_{0,i}^{TB} + \alpha_{1,i}^{TB} ln(B)_{i,c,t} + \gamma_{i,c,t}^{TB} \quad (2)$$

$AR_{i,c.t}$: revenue adjusted for discretionary measures of tax category c of country i at time t,
$B_{i,c.t}$: tax base of tax category c of country i at time t,
$\gamma_{i,c,t}$: the error term for tax category c of country i at time t.
α_1^{TB}: Long-run tax-to-base elasticity that measures the per cent revenue change following a 1% change in the relevant tax base.

Equation (2) may be subject to a spurious regression problem and/or small sample estimation bias, as tax revenues and bases are non-stationary. Therefore, we will employ the dynamic ordinary least squares estimator (DOLS), which adds leads and lags of right-hand side variables in their first differences to Equation (2), yields consistent and asymptotically efficient coefficients.

$$ln(AR)_{i,c.t} = \alpha_{0,i}^{TB} + \alpha_{1,i}^{TB} ln(B)_{i,c,t} + \sum_{j=-q}^{p} \emptyset_{i,j}^{TB} \Delta ln(AR)_{i,c,t+j} + \gamma_{i,c,t}^{TB} \quad (3)$$

where the lead and lag values, q and p, are determined according to the Schwarz information criterion, we address potential inconsistencies in the estimated standard errors due to autocorrelation or heteroscedasticity by using the procedure proposed by Newey and West (1987).

ESTIMATION METHODOLOGY

Similarly, for the **short-term elasticity**, we employ the following equation

$$\Delta\, ln(AR)_{i,c.t} = \beta_{0,i}^{TB} + \beta_{1,i}^{TB} \Delta ln(B)_{i,c,t} + \beta_{2,i}^{TB} \gamma_{i,c,t-1}^{TB} + \mu_{i,c,t} \qquad (4)$$

β_1^{TB} denotes the short-term symmetric tax-to-base elasticity.

$\gamma_{i,c,t-1}^{TB}$ is the error correction term derived from Equation (3).

β_2^{TB} represents the adjustment parameter reflecting the percentage of the previous year's deviation from the long-term tax level corrected in the current period.

ESTIMATION METHODOLOGY

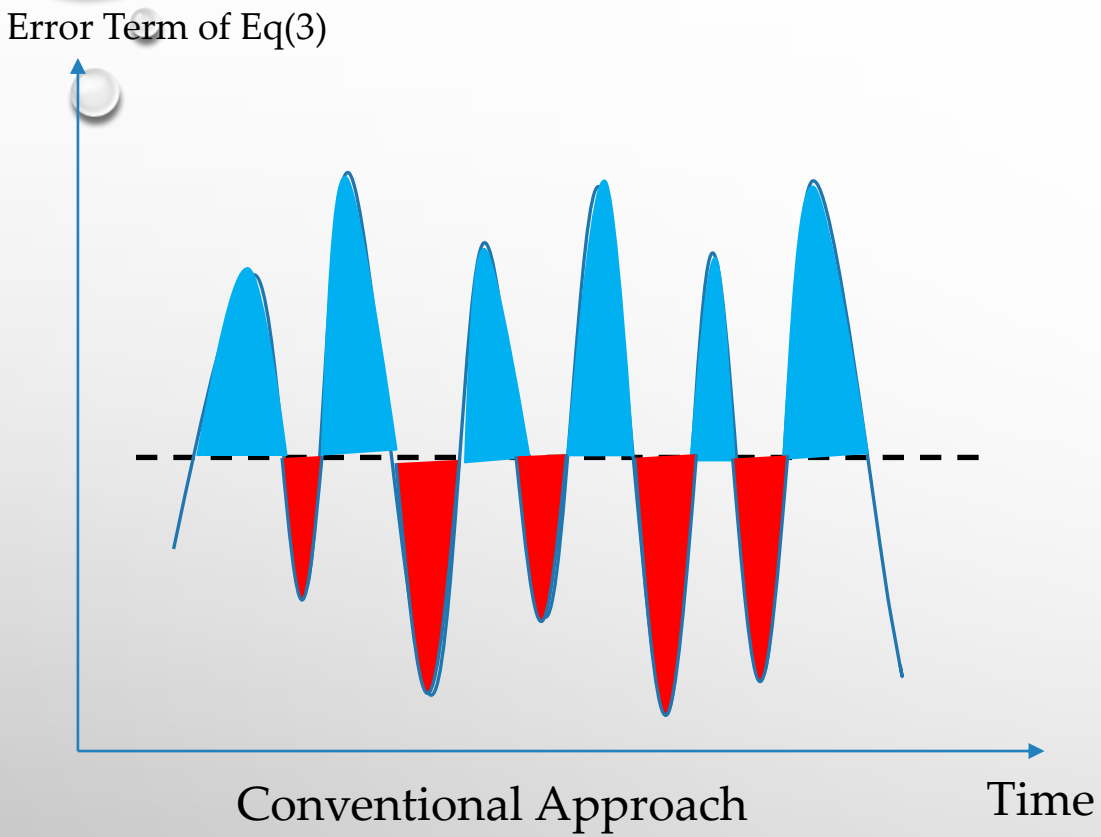
$$\Delta ln(AR)_{i,c.t}$$
$$= \beta_{0,i}^{TB} + \beta_{1,i}^{TB}\Delta ln(B)_{i,c,t} + \beta_{2,i}^{TB}\gamma_{i,c,t-1}^{TB} + \theta_{1,i}^{TB}DB_{i,t-1}^{+}\Delta ln(B)_{i,t} + \theta_{2,i}^{TB}DB_{i,t-1}^{+}\gamma_{i,c,t-1}^{TB}$$
$$+ \gamma_{1,i}^{TB}DB_{i,t-1}^{-}\Delta ln(B)_{i,t} + \gamma_{2,i}^{TB}DB_{i,t-1}^{-}\gamma_{i,c,t-1}^{TB} + v_{i,c,t}^{TB} \quad (5)$$

