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Tax smoothing versus tax shifting

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Abstract

Household-specific growth rates of the tax base imply that the timing of tax collections determines the distribution of tax burdens and wealth across households. Changes in fiscal policy do not only shift tax burdens across generations, but also within cohorts. Institutional deficit constraints settle tax shifting conflicts in favor of individuals with high income growth. With distortionary taxes, policy makers trade off the relative wealth effects of fiscal policy and the efficiency cost of household-specific deadweight burdens. I apply the incidence analysis of fiscal policy to answer the question how the German unification should have optimally been financed.

JEL classification: E61; E62; H63

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1. Introduction

Confronted with the need to raise revenue, governments must balance efficiency and equity considerations. In macroeconomics, the latter are often associated with the intergenerational wealth effects of government debt. This paper argues that in many circumstances, there are important *intra*generational wealth and welfare effects of government debt policy that are unrelated to the policy's impact on the generational accounts.

The financing of the German unification is a case in point. Starting from low levels, East German labor productivity and per capita labor incomes have started to catch up with West Germany's. The difference between the growth rates of the tax base in East and West Germany implies that the timing of tax collections determines the cross sectional

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distribution of tax burdens: Taxes levied in the 1990s were overwhelmingly paid by West Germans since their compatriots in the East had very low incomes; taxes levied in the future, in contrast, will be shared more equally between East and West Germans since per capita incomes will have converged. In essence, therefore, budget deficits and subsequent surpluses—as aimed for by German policy makers in the 1990s—replicate a wealth tax that is progressive in the growth rate of income. Ceteris paribus, a balanced budget policy would have benefited East Germans and hurt West Germans relative to the fiscal policy that was actually enacted.

I analyze the intragenerational welfare effects of fiscal policy in a version of Lucas and Stokey's (1983) benchmark economy. Lucas and Stokey (1983) show within a framework characterized by distortionary taxes, intergenerational altruism, and a representative agent, that Ramsey's (1927) findings translate into a tax smoothing prescription according to which the optimal fiscal policy smooths deadweight burdens across time and states of nature (cf. also Bohn, 1990; Chari et al., 1991). In this framework, I introduce intragenerational heterogeneity in the form of household-specific growth rates of labor productivity. The resulting economy differs from the many-person Ramsey setup of Diamond and Mirrlees (Diamond and Mirrlees, 1971a, 1971b; Diamond, 1975) because the government is restricted to a uniform labor income tax schedule. Optimal fiscal policy trades off the benefits and cost of tax smoothing and tax shifting. For given paths of government spending and aggregate productivity and for a given governmental objective function, the optimal sequence of budget deficits depends on the productivity profiles of all groups in society.

While the model economy features distortionary taxes, it is clear that intragenerational wealth effects arise independently of tax induced distortions:[1] Household-specific growth rates of the tax base break Ricardian equivalence even if markets are complete, taxes are non-distortionary, and generations are altruistically linked.[2] The non-neutrality of fiscal policy changes is then solely due to the presence of individual budget constraints in the cross section; it disappears only if households trade behind a Veil of Ignorance.[3]

Section 2 presents the model and analyzes the wealth and welfare effects of fiscal policy in general equilibrium. In Section 3, I analyze optimal policy. I compare the Ramsey

[1] This contrasts with Bassetto (1999). There, only one group of households is taxed such that the tax burden cannot be shifted. Since taxes are distortionary, a change in fiscal policy affects the deadweight burden borne by the taxpayers. Moreover, it indirectly shifts wealth between taxpayers and non-tax-paying "renters," if the timing of tax collections affects the interest rate. In my model, fiscal policy affects the wealth distribution both directly and indirectly.

[2] Cf. Bernheim (1987), Bernheim and Bagwell (1988), and Elmendorf and Mankiw (1999) for discussions of the Ricardian equivalence proposition. Cf. Diamond (1965), Blanchard (1985), and Auerbach et al. (1991) for analyses of the intergenerational distributive effects of fiscal policy that arise in the absence of intergenerational altruism. My emphasis on direct intragenerational wealth effects contrasts with Bernheim (1987, p. 271) who dismisses them as being of "second-order importance." Bernheim's assessment derives from his interest in the validity of Ricardian equivalence on the aggregate level, combined with his assumption that heterogeneous households exhibit similar propensities to consume out of their wealth. For an analysis of the lifetime tax burden of heterogeneous groups due to different kinds of taxes, cf. Fullerton and Rogers (1993).

[3] Household-specific budget constraints can be interpreted as a form of market incompleteness (Geanakoplos, 1990, p. 3). Ricardian equivalence holds if, in this broad sense, markets are complete (cf. also Gale, 1990).

equilibrium to the equilibrium in an economy where households act behind the Veil of Ignorance, and I show that the results of the model are robust to the introduction of non-linear taxes. Section 4 discusses policy implications in the context of the German unification example. The results suggest that deficit financing of the German unification favored West Germans by shifting part of the tax burden from West to East Germans. Section 5 discusses the maturity structure of public debt that renders the social welfare maximizing policy time consistent. Section 6 concludes with a brief discussion of further implications and applications of the model.

2. The model

2.1. Structure of the economy

The economy is closed. As in Lucas and Stokey (1983), it consists of a government and a continuum of households of measure one. Households live from period 0 to period T (T may be ∞). Both the government and households perfectly foresee the deterministic sequences of all exogenous variables. (For an analysis under uncertainty, cf. the working paper version (Niepelt, 2002).)

The population is split into two groups: Type a households amount to a fraction η of the consumers ($0 < \eta < 1$), type b households to a fraction $1-\eta$. The welfare of a household is defined to be the discounted (by factor β^t) sum of felicity functions. The latter are given by $u(c_t^a, x_t^a) \equiv \ln(c_t^a) + \gamma^a \ln(x_t^a)$ for a-types and $v(c_t^b, x_t^b) \equiv \ln(c_t^b) + \gamma^b \ln(x_t^b)$ for b-types, where c_t^i and x_t^i denote type i's consumption at time t of the single good and leisure, respectively, and $\gamma^i > 0, i = a, b$. The logarithmic utility assumption is not important for the results of the paper. It simplifies the equilibrium conditions by fixing the expenditure shares and inducing fixed ratios of consumption across types. (In Appendix A.1, I provide a general (in the class of time separable utility functions) characterization of the Ramsey policy. The gain in generality comes at the high cost of a loss of analytical tractability.) Each household is endowed with one unit of time per period. Production is linear in labor with productivities w_t^i, $i = a, b$. For notational convenience, I define $w_t \equiv w_t^a / w_t^b$, $\gamma \equiv \gamma^a / \gamma^b$, $c_t \equiv c_t^a / c_t^b$, and $x_t \equiv x_t^a / x_t^b$.

