Supplementary material

Appendix A: Formal theoretical model

A simple formal model of government tax-setting is presented below. It is loosely based on a simplified version of the budget process model developed by Hallerberg et al. (2009, pp. 25–31).

General setup

A government sets a tax level t[1] on a number of constituencies, each of which are denoted by i. These constituencies can be thought of in terms of geography or social groups. Intuitively, different tax instruments affect different geographical areas and/or social groups differently; consumption taxes affect low-income households more than high-income households, as the former consume a large fraction of their income, whereas an increase in a progressive income tax affects high-income households more than low-income households. However, tax avoidance possibly also reduces the revenue from each constituency tax. Tax avoidance increases with the number of constituencies. Intuitively, having more geographical units and/or social groups, each of which are levied a specific tax, makes it easier for individuals and corporations to reclassify income[2] and/or shift activities from one geographical area to another to minimize tax payments. The number of constituencies is denoted by n. Total taxes T is the sum of all tax levels levied on the different constituencies, each divided by the number of constituencies to represent the loss from tax avoidance.

$$T = \sum_{i=1}^{n}(t_i/n) \quad (1)$$

[1] It is implicitly assumed throughout the model that the tax level is always positive.

[2] An obvious example is classifying capital income as wage income or vice versa for self-employed if different taxes exist for social groups depending on either capital income or wage income.

The cabinet's budget procedure determines how the tax level on each constituency is set. The cabinet can decide the tax level using a decentralized or centralized budget procedure.

Decentralized budget procedure

Consider a government cabinet in which each cabinet member[3] represents a given constituency and acts in their interest. With a decentralized budget procedure, the cabinet decides tax policy through non-hierarchical bargaining between its members. Each potential tax increase is decided individually, meaning that the government members must agree to add increases to each tax instrument to finance expenditures in the budget. Each cabinet member can therefore veto tax increases targeting their own constituency, and the tax level for each constituency is thus set according to the preference of the cabinet member representing it.

The preferences of the individual cabinet member can be represented by the utility function below. Each member draws utility from an exogenous set transfer to the cabinet member's constituency denoted by *x* and the overall improvement of the public budget, which is achieved through the cabinet's tax policies and the welfare of their constituencies.

$$U_i = x_i + total\ budget\ improvement_i + contituency\ welfare_i \quad (2)$$

Budget improvement is the tax level multiplied by the number of other constituencies. Intuitively, the cabinet members extrapolate the revenue potential of the tax level of their own constituencies to other constituencies. For a given improvement in the public budget, adding more constituencies to

[3] This can be thought of as both portfolio ministers and/or coalition parties.

share the fiscal burden of improving the budget logically reduces the average tax level of each constituency from the perspective of the individual cabinet member. Intuitively, adding more constituencies to share the burden of the fiscal improvement increases the opportunities to freeride on the taxation of the other constituencies. Each cabinet member thus potentially overstates the actual budget improvement contribution of the tax level levied on their own constituency.

$$total\ budget\ improvement_i = t_i n \tag{3}$$

Constituency welfare is one divided by the tax level levied on each constituency. This represents the distortion of the tax on the constituency's economic activity.

$$contituency\ welfare_i = \frac{1}{t_i} \tag{4}$$

Each cabinet member thus optimizes the function below with regards to *t*

$$U_i = x_i + t_i n + \frac{1}{t_i} \tag{5}$$

The first-order condition is

$$0 = n - \frac{1}{t_i^2} \tag{6}$$

Isolating *t* yields

$$t_i = \sqrt{\frac{1}{n}} \tag{7}$$

In the case of a decentralized budget procedure, the tax level for each constituency is therefore falling with the number of constituencies represented by cabinet members. This result can be seen as a slightly augmented version of the well-known common-pool problem in public finances or the *law of 1/n* (Weingast et al. 1981, p. 654), where the scale of public projects increases with the

number of politically represented constituencies, taxation being the dependent variable instead of public project scale.

Centralized budget procedure

In the case of a centralized budget procedure, the finance minister has agenda-setting power over the tax level for each constituency. The finance minister is assumed to represent no constituency and is only concerned with the budget improvement and the total welfare effect of the tax on each constituency. Formalized, the finance minister's utility function when setting a constituency tax is

$$U_{fm} = single\ budget\ improvement_i + total\ welfare \tag{8}$$

Since the finance minister sets the tax level of each constituency separately, they only factor in the budget improvement of the tax level of each individual constituency when setting it.

$$single\ budget\ improvement_i = t_i \tag{9}$$

The value for the budget improvement is thus different from the cabinet members, who consider an optimistic aggregate budget improvement based on extrapolation of the tax level to the wider number of constituencies.

The total welfare function is also different from the constituency welfare function, as the finance minister considers the negative welfare effect of the tax level vis-à-vis the total number of constituencies. Intuitively, the finance minister considers the cost of a given tax for the country as a whole, not just the constituency on which it is levied.

$$total\ welfare = \frac{n}{t_i} \tag{10}$$

Substituting equation 9 and 10 into equation 8, the finance minister has the following utility function

$$U_{fm} = t_i + \frac{n}{t_i} \tag{11}$$

However, the finance minister can only set tax levels according to own utility function with probability *P*. Intuitively, the cabinet might overrule the finance minister's initial taxation proposal. *P* is a function of the finance minister's agenda-setting power denoted by *a* times the number of constituencies, since greater veto-player distance, here represented by the number of constituencies, makes it harder to deviate from the status quo (Tsbelis 2002) of the initial taxation proposal.