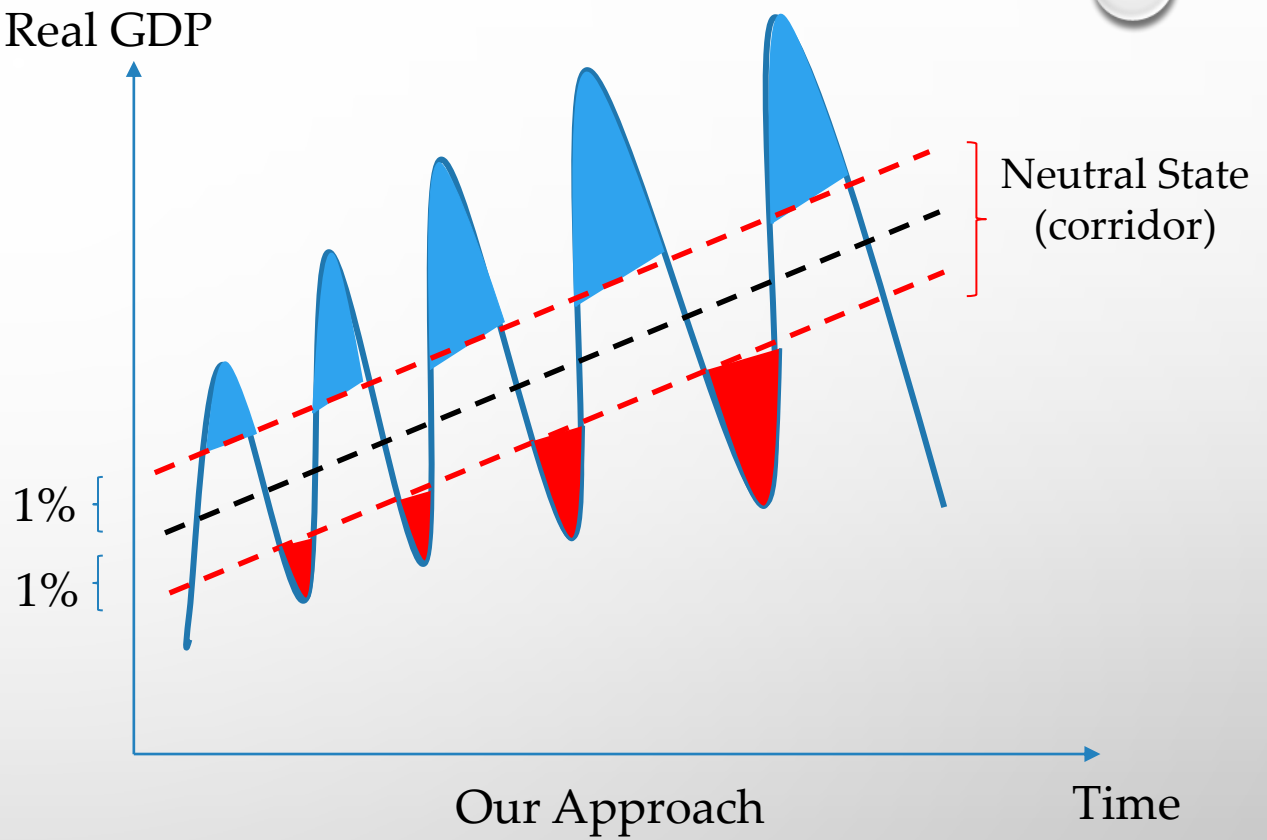
with: $DB_{i,t}^{+} = \begin{cases} 1, if\ gap > 0.01 \\ otherwise \end{cases}$ and $DB_{i,t}^{-} = \begin{cases} 1, if\ gap < -0.01 \\ otherwise \end{cases}$