The exogenous resource requirement of the government, g_t, is financed out of taxes and budget deficits. Because the government only observes a household's labor income, but not type, productivity, or labor supply, it must resort to a labor income tax schedule.[4] The important implication is that the government cannot differentiate the time profile of tax rates across individuals independent of their labor income. For the time being, I assume a proportional labor income tax such that average and marginal tax rates are identical. (This assumption can be relaxed, see below.) This renders the structure of the government's problem similar to the many-person Ramsey setup (cf. Diamond and Mirrlees, 1971a, 1971b; Diamond, 1975); the crucial difference is the requirement that

4 Cf. Atkinson and Stiglitz (1976).

tax rates on sales of labor services by different household types be uniform.[5] Due to the static technology that prevents intertemporal substitution in production, a certain allocation does not pin down relative producer prices across time. Since households receive no lump sum income, this implies that the tax rate on purchases of the consumption good can be normalized to zero.

Households behave competitively. They take the sequences of labor productivity, prices of the consumption good $\{p_t\}_{t=0}^T$, and tax rates $\{\tau_t\}_{t=0}^T$ as given and plan consumption and leisure $\{c_t^i, x_t^i\}_{t=0}^T$, $i = a, b$, as well as the holdings of financial claims in order to maximize utility.

A competitive equilibrium in this economy consists of a tax and debt plan, a price sequence, and consumption and leisure choices satisfying the economy's resource constraints,

$$\begin{aligned} &e_t \equiv \eta w_t^a + (1-\eta) w_t^b - g_t = \eta\big(c_t^a + w_t^a x_t^a\big) + (1-\eta)\big(c_t^b + w_t^b x_t^b\big), \qquad (1)\\ &\quad t = 0, 1, 2, \ldots, T,\\ &0 \leqslant x_t^i \leqslant 1, \quad i = a, b,\ t = 0, 1, 2, \ldots, T, \end{aligned}$$

the budget constraints of households and the government, and that correspond with utility maximization on the part of consumers. I assume that government expenditure is always feasible, $e_t > 0$, $t = 0, 1, 2, \ldots, T$, and that equilibria are interior. In equilibrium, a temporary government budget deficit is matched by savings of the private sector. The government's intertemporal budget constraint is automatically satisfied, whenever the households' budget constraints and the aggregate resource constraints are.

The weighted—by $\theta^a \eta$ and $\theta^b(1-\eta)$—sum of the welfare of the two types defines the government's objective function.[6] Among the tax plans that result in a competitive equilibrium, the government chooses one that maximizes social welfare. Until later, I neglect issues of time consistency and assume that the government is able to commit to this ex ante optimal policy.

2.2. Households' problem

A household of type i, $i = a, b$, solves the problem[7]

$$\max_{\{c_t^i, x_t^i\}_{t=0}^T} \sum_{t=0}^{T} \beta^t \big[\ln\big(c_t^i\big) + \gamma^i \ln\big(x_t^i\big)\big]$$

$$\text{s.t.} \quad \sum_{t=0}^{T} p_t (1-\tau_t) w_t^i = \sum_{t=0}^{T} p_t \big[c_t^i + (1-\tau_t) w_t^i x_t^i\big].$$

[5] In each period, there are three goods: The consumption good, hours supplied by a-types, and hours supplied by b-types. Different household types value goods differently and are endowed with different goods. The restriction that the government imposes equal tax rates on both types (captured by Eq. (5) below) amounts to a uniformity requirement that is not present in the standard many-person-Ramsey setup.

[6] Under the additional assumption $\theta^a = \theta^b$, the Benthamite social welfare function results.

[7] I assume that no debt is outstanding at the beginning of period 0.

The budget constraint requires household wealth, the market value of productivity endowments after taxes, to equal the market value of goods and leisure consumption. The first-order conditions of this problem define the household's consumption and leisure choices as functions of productivities, tax rates, and prices.[8] To reduce the number of variables, I substitute out prices and tax rates to find the implementability constraints:

$$\sum_{t=0}^{T} \beta^t \left[1 - \gamma^a \left(1 - x_t^a\right)/x_t^a\right] = 0, \tag{2}$$

$$\sum_{t=0}^{T} \beta^t \left[1 - \gamma^b \left(1 - x_t^b\right)/x_t^b\right] = 0, \tag{3}$$

$$\frac{c_t^a}{c_t^b} = \frac{c_0^a}{c_0^b} \equiv c, \quad t = 1, 2, \ldots, T, \tag{4}$$

$$\frac{x_t^a w_t^a}{x_t^b w_t^b \gamma} = c, \quad t = 0, 1, 2, \ldots, T. \tag{5}$$

Equations (2) or (3) correspond to the single implementability constraint arising in a representative agent setup. They combine the budget constraint with the static and dynamic optimality conditions. Conditions (4) and (5) capture the restrictions that both types of households face the same prices and marginal tax rates. (2)–(5) simplify to

$$\frac{\gamma^b}{1 + \gamma^a} \frac{1}{\sum_{t=0}^{T} \beta^t} \sum_{t=0}^{T} \beta^t \frac{w_t}{x_t^b} = c, \tag{6}$$

$$\frac{1 + \gamma^b}{\gamma^b} \sum_{t=0}^{T} \beta^t = \sum_{t=0}^{T} \beta^t \frac{1}{x_t^b}, \tag{7}$$

$$c_t^a = c_t^b c, \quad t = 0, 1, 2, \ldots, T, \tag{8}$$

$$x_t^a = x_t^b c\gamma / w_t, \quad t = 0, 1, 2, \ldots, T. \tag{9}$$

Equations (6)–(9) represent all equilibrium restrictions implied by optimal household behavior.

2.3. Constraints of the government's problem

When choosing the tax profile, the government must take its own budget constraint, the implementability constraints (6)–(9), and the resource constraints into account. Given the latter, one of the three budget constraints is redundant.

Substituting for c_t^a and x_t^a (from (8) and (9)) in the resource constraint, results in

$$c_t^b = \frac{e_t - x_t^b w_t^b (\eta c\gamma + 1 - \eta)}{\eta c + 1 - \eta}, \quad t = 0, 1, 2, \ldots, T. \tag{10}$$

[8] $\beta^t c_0^i / c_t^i = p_t / p_0$, $t = 0, 1, 2, \ldots, T$; $w_t^i (1 - \tau_t)/c_t^i = \gamma^i / x_t^i$, $t = 0, 1, 2, \ldots, T$; and the budget constraint.