Accordingly, as long as the finance minister has at least some agenda-setting power (in formal terms $a > 0$), the number of constituencies will positively affect the probability that the finance minister's preferred level of taxation is implemented. The finance minister thus optimizes the function below with regards to t

$$U_{fm} = P(t_i + \frac{n}{t_i}) = an(t_i + \frac{n}{t_i}) = ant_i + \frac{ann}{t_i} \tag{12}$$

The following first-order condition is

$$0 = an - \frac{ann}{t_i^2} \tag{13}$$

Isolating *t* yields

$$t_i = \sqrt{n} \tag{14}$$

Comparing equation 7 (the constituency tax setting under the decentralized budget procedure) and equation 14 (the constituency tax setting under the centralized budget procedure) in relation to the total taxes function from equation 1, it is easy to see that for $n > 1$, total taxes are ceteris paribus set lower under the decentralized budget procedure than under the centralized budget procedure. It also becomes clear that total taxation falls with the number of constituencies under a decentralized budget procedure in line with a common-pool argument, whereas the total taxes increase with the number of represented constituencies in a centralized budget procedure.

Appendix B: Output gap as business cycle variable

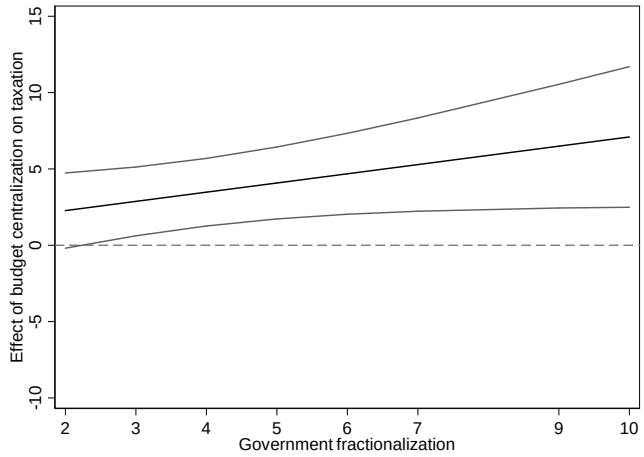
Table B1

	(1)	(2)	(3)	(4)
Delegation centralization index	3.859 (1.468)**	–	1.064 (1.976)	–
Contracts centralization index	–	2.306 (0.812)**	–	4.640 (1.988)**
Delegation index × government fractionalization	–	–	0.603 (0.391)	–
Contracts index × government fractionalization	–	–	–	–0.508 (0.417)
General government spending % of GDP	0.217 (0.063)***	0.183 (0.045)***	0.236 (0.062)***	0.170 (0.043)***
Government fractionalization	–0.366 (0.149)**	–0.339 (0.173)*	–0.748 (0.341)**	–0.066 (0.281)
Legislative election	–0.027 (0.154)	–0.063 (0.146)	–0.047 (0.149)	–0.066 (0.150)
Share of leftwing cabinet members	0.009 (0.003)**	0.011 (0.003)***	0.009 (0.003)***	0.011 (0.003)***
GDP per capita constant prices	–0.000 (0.000)	–0.000 (0.000)**	–0.000 (0.000)	–0.000 (0.000)**
Output gap	0.173 (0.119)	0.199 (0.099)*	0.181 (0.120)	0.195 (0.097)*
Country-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
Number of countries	15	15	15	15
Number of observations	273	273	273	273
Within R-squared	0.46	0.47	0.47	0.48

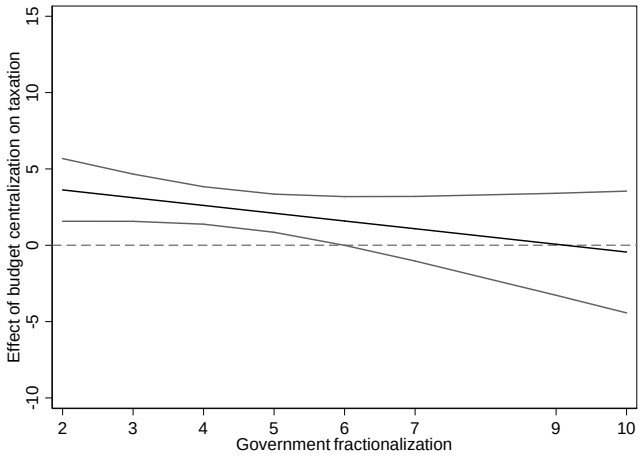
The dependent variable is taxation as % of GDP. Country-clustered standard errors in parentheses. *p < 0.10, **p < 0.05, ***p < 0.01.

Figure B1: The effect of centralization contingent on government fractionalization

a: Delegation centralization



b. Contracts centralization



Note: Outer lines show 90% confidence intervals. A is based on column 3 in Table B1, while b is based on column 4 in Table B1.