$DB_{i,t}$ is a dummy for country i at time t based on the sign of the output gap. $DB_{i,t}^{+}$ ($DB_{i,t}^{-}$) takes the value of 1 when the output gap is greater (less) than (minus) 1%.

The coefficient for the tax base is β_1^{TB} for normal times, (β_1^{TB}+θ_1^{TB}) for booms, and (β_1^{TB}+γ_1^{TB}) for recessions. Analysing β_2^{TB}, (β_2^{TB}+θ_2^{TB}), and (β_2^{TB}+γ_2^{TB}), we test whether the speed of adjustment back to the long-term equilibrium between revenues and tax base differs between normal times, booms, and recessions, respectively.

ESTIMATION METHODOLOGY





The error correction term is translated into a dummy, taking the value 1 when revenues are above the estimated long-run relationship.

Straightforward to implement, yet it is not really the type of asymmetry economists are normally interested in.

Table A3: Summary of Good, Bad, and Normal Times Dummies

	US	Germany	UK
Number of good times	33	33	24
Number of bad times	26	33	27
Number of normal times	95	88	103

ESTIMATION METHODOLOGY

Base-to-GDP Elasticities

$$ln(B)_{i,c.t} = \alpha_{0,i}^{BY} + \alpha_{1,i}^{BY} ln(Y)_{i,t} + \sum_{j=-q}^{p} \pi_{i,j}^{BY} \Delta ln(B)_{i,t+j} + \epsilon_{i,c,t}^{BY} \quad (6)$$

$Y_{i,t}$stands for the GDP of country *i* in time *t*, and the coefficient of interest $\alpha_{1,i}^{BY}$ denotes the long-run base-to-GDP elasticity that measures the per cent base changes following a 1% change in GDP.

The transformed SR equation given in Equation (5) takes the following form:

$$\Delta ln(B)_{i,c.t} = \beta_{0,i}^{BY} + \beta_{1,i}^{BY} \Delta ln(Y)_{i,c,t} + \beta_{2,i}^{BY} \gamma_{i,c,t-1}^{BY} + \mu_{i,c,t} \quad (7)$$

where $\beta_{1,i}^{BY}$ indicates the short-run base-to-GDP elasticity.

To estimate the asymmetric base-to-GDP elasticities, we utilise the following equation:

$$\Delta ln(B)_{i,c.t} = \beta_{0,i}^{BY} + \beta_{1,i}^{BY} \Delta ln(Y)_{i,c,t} + \theta_{1,i}^{BY} DB_{i,t} \Delta ln(Y)_{i,t} + \beta_{2,i}^{BY} \gamma_{i,c,t-1}^{BY} + \theta_{2,i}^{BY} DB_{i,t-1} \gamma_{i,c,t-1}^{BY} + v_{i,c,t}^{BY} \quad (8)$$

ESTIMATION METHODOLOGY

Overall Tax Revenue-to-GDP Elasticities

LR: $$\alpha^{TY} = \alpha^{TB} * \alpha^{BY} \quad (9)$$

SR: $$\beta^{TY} = \beta^{TB} * \beta^{BY} \quad (10)$$

Equations (9) and (10) are also employed to calculate the asymmetric elasticities.