Without further restrictions on fiscal policy, the government faces a single intertemporal budget constraint,

$$\sum_{t=0}^{T} p_t\big[g_t - \tau_t\big(\eta w_t^a\big(1-x_t^a\big) + (1-\eta) w_t^b\big(1-x_t^b\big)\big)\big] = 0,$$

or, using again the households' first-order conditions to substitute out prices and tax rates,

$$\sum_{t=0}^{T} \beta^t s_t = 0, \tag{11}$$

$$s_t \equiv \eta c\big(1+\gamma^a\big) + (1-\eta)\big(1+\gamma^b\big) - \gamma^b(\eta w_t + 1 - \eta)/x_t^b.$$

Under institutional restrictions on government financing, (11) is replaced by tighter constraints.[9] A balanced budget (BB) requirement constitutes an important special case among such institutional restrictions. A strict BB rule requires tax revenue to equal government expenditure in each period, i.e.

$$s_t = 0, \quad t = 0, 1, 2, \ldots, T. \tag{12}$$

Under a strict BB rule, the allocation satisfies (6)–(9), (10) and (12), and involves no degrees of freedom. Under no BB rule, it satisfies (6)–(9), (10) and (11), and does involve degrees of freedom. I will first solve for the former allocation, because it serves as a reference point for the analysis of policy changes. Afterwards, I will solve for the latter allocation as a function of the government's free policy instruments. This, in turn, will allow me to characterize the optimality conditions with respect to those instruments.

2.4. Allocation under a strict BB rule

To derive the allocation under a strict BB policy (7) and (12) are solved for c; (12) for x_t^b, $t = 0, 1, 2, \ldots, T$; (10) for c_t^b, $t = 0, 1, 2, \ldots, T$; and finally (8) and (9) for c_t^a, x_t^a, $t = 0, 1, 2, \ldots, T$:[10]

$$\bar{c} = \frac{1+\gamma^b}{1+\gamma^a}\,\frac{B-(1-\eta)\Omega}{\eta\Omega}, \tag{13}$$

$$\bar{x}_t^b = \frac{\gamma^b}{1+\gamma^b}\,\frac{\eta w_t + 1 - \eta}{B}\Omega, \quad t = 0, 1, 2, \ldots, T, \tag{14}$$

$$\bar{c}_t^b = \frac{(\eta w_t^a + (1-\eta) w_t^b)\big(1 + (1-\eta)\frac{\Omega}{B}\frac{\gamma^a-\gamma^b}{1+\gamma^b}\big) - g_t(1+\gamma^a)}{(1+\gamma^b)(B/\Omega - (1-\eta)) + (1-\eta)(1+\gamma^a)},$$
$$t = 0, 1, 2, \ldots, T, \tag{15}$$
$$\bar{c}_t^a = \bar{c}_t^b \bar{c}, \quad t = 0, 1, 2, \ldots, T,$$

[9] In that case, one of the households' budget constraints—not the government's budget constraint—is redundant.

[10] For any variable q_t, let $\bar{q}_t$ denote the value under a strict BB policy.

$$\bar{x}_t^a = \bar{x}_t^b \bar{c}\gamma / w_t, \quad t = 0, 1, 2, \ldots, T,$$
$$\Omega \equiv \sum_{t=0}^{T} \beta^t (\eta w_t + 1 - \eta)^{-1}, \qquad B \equiv \sum_{t=0}^{T} \beta^t.$$

Under a strict BB rule, the allocation is fully determined by the aggregate equilibrium conditions and the households' optimizing behavior. The government's optimal taxation program is trivial, as it involves no degrees of freedom.

2.5. Allocation under no BB rule

In the absence of a BB rule, the government's choices with respect to c and x_t^b, $t = 0, 1, 2, \ldots, T$, are only restricted by (6) and (7) (since (11) is redundant). The associated degrees of freedom correspond with the government's flexibility to shift tax collections across time. Without loss of generality, I choose x_t^b, $t = 1, 2, \ldots, T$, to represent the policy instruments. (Since tax rates have been substituted out, the "real" policy instruments are no longer present in the equation system. However, a specific sequence of x_t^b's directly corresponds with a sequence of these "real" instruments.) To derive the allocation under no BB rule, solve (7) for x_0^b (given the values of the policy instruments x_t^b, $t = 1, 2, \ldots, T$); (6) for c; (10) for c_t^b, $t = 0, 1, 2, \ldots, T$; and finally (8) and (9) for c_t^a, x_t^a, $t = 0, 1, 2, \ldots, T$:

$$x = \text{vector of policy instruments } x_t^b, \quad t = 1, 2, \ldots, T,$$
$$x_0^b(x) = \left(\frac{1+\gamma^b}{\gamma^b} B - \sum_{t=1}^{T} \beta^t \frac{1}{x_t^b} \right)^{-1}, \tag{16}$$
$$c(x) = w_0 \frac{1+\gamma^b}{1+\gamma^a} + \frac{\gamma^b}{1+\gamma^a} \frac{1}{B} \sum_{t=1}^{T} \beta^t \frac{w_t - w_0}{x_t^b}, \tag{17}$$
$$c_t^b(x) = \frac{e_t - x_t^b w_t^b (\eta c(x)\gamma + 1 - \eta)}{\eta c(x) + 1 - \eta}, \quad t = 1, 2, \ldots, T, \tag{18}$$
$$c_0^b(x) = \frac{e_0 - x_0^b(x) w_0^b (\eta c(x)\gamma + 1 - \eta)}{\eta c(x) + 1 - \eta}, \tag{19}$$
$$c_t^a(x) = c_t^b(x) c(x), \quad t = 0, 1, 2, \ldots, T,$$
$$x_t^a(x) = x_t^b c(x)\gamma / w_t, \quad t = 1, 2, \ldots, T,$$
$$x_0^a(x) = x_0^b(x) c(x)\gamma / w_t.$$

2.6. Redistribution

Equation (17) captures the tax shifting result in general equilibrium. It shows that changes in fiscal policy affect relative wealth[11] if w_t varies over time. (If w_t is constant the second term in (17) collapses to zero.) Consider, for example, an increase in x_t^b

[11] Relative wealth equals $c(1+\gamma^a)/(1+\gamma^b)$.

accompanied by a decline in x_0^b (given by (16)). This policy change implies an increase of x_t^b/x_s^b and a decline of x_0^b/x_s^b, $s = 1, \ldots, t-1, t+1, \ldots, T$. In equilibrium, the higher x_t^b/x_s^b and lower x_0^b/x_s^b ratios are associated with a fall of $p_t(1-\tau_t)$ and an increase of $p_0(1-\tau_0)$, relative to each $p_s(1-\tau_s)$, because households choose fixed expenditure shares for their leisure consumption. Households that experience a comparatively high (low) relative productivity in period 0 (t) benefit from this effect.