Appendix C: Alternative measure of government fractionalization

Table C1

	(1)	(2)
Delegation centralization index	10.024 (4.121)**	–
Contracts centralization index	–	2.690 (1.169)**
Government Herfindahl index	6.346 (2.762)**	1.830 (1.108)
Delegation index × government Herfindahl index	–8.956 (4.200)*	–
Contract index × government Herfindahl index	–	–0.312 (1.551)
General government spending % of GDP	0.259 (0.071)***	0.184 (0.045)***
Legislative election	–0.047 (0.130)	–0.072 (0.130)
Share of leftwing cabinet members	0.007 (0.004)	0.009 (0.004)**
GDP per capita constant prices	–0.000 (0.000)	–0.000 (0.000)
GDP growth	–0.052 (0.082)	–0.044 (0.089)
Country-fixed effects	Yes	Yes
Year-fixed effects	Yes	Yes
Number of countries	276	276
Number of observations	15	15
Within R-squared	0.41	0.42

The dependent variable is taxation as % of GDP. Country-clustered standard errors in parentheses.
*p < 0.10, **p < 0.05, ***p < 0.01.

Appendix D: Inclusion of a lagged dependent variable

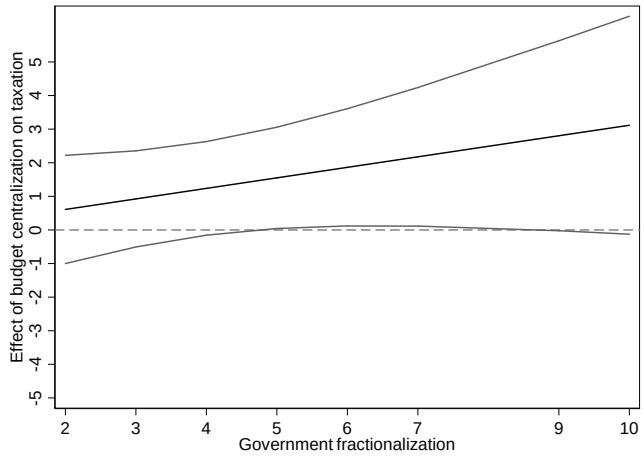
Table D1

	(1)	(2)	(3)	(4)
Lagged dependent variable	0.607 (0.089)***	0.587 (0.090)***	0.600 (0.091)***	0.578 (0.088)***
Delegation centralization index	1.413 (0.835)	–	–0.016 (1.359)	–
Contracts centralization index	–	1.147 (0.489)**	–	2.202 (1.160)*
Delegation index × government fractionalization	–	–	0.313 (0.285)	–
Contracts index × government fractionalization	–	–	–	–0.222 (0.243)
General government spending %.of GDP	0.066 (0.028)**	0.045 (0.022)*	0.075 (0.030)**	0.041 (0.022)*
Government fractionalization	–0.230 (0.093)**	–0.227 (0.102)**	–0.431 (0.228)*	–0.110 (0.174)
Legislative election	–0.065 (0.188)	–0.079 (0.176)	–0.075 (0.185)	–0.080 (0.177)
Share of leftwing cabinet members	0.005 (0.003)**	0.006 (0.003)**	0.005 (0.003)*	0.006 (0.003)**
GDP per capita constant prices	–0.000 (0.000)	–0.000 (0.000)	–0.000 (0.000)	–0.000 (0.000)
GDP growth	–0.061 (0.051)	–0.060 (0.050)	–0.065 (0.050)	–0.065 (0.051)
Country-fixed effects	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
Number of countries	15	15	15	15
Number of observations	276	276	276	276
Within R-squared	0.66	0.67	0.66	0.67

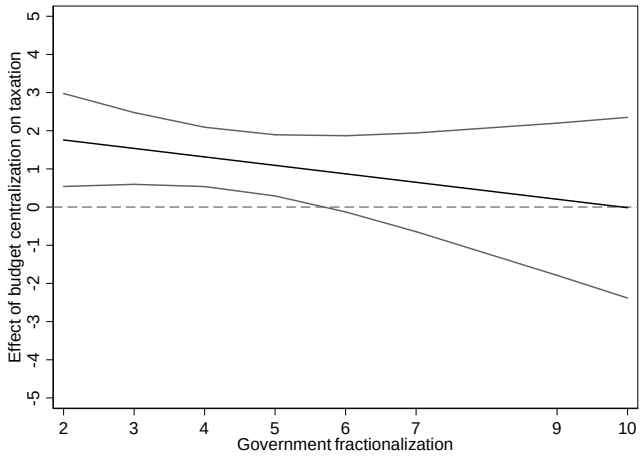
The dependent variable is taxation as % of GDP. Country-clustered standard errors in parentheses.
*p < 0.10, **p < 0.05, ***p < 0.01.

Figure D1: The effect of centralization contingent on government fractionalization

a: Delegation centralization



b. Contracts centralization



Note: Outer lines show 90% confidence intervals. A is based on column 3 in Table D1, while b is based on column 4 in Table D1.