The estimation of the overall tax-to-output elasticities as laid out in Equations (9) and (10) follows OECD studies, who do not directly estimate the relationship in a regression of tax revenues on income but in a two-step procedure.

Empirical Findings - Symmetric Elasticities: Tax-to-Base

	Long Run			Short Run		
Tax Base	(I)	(II)	(III)	(IV)	(V)	(VI)
	US	Germany	UK	US	Germany	UK
Total Tax Base	1.09***	1.12***	0.96***	1.62***	0.45***	0.76***
Adjustment parameter				–0.06**	–0.13***	–0.33***
Wages & Salaries	1.28***	2.02***	1.12***	2.41***	0.76***	1.02***
Adjustment parameter				–0.23***	–0.14***	–0.28***
Compensation	0.99***	1.01***	1.01***	0.55***	0.42***	1.01***
Adjustment parameter				–0.17***	–0.20***	–0.19***
Private Consumption	0.88***	0.64***	0.84***	0.87***	0.51***	0.52**
Adjustment parameter				–0.07**	–0.10**	–0.25***
Corporate Profits	0.85***	1.58***	0.82***	1.18***	0.30*	1.06***
Adjustment parameter				–0.09**	–0.24***	–0.30***

Note: Underlining indicates statistically different from 1 at 5% level, *** p < 0.01, ** p < 0.05, * p < 0.1.

$LR_{US, Germ} > 1$ ➔ Progressive, $LR_{UK} < 1$ ➔ Regressive

$LR_{Germ} > 2$ ➔ Progressive, Marginal Tax Rate > Average Tax Rate

SR_{Germ} ~ Unity ➔ A significantly lower impact of wages on rev. than does in the LR.

Empirical Findings - Symmetric Elasticities: Base-to-Output

	Long Run			Short Run		
Tax Base	(I)	(II)	(III)	(IV)	(V)	(VI)
	US	Germany	UK	US	Germany	UK
Total Tax Base	1.04***	0.99***	1.03***	0.77***	0.75***	0.83***
Adjustment parameter				–0.20***	–0.24***	–0.09**
Wages & Salaries	0.95***	0.94***	0.98***	0.67***	0.66***	0.46***
Adjustment parameter				–0.06*	–0.10***	–0.08***
Compensation	0.97***	0.95***	1.01***	0.65***	0.61***	0.45***
Adjustment parameter				–0.06*	–0.12***	–0.06***
Private Consumption	1.06***	0.91***	1.04***	0.65***	0.51***	0.57***
Adjustment parameter				–0.22***	–0.17***	–0.05
Corporate Profits	1.39***	1.16***	1.00***	2.75***	2.02***	2.73***
Adjustment parameter				–0.08**	–0.42***	–0.11***

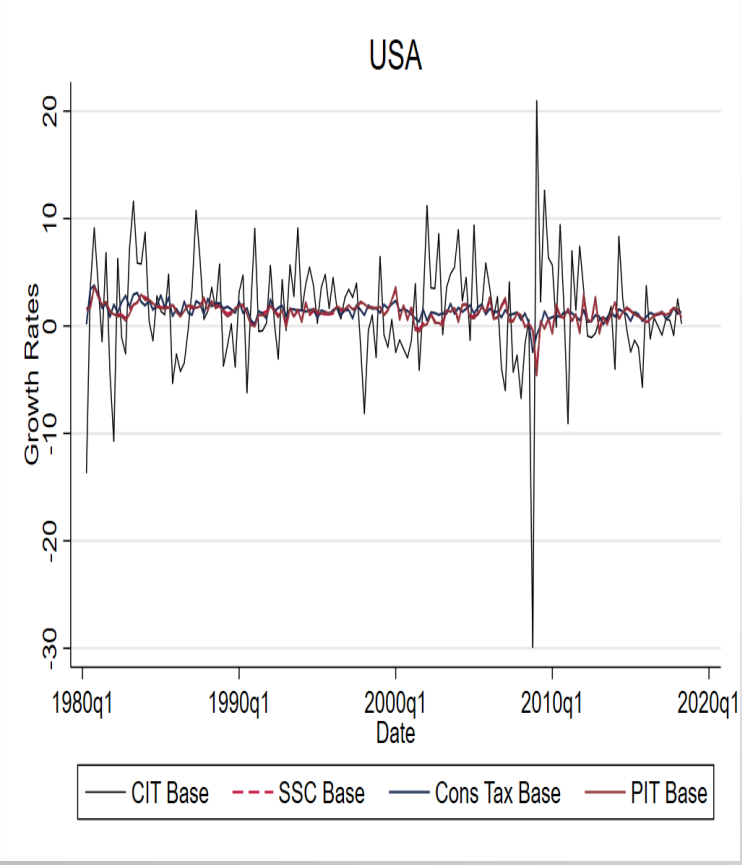
Note: Underlining indicates statistically different from 1 at 5% level, *** p < 0.01, ** p < 0.05, * p < 0.1.