The wealth shift operates through two channels. First, tax rates change, which alters after tax productivities and wealth. Second, demand responses imply, that prices adjust in order to equilibrate markets. These price changes affect wealth by altering the market values (after tax) of time endowments. Equation (17) reports the compounded relative wealth effect due to these two channels.[12]

3. Optimal fiscal policy

The optimal policy maximizes social welfare, subject to the constraints governing the allocation under no BB rule. In equilibrium, social welfare can be expressed without explicit reference to c_t^a and x_t^a because (using (8) and (9))

$$u\left(c_t^a, x_t^a\right) = v\left(c_t^b, x_t^b\right) + \left(\gamma^a - \gamma^b\right)\ln\left(x_t^b\right) + \left(1+\gamma^a\right)\ln(c) + \gamma^a \ln(\gamma/w_t).$$

The government's program therefore reads[13]

$$\begin{aligned}
&\max_{\{x_t^b\}_{t=1}^T} \sum_{t=0}^{T} \beta^t \Big\{ \left(\theta^a \eta + \theta^b (1-\eta)\right)\left[\ln\left(c_t^b\right) + \gamma^b \ln\left(x_t^b\right)\right] \\
&\qquad\qquad + \theta^a \eta \left[\left(\gamma^a - \gamma^b\right)\ln\left(x_t^b\right) + (1+\gamma^a)\ln(c) + \gamma^a \ln(\gamma/w_t)\right]\Big\} \\
&\text{s.t.} \quad (16)\text{–}(19).
\end{aligned} \tag{20}$$

I substitute (16)–(19) into the government's objective function and differentiate with respect to the policy instruments.[14] A typical first-order condition with respect to x_t^b takes the form $\sum_{j=1}^{3} D_{jt} = 0$, where

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[12] Note that the resource constraint plays no role in determining c. For a given sequence $\{x_t^b\}_{t=1}^T$, the implementability constraints alone pin down the wealth distribution. This property is due to the logarithmic utility assumption and the absence of an exogenous income stream. These ingredients imply that the equilibrium conditions are block recursive: The policy instruments together with conditions (6), (7), and (9) determine $\{x_t^i\}_{t=0}^T$, $i = a, b$, and c. The resource constraint and (8) then fix $\{c_t^i\}_{t=0}^T$, $i = a, b$, and the households' first-order conditions pin down $\{p_t/p_0\}_{t=1}^T$ and $\{\tau_t\}_{t=0}^T$. Alternatively, households' leisure demands and the definition of household wealth link c, $\{x_t^i\}_{t=0}^T$, $i = a, b$, and the relative prices of productivity endowments $\{p_t(1-\tau_t)/p_0(1-\tau_0)\}_{t=1}^T$. Given these values, the resource constraint and households' demands for goods determine $\{c_t^i\}_{t=0}^T$, $i = a, b$, $\{p_t/p_0\}_{t=1}^T$, and $\{\tau_t\}_{t=0}^T$.

[13] In stating the government's program, I neglect the inequality constraints in (1).

[14] In Appendix A.1, I discuss the generalized version of (20) and compare the first-order conditions of that program with those found by Lucas and Stokey (1983).

$$D_{1t} \equiv \left(\theta^a \eta + \theta^b(1-\eta)\right)\left[\beta^t\left(\frac{1}{c_t^b}\frac{\partial c_t^b}{\partial x_t^b} + \frac{\gamma^b}{x_t^b}\right) + \left(\frac{1}{c_0^b}\frac{\partial c_0^b}{\partial x_0^b} + \frac{\gamma^b}{x_0^b}\right)\frac{\partial x_0^b}{\partial x_t^b}\right],$$

$$D_{2t} \equiv \left\{\left(\theta^a \eta + \theta^b(1-\eta)\right)\left[\sum_{s=0}^{T}\beta^s \frac{1}{c_s^b}\frac{\partial c_s^b}{\partial c}\right] + \theta^a \eta\left[(1+\gamma^a)B\frac{1}{c}\right]\right\}\frac{\partial c}{\partial x_t^b},$$

$$D_{3t} \equiv \theta^a \eta\left[\left(\gamma^a - \gamma^b\right)\left(\beta^t \frac{1}{x_t^b} + \frac{1}{x_0^b}\frac{\partial x_0^b}{\partial x_t^b}\right)\right].$$

Terms D_{1t}, D_{2t}, and D_{3t} summarize the social welfare implications of a change in x_t^b in general equilibrium. Consider first D_{1t}: A marginal increase in leisure provides utility (γ^b/x_t^b) but goes hand in hand with a decrease in goods consumption (due to the resource constraint), thereby negatively affecting utility $(1/c_t^b\ \partial c_t^b/\partial x_t^b)$. Furthermore, the change in x_t^b must be accompanied by a variation in x_0^b (and therefore c_0^b) to be implementable. D_{1t} accounts for these four effects, holding the wealth distribution constant. D_{2t} measures the social welfare effect due to the impact of the policy change on the wealth distribution. D_{3t} corrects for differences in household preferences for leisure.

The partial derivatives in D_{1t}, D_{2t}, and D_{3t} (following from (16)–(19)) are given by

$$\frac{\partial c_t^b}{\partial x_t^b} = -\frac{w_t^b(\eta c\gamma + 1 - \eta)}{\eta c + 1 - \eta} = -\frac{\gamma^b}{1-\tau_t}\frac{c_t^b}{x_t^b}\frac{\eta c\gamma + 1 - \eta}{\eta c + 1 - \eta}, \quad t = 0, 1, 2, \ldots, T, \tag{21}$$

$$\begin{aligned}\frac{\partial c_t^b}{\partial c} &= -\frac{\eta e_t - (1-\eta)\eta w_t^b x_t^b(1-\gamma)}{(\eta c + 1 - \eta)^2} \\ &= -c_t^b \frac{\eta(\gamma w_t^b x_t^b + c_t^b)}{\eta c_t^a + (1-\eta)c_t^b} = -\frac{\eta(w_t^a x_t^a + c_t^a)}{\eta c_t^a + (1-\eta)c_t^b}\frac{c_t^b}{c}, \quad t = 0, 1, 2, \ldots, T,\end{aligned} \tag{22}$$

$$\frac{\partial x_0^b}{\partial x_t^b} = -\frac{\beta^t (x_0^b)^2}{(x_t^b)^2}, \quad t = 1, 2, \ldots, T, \tag{23}$$

$$\frac{\partial c}{\partial x_t^b} = -\frac{\gamma^b}{1+\gamma^a}\frac{1}{B}\beta^t \frac{w_t - w_0}{(x_t^b)^2}, \quad t = 1, 2, \ldots, T. \tag{24}$$

$\partial c_t^b/\partial x_t^b$ reflects the resource constraint and the equilibrium conditions (8) and (9): An increase in x_t^b reduces production which necessitates a cut in consumption. $\partial c_t^b/\partial c$ manifests the same restrictions: An increase in c raises both x_t^a relative to x_t^b and c_t^a relative to c_t^b. The first effect reduces aggregate production and consumption of all households. The second effect amplifies the reduction for b-types. The partial derivative gives the resulting cumulative effect on c_t^b. $\partial x_0^b/\partial x_t^b$ represents the implementability constraint of b-types. Finally, $\partial c/\partial x_t^b$ reflects all implementability constraints. It measures to what extent the wealth ratio adjusts in response to a policy change, such that households' expenditure shares remain fixed.

Returning to the expressions for D_{1t}, D_{2t}, and D_{3t}, it is helpful to consider several special cases that isolate the various welfare effects captured by the first-order condition.

Assume first that households are homogeneous, $\gamma = 1$ and $c = 1$.[15] This implies that $D_{2t} = D_{3t} = 0$ and

$$\frac{\partial c_t^b}{\partial x_t^b} = -w_t^b.$$

The marginal rate of transformation between leisure and consumption on the aggregate level, $-w_t^b$, and as perceived by an individual household, $-w_t^b(1-\tau_t)$, therefore only differs for $\tau_t \neq 0$. D_{1t} simplifies to

$$\bigl(\theta^a\eta + \theta^b(1-\eta)\bigr)\left[\beta^t \frac{\gamma^b}{x_t^b}\left(1 - \frac{1}{1-\tau_t}\right) + \frac{\gamma^b}{x_0^b}\left(1 - \frac{1}{1-\tau_0}\right)\frac{\partial x_0^b}{\partial x_t^b}\right],$$

which represents a weighted sum of tax distortions. If $\tau_t = \tau_0 = 0$, the welfare effect from a small change in x_t^b and, correspondingly, x_0^b is zero. If, however, either $\tau_t \neq 0$ or $\tau_0 \neq 0$, the government can potentially improve welfare by adjusting the tax rates such as to reduce the total deadweight burden. Substitution of the equilibrium values under a BB, for example, implies that a marginal increase of x_t^b around the BB allocation improves welfare, if $\bar{\tau}_0 > \bar{\tau}_t$. D_{1t} therefore captures the marginal social welfare effect from tax smoothing.

Suppose next that households differ with respect to their preferences, $\gamma \neq 1$, but relative productivities are constant, $w_t = w$, $t = 0, 1, 2, \ldots, T$, such that relative wealth is fixed and $D_{2t} = 0$. The aggregate marginal rate of transformation between b-types' leisure and consumption,

$$\frac{\partial c_t^b}{\partial x_t^b} = -w_t^b \frac{\eta c\gamma + 1 - \eta}{\eta c + 1 - \eta},$$

now depends on the composition of the population and differs from that perceived by an individual household, $-w_t^b(1-\tau_t)$, even if the tax rate is zero. D_{1t} reads

$$\bigl(\theta^a\eta + \theta^b(1-\eta)\bigr)\left[\beta^t \frac{\gamma^b}{x_t^b}\left(1 - \frac{1}{1-\tau_t}\frac{\eta c\gamma + 1 - \eta}{\eta c + 1 - \eta}\right) + \frac{\gamma^b}{x_0^b}\left(1 - \frac{1}{1-\tau_0}\frac{\eta c\gamma + 1 - \eta}{\eta c + 1 - \eta}\right)\frac{\partial x_0^b}{\partial x_t^b}\right]$$

and D_{3t} corrects for the fact that a-types derive different marginal utility from leisure than b-types. If the government behaved fully in the interest of b-types ($\theta^a = 0$), it would set D_{1t} equal to zero. In the opposite case ($\theta^b = 0$), it would set a modified expression $D_{1t}^\star$ equal to zero, where $D_{1t}^\star$ has γ^b in the first and third term of D_{1t} replaced by γ^a to take the different marginal utility of leisure of a-types into account. Around the BB allocation, a rise in x_t^b improves the welfare of both types, if $\bar{\tau}_0 > \bar{\tau}_t$. Off the BB allocation, however, the direction of an optimal policy change generally depends on the welfare weights. Although the government can still not affect the wealth distribution (c is fixed), it can affect relative welfare because fiscal policy imposes type-specific deadweight burdens. There no longer

[15] The same discussion applies under the assumption that households have identical preferences and face different productivities, with a fixed ratio, $w_t = w$, $t = 0, 1, 2, \ldots, T$.

exists one particular tax smoothing policy; the choice of fiscal policy involves a normative judgment, even if it does not redistribute wealth.

Suppose finally that households have identical preferences but relative productivities vary over time: $\gamma = 1$, $w_s \neq w_t$ for some $s \neq t$. Then, $D_{3t} = 0$ and D_{1t} accounts for the symmetric welfare effect on households due to changes in the deadweight burden. With w_t fluctuating, the government can now influence the wealth distribution ($\partial c/\partial x_t^b \neq 0$). Since the social welfare effect of redistribution generally differs from zero, the government takes advantage of this possibility. The tax smoothing prescription for optimal policy does not apply, not even locally around the BB allocation.

In the general case ($\partial c/\partial x_t^b \neq 0$ and $\gamma \neq 1$), the different channels interact and fiscal policy shifts both wealth and deadweight burdens. A simple decomposition of the resource constraint offers an alternative perspective on this interaction. Define the fiscal burden of a- and b-types in period t, $\kappa_t g_t$ and $(1-\kappa_t)g_t$, to be the amounts of government expenditure in period t produced by a-types and b-types, respectively:

$$\kappa_t g_t = \eta w_t^a - \eta\big(c_t^a + w_t^a x_t^a\big),$$
$$(1-\kappa_t) g_t = (1-\eta) w_t^b - (1-\eta)\big(c_t^b + w_t^b x_t^b\big).$$