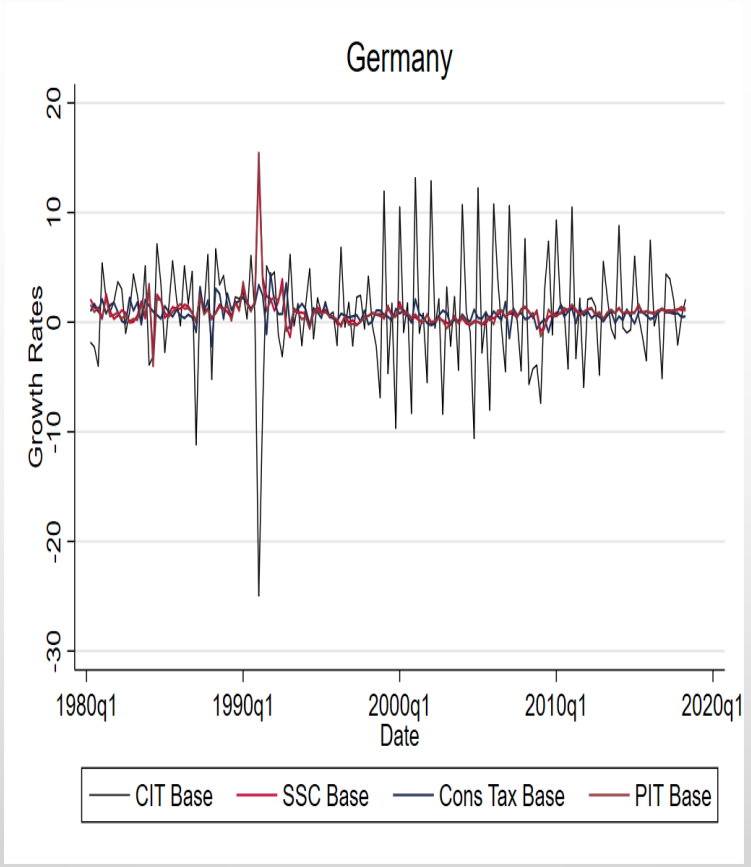
In this setup, it is important to clearly define LR and the SR elasticities.

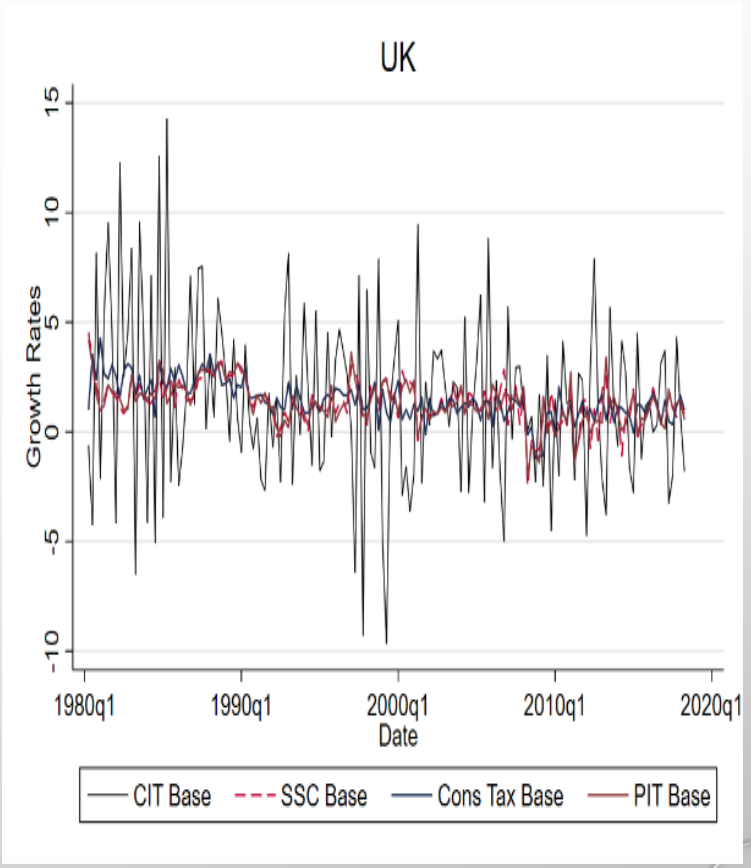
As the LR elasticities are obtained from log-level regressions, they show how rapidly a tax base grows compared to income.