The ratio of the two total fiscal burdens at market prices, $\rho \equiv \sum p_t \kappa_t g_t / \sum p_t (1-\kappa_t) g_t$, provides a summary measure of the relative incidence of taxation. Note that total goods and leisure consumption at time t (the sum of the right most expressions in the equations above) is fixed because government expenditure and productivities are exogenous. Fiscal policy can therefore affect κ_t, only if it alters the ratio of total consumption across types. However, this ratio is given by

$$\frac{c_t^a + w_t^a x_t^a}{c_t^b + w_t^b x_t^b} = c\,\frac{c_t^b + \gamma w_t^b x_t^b}{c_t^b + w_t^b x_t^b},$$

so that policy cannot affect κ_t unless it either changes the wealth distribution or preferences differ. Moreover, if κ_t is unaltered by policy changes, the same holds true for ρ.[16]

3.1. Sources of the conflict between tax smoothing and tax shifting

We have seen that fiscal policy simultaneously affects tax distortions and the distribution of wealth and welfare. This gives rise to a conflict between the tax smoothing and tax shifting objectives. Below, I offer two perspectives on the source of this conflict. I show first, that the conflict disappears under the Veil of Ignorance. Thereafter, I relate the conflict to the uniformity requirement on the tax function. In that context, I also discuss non-linear taxation.

[16] If $\gamma = 1$ and $\partial c/\partial x_t^b = 0$, $t = 1, 2, \ldots, T$, then it must be the case that relative productivities are constant and equal to c. This, in turn, implies that $\kappa_t = \kappa = \eta c/(1-\eta+\eta c)$ and $\rho = c\eta/(1-\eta)$.

3.1.1. Incomplete insurance

Consider the situation where households write contracts before learning about their own type. Behind this Veil of Ignorance (Rawls, 1971), households share the risk of being assigned a specific type. Consumers maximize expected utility

$$\sum_{t=0}^{T} \beta^t \big[\eta u\big(c_t^a, x_t^a\big) + (1-\eta) v\big(c_t^b, x_t^b\big)\big]$$

subject to the intertemporal budget constraint[17]

$$\sum_{t=0}^{T} p_t (1-\tau_t)\big[\eta w_t^a + (1-\eta) w_t^b\big]$$
$$= \sum_{t=0}^{T} p_t \big[\eta c_t^a + (1-\eta) c_t^b + (1-\tau_t)\big(\eta w_t^a x_t^a + (1-\eta) w_t^b x_t^b\big)\big],$$

where c_t^i, x_t^i, $i = a, b$, denotes consumption of the good and leisure of a household that turns out to be of type i. The implementability constraints arising from this program differ from those in the main model in two ways: The two budget constraints are replaced by the single one, and $c = 1$. The ex ante welfare effect of a marginal increase in x_t^b now resembles, not surprisingly, the one in the representative agent framework (cf. the expression for D_{1t} on page 36). It is given by

$$\big(\eta\gamma^a + (1-\eta)\gamma^b\big)\left[\beta^t \frac{1}{x_t^b}\left(1 - \frac{1}{1-\tau_t}\right) + \frac{1}{x_0^b}\left(1 - \frac{1}{1-\tau_0}\right)\frac{\partial x_0^b}{\partial x_t^b}\right],$$

a weighted sum of tax distortions.[18] Around the BB allocation, a marginal rise in τ_t increases the ex ante welfare of households, if $\bar{\tau}_0 > \bar{\tau}_t$.

Behind the Veil of Ignorance, the private sector behaves as a normative representative agent. The optimal policy thus amounts to tax smoothing. If households are heterogeneous and individual budget constraints bind, this is no longer true. A fiscal policy that is optimal with respect to a hypothetical representative consumer with "average endowments" and "average preferences" is generally inadequate. Primarily, it is not feasible. Even if it were feasible, it would neglect the fact that changes in fiscal policy have important distributive effects.

3.1.2. Uniform taxation

Suppose the government is able to levy taxes in such a way as to independently set marginal tax rates on labor income of a- and b-types. In this case, the implementability constraint (5) is no longer present. The equilibrium conditions then are given by Eqs. (2), (7), (8), and a modified version of (10), namely

$$c_t^b = \frac{e_t - x_t^b w_t^b (1-\eta) - x_t^a w_t^a \eta}{\eta c + 1 - \eta}, \quad t = 0, 1, 2, \ldots, T.$$

[17] Note that there is no aggregate risk with respect to the distribution of types in the population.

[18] A parallel result holds for general utility functions. Ex post, the two welfare effects differ if $\gamma \neq 1$.

Without condition (5), the government can freely choose not only x_t^b, $t = 1, 2, \ldots, T$, but also x_t^a, $t = 1, 2, \ldots, T$, and c. (x_0^b is then pinned down by (7); x_0^a by (2); and $\{c_t^a, c_t^b\}$ by the modified resource constraint above, the choice of c, and (8).) This implies that the government can smooth tax distortions for any group (by adjusting x_t^b and x_0^b, say, to smooth taxes for group b) without having to incur a change in relative wealth. Absent cross sectional restrictions on marginal tax rates, no trade off between tax smoothing and tax shifting arises.

Conversely, *any* (binding) cross sectional restriction on marginal tax rates constrains the government's freedom to choose x_t^a independently of x_t^b, and thus to choose c independently of $\{x_t^b\}$. Any such cross sectional restriction on marginal tax rates thus generates a trade off between tax smoothing and tax shifting. A sufficiently non-linear tax schedule allows fiscal policy makers to decouple efficiency and (intragenerational) equity considerations only if the number of types in the population is so small that marginal tax rates for every type can be set independently of each other.[19] In a more realistic setting, with a continuum of types say (cf. Mirrlees, 1971), the conflict between tax smoothing and tax shifting remains present even if the government has access to a sufficiently non-linear tax schedule.

4. Financing the German unification

In the early 1990s, Germany faced a sudden, supposedly temporary increase in government expenditures relative to GDP.[20] This increase did not only result from strong public investment in and transfers to the "Neue Länder" but also from transfers to the Soviet Union, loans to Eastern European countries, and contributions to the financing of the Gulf war. In accordance with the tax smoothing view, the government argued in favor of deficits and relatively small tax increases in order to finance the expenditure spike.[21] The parliament endorsed this strategy and approved a quickly rising debt quota. Since productivity in the East was to catch up with the Western level, this choice of a flat tax profile implied a more equal distribution of the total tax burden between East and West Germans than a front loaded profile. As a result, West Germans' total tax burden is lower than under an alternative policy without the high budget deficits in the 1990s.[22]

To estimate the welfare implications of this effect, I apply a calibrated version of the model. In applying the model to the question at hand, I posit, first, that financial market imperfections, especially borrowing constraints are not of first-order importance in Germany. If East Germans faced liquidity constraints, the government's potential to increase their welfare by a front loaded tax profile would severely be restricted. High car

19 In the model considered in this paper, with just two types, this would be the case. At the same time, however, taxes would no longer be distortionary.

20 For a detailed discussion of several economic aspects of the German unification, cf. Sinn and Sinn (1992).

21 Cf., for example, the speech of finance minister Theo Waigel to the German parliament, March 12, 1991.

22 Tax schedules in East and West Germany are not strictly uniform but their underlying time profiles are tightly connected. Although implementing different tax profiles in East and West Germany would have been advantageous, such a policy would have been politically infeasible.

sales in East Germany in the early 1990s suggest, however, that liquidity constraints were indeed not binding for many households. Secondly, I disregard the effects of fiscal policy on the generational accounts. Equivalently, I interpret the fact that Germans leave bequests as evidence for intergenerational altruism. Finally, I neglect migration. This is irrelevant as long as the productivity profile of a household is person specific.

I simulate an economy lasting for six decades, from 1991 to 2050. I assume that by 2030, East German productivity—which equals roughly 40 percent of the Western value in 1991—will have reached the Western level; that the government expenditure-to-GDP ratio will have converged to 40 percent; and that after 2030, Germany will move along a balanced growth path. In Appendix A.2, I discuss details of the calibration.

Figure 1 illustrates the optimal fiscal policy under different welfare weights for West Germans: $\theta^a = 0.3$, $\theta^a = 0.5$, and $\theta^a = 0.7$. The weight for East Germans is given by $\theta^b = 1 - \theta^a$.[23] Under $\theta^a = 0.3$, the government values the welfare of East Germans higher (by a factor > 2) than the welfare of West Germans. Since East Germans are poorer than West Germans, redistribution from the latter to the former is a prior objective. The government achieves this objective by setting high tax rates at an early stage (≈ 50 percent during the first decade) when West Germans enjoy strong productivity advantages. Indeed, the tax shifting motive is so pronounced that the optimal policy approximately follows a BB rule. Tax rates in the first decade are sufficiently high to finance the government expenditure spike fully out of tax revenue. After 2000, the rates decline sharply and converge to the long run expenditure-to-GDP ratio. The optimal policy under $\theta^a = 0.7$ stands in stark contrast to this "close-to-BB" policy. If the government values the welfare of West Germans higher than the welfare of East Germans, redistribution is relatively unimportant and the government's major objective is to minimize deadweight burdens. The

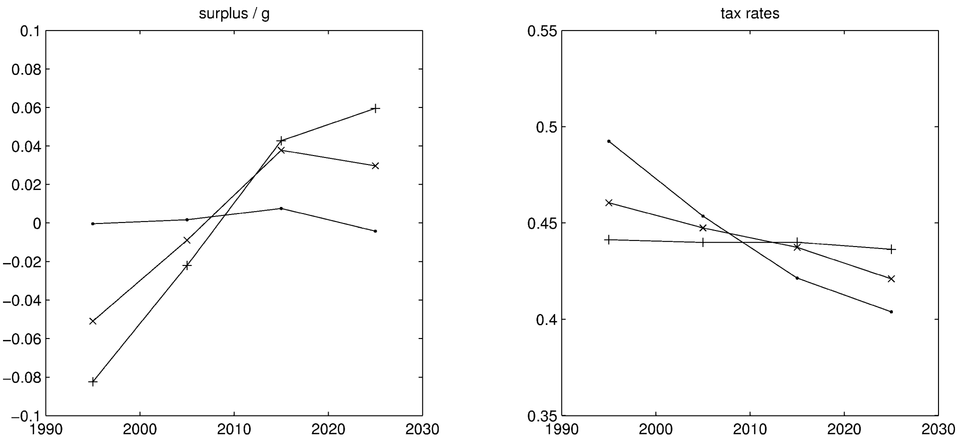

Fig. 1. Optimal policies under $\theta^a = 0.3$ ($\cdot$), $\theta^a = 0.5$ ($\times$), $\theta^a = 0.7$ ($+$).

[23] The graph displays only the first four decades. After 2030, the economy moves along a balanced growth path: productivity, government expenditure, and consumption grow at constant positive rates; tax rates and labor supply are constant.

optimal policy is then characterized by a smooth tax profile (tax rates around 44 percent), similar to the one at which the German government actually aimed. High deficits in the first two decades (with an initial deficit quota relative to government expenditure of 8.2 percent, close to the one in the data) are followed by surpluses. Under balanced welfare weights ($\theta^a = 0.5$), tax rates slowly decline. Moderate initial deficits are followed by small surpluses.

The implied welfare differences between the three policies are considerable. The move from the close-to-BB policy to the policy of smooth tax rates reduces the welfare of East Germans to the same extent as a permanent reduction of their consumption by ca. 1 percent or a reduction of ca. 4 percent throughout the first decade. Significantly higher (two digit) welfare costs result under the assumption of a higher initial productivity difference, a shorter time horizon, or a low utility weight on leisure. These costs arise because a smooth tax profile hurts East Germans more through the tax shifting channel than it benefits them through the improvement in their intertemporal terms of trade (i.e., the lower interest rates associated with a tax smoothing policy).[24]

Since the model abstracts from the effects of tax policy on both (human) capital accumulation and income from initially outstanding asset holdings, one might wonder whether consideration of these aspects may reverse the result. The opposite is likely to be the case. Consider first the unmodeled effect of tax policy on capital accumulation and thereby labor productivity. Economic theory suggests that private investment responds less to the present income tax rate than to expected future tax rates. Under the close-to-BB policy, tax rates are slightly higher in the second decade but significantly lower in all later decades. It is therefore unlikely that the close-to-BB policy would have discouraged investment relative to the alternative policies with smoother tax rates. With respect to the second issue, note that an increase in the interest rate in the first decade (as associated with the close-to-BB policy) would have devalued initially outstanding long term bonds. This effect would have harmed West Germans much more than East Germans, since only the former held such assets. The general picture arising from the simulation—that the policy of smooth tax rates channels resources from the poorer East to the richer West—therefore appears robust.

One constraint faced by policy makers that *is* present in the model is the maximum of the Laffer curve. An interesting question is whether this constraint (nearly) binds in the simulated economy.[25] As it turns out, this is not the case; tax revenue is significantly lower than at the top of the Laffer curve. Tax rates and revenues during the first decade could be raised beyond their levels under the close-to-BB policy if the government wished to implement stronger redistribution from West to East. Under $\theta^a = 0.1$, for example, the optimal initial tax rate approaches 60 percent and the initial tax revenue from West and East Germans exceeds the one under the close-to-BB policy by about 10 and 6 percent, respectively.