The SR elasticities are estimated by the change in the log of the relevant variables; they can be treated as the cyclical component of tax-base variability.

Figure A4: Change in Growth Rates of Variables







Empirical Findings - Symmetric Elasticities: Tax-to-Output

	Long Run			Short Run		
Tax Type	(I)	(II)	(III)	(IV)	(V)	(VI)
	US	Germany	UK	US	Germany	UK
Total Taxes	1.13	1.08	0.99	1.25	0.34	0.63
Personal Income Tax	1.22	1.9	1.10	1.61	0.5	0.47
Social Security Contributions	0.96	0.96	1.02	0.36	0.26	0.45
Consumption Tax	0.93	0.58	0.87	0.57	0.26	0.30
Corporate Income Tax	1.18	1.83	0.82	3.25	0.61	2.89

Recall:

Overall Tax Revenue-to-GDP Elasticities

LR: $\alpha^{TY} = \alpha^{TB} * \alpha^{BY}$ (9)

SR: $\beta^{TY} = \beta^{TB} * \beta^{BY}$ (10)

Empirical Findings – Asymmetric Elasticities

In this regard, we report the SR estimates for

a. tax-to-base elasticities
b. base-to-GDP elasticities

generated using an ECM, which is conditional on the state of the business cycle.

Tax-to-base elasticities:

- For SSC, the bad times tax-to-base elasticities exceed the SR symmetric elasticities in all countries.
- For consumption tax, this result also holds for Germany and the UK.
- German aggregated tax elasticities are the lowest across the three countries.
- German personal income tax elasticities are the lowest during normal times and expansions, whereas US aggregated and personal income tax elasticities are the largest during normal times.
- Overall, for tax-to-base elasticities, we find business cycle asymmetries across countries, but not within countries.

Base-to-output elasticities:

- Significant business cycle asymmetries are detected for German and UK personal income tax and social security contributions. Elasticities are significantly lower during recessions than during booms. This means that we find fewer asymmetries across countries but some across tax types.

Empirical Findings – Asymmetric Elasticities

There are also some common patterns for all countries:

- For corporate income taxes in all countries, the good times tax-to-base elasticities are higher than bad times tax-to-base elasticities.
- For base-to-GDP elasticities, social security contributions and personal income tax elasticities are higher in booms than in recessions in all three economies.
- However, in terms of statistical significance, most of the boom and recession elasticities are neither statistically different from each other nor across countries.

Robustness

1. Instead of DOLS, we employed an OLS model to estimate the symmetric elasticities.

   The differences are minimal and generally not statistically significant at the 5% level.

2. We calculate elasticities with alternative bases. In this regard,

   We include house price changes (given the deductibility of mortgage payments) as a control variable, however, SR and LR elasticities did not change.

   Consumption tax is taken not only from private consumption but also government consumption and investment, so these are also added as controls, our results are insensitive to this exercise.

   For employee social security contributions, we use total compensation as a tax base. One can argue, however, that employers' and employees' shares are derived from gross wages. Consequently, as a robustness check, we use gross wages as the base for social security contributions.

Conclusion

1. In Germany and the UK, long-term tax-to-base elasticities are generally higher than short-term elasticities, whereas results for the US are mixed.

2. Short-term elasticities for base-to-output elasticities tend to be smaller than unity, whereas long-term elasticities are close to unity.

3. German and UK tax-to-output elasticities in the short term are lower than long-term elasticities, with mixed results for the US.

4. For tax-to-base elasticities, we find business cycle asymmetries across countries, but not within countries.

5. For base-to-output elasticities, our results suggest few asymmetries across countries, but more asymmetries across tax types.

6. Typically, the above conclusions do not hold for corporate income tax.

THANK YOU!