Judged by the government's intentions and by the deficit quota in the 1990s, Germany finances the unification by a policy of smooth tax rates, i.e., a policy distinctly favoring

[24] Moreover, the intertemporal price effect vanishes if Germany is modeled as a small open economy.

[25] I thank the referee for raising this issue.

West Germans. This "Western" bias on the financing side sharply contrasts with the "Eastern" bias on the expenditure side, as manifested by large transfers to the "Neue Länder" (cf., for example, Schwinn, 1997, Table 2.4). This suggests that the government implemented a constrained inefficient policy in the sense that it did not simultaneously optimize both government expenditure and revenues. The social cost of administrative effort, fraud, etc. associated with payments to East Germany could have been reduced if the latter had been partially replaced by a more front loaded tax profile. Several alternative explanations for the opposing policy biases are conceivable. The government might, for example, have tried to undo some of the well publicized transfers to East Germany by less transparent tax shifting. A possible rationale for such behavior could be that the government acted on behalf of (some) West Germans, but sought to gain votes from East Germans.[26] Alternatively, the authorities were simply not aware of the policy's intragenerational distributive consequences. They erroneously considered Germany to be inhabited by a representative household (along the dimensions relevant for fiscal policy) and, accordingly, chose a smooth tax profile on efficiency grounds. The intention to minimize the deadweight burden led to an unintended redistribution from East to West. Finally, the government might have attributed greater importance to the presence of *inter*generational heterogeneity than the model does. If young and old East Germans are not altruistically linked, concern for old East Germans may have dictated a more backloaded tax profile than the simulation, which abstracts from intergenerational heterogeneity, suggests.[27]

5. Time consistency

Lucas and Stokey (1983) showed that in a representative agent economy, the government can commit to the ex ante optimal fiscal policy by choosing the maturity structure of public debt in an appropriate way.[28] Bassetto (1999) demonstrates that the same is true in his model with a "taxpayer" and a "rentier," as long as the government can adjust any one of the bilateral debt positions in the economy after having observed the others. In Appendix A.3, I show that a similar condition applies in the setup considered here.[29]

In the representative agent setting, the government faces a single implementability constraint. The possibility of time inconsistency arises because the household's optimal response to a distortionary tax ex post differs from its ex ante response. The optimal tax profile itself therefore also changes over time. In order to commit to a specific profile, the government needs to influence the constraints subject to which it re-optimizes in later periods. This can be done by employing ex ante neutral devices that are non-neutral—along the relevant margins—ex post. To counterbalance all ex post incentives, the government

[26] This argument requires heterogeneity among West Germans (that is unrelated to the issues discussed here) which induces the government to seek the support of East Germans.

[27] I thank the referee for proposing this interpretation.

[28] The discussion presumes that the government must honor outstanding government debt.

[29] Cf. Rogers (1986) for a discussion of time inconsistency in a framework with heterogeneous households, labor and capital taxes, and no government debt.

needs as many independent devices of that sort as there are tax rates to be committed to. The maturity structure provides these devices because it determines the extent to which a change in the allocation translates into a change of the value of outstanding government debt (Persson and Svensson, 1986).

With heterogeneous households, the government faces multiple implementability constraints. Not only is it prohibited from directly transferring resources between the private sector and the government, but it is also prohibited from directly transferring resources across types. With the households' optimal response to a distortionary tax profile changing over time, the government's re-optimization along the intertemporal tax smoothing margin and the cross sectional tax shifting margin would generally result in ex post policy choices that differ from the Ramsey outcome. To avoid time inconsistency, the government needs to employ a commitment device that counterbalances both these differential ex post incentives. An appropriately chosen maturity structure of government debt can again serve as such a device. As shown in the Appendix, this "optimal" public maturity structure depends on the maturity structure of all privately issued bonds. The dependence arises because the welfare effects of a policy change ex post depend on the total exposure of households to the different maturities.

6. Conclusion

Heterogeneous income profiles turn fiscal policy into a powerful distributive mechanism. One implication of this mechanism, the intergenerational wealth effects of government debt, has attracted considerable attention in the macroeconomic literature. The general tax shifting principle has gone nearly unnoticed, though. This focus on intergenerational wealth effects may have been too narrow. Since different generations within the same family are much more likely to be altruistically linked than members of different families, intragenerational tax shifting should be at least as prevalent as its intergenerational counterpart. Moreover, since tax shifting gives rise to first-order welfare effects, its importance for optimal debt policy should be at least as great as that of tax distortions whose second-order welfare effects are generally stressed.

The implications for optimal government debt policy are wide ranging. If policy makers are concerned about inequality, they should impose a relatively front loaded tax profile if regional disparities in per capita income are expected to narrow. Deficit data for the USA suggest that such a policy was actually implemented by Congress.[30] Germany's financing of the unification, in contrast, does not conform with this prescription. Other policy implications relate, for example, to the optimal tax policy over the business cycle:

[30] The residual (actual minus predicted) budget-deficit-to-GNP ratio from a pure tax smoothing model (Barro, 1986, Table 4) is negatively correlated with the dispersion of per capita income across US states (which declined over time). I assume that the government's objective function aggregates the welfare of states. I measure income inequality across states by the relative per capita personal income of rich versus poor US states where rich (poor) is defined as above (below) average in 1955. I use annual income data from `http://www.bea.doc.gov/bea/regional/spi`. Allowing for a structural break after 1943, the two series are negatively (-0.52, or -0.65 for five year averages) correlated between 1929 and 1983.

If policy makers are concerned about inequality, they should levy income taxes less pro cyclically than suggested by the tax smoothing view since the poor face a more pro cyclical income path than the rich (cf. Castañeda et al., 1998).

From a positive perspective, the welfare implications of intragenerational tax shifting shed new light on the observed political conflict about constitutional restrictions on fiscal policy. In contrast to existing models that stress the role of intergenerational conflict or an inefficient political process the present framework can easily rationalize why some, but not all, groups within a generation are in favor of a BB requirement: Ceteris paribus, individuals with a rising income path prefer high contemporaneous and low future tax rates, whereas individuals with a downward sloping income profile favor public debt. This prediction of the model matches the results from opinion polls on the attitude towards a BB requirement (Blinder and Holtz-Eakin, 1984).[31]

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Appendix A

A.1. Generalization of the government's program

In this appendix and the one below on time consistency, I analyze the government's program under the assumption of general time separable utility functions and stochastic exogenous variables. Both the government and the households possess perfect information about the joint distribution of the exogenous variables. I denote a realization of the vector of exogenous variables (government spending and productivities) at time t by ϵ_t and a specific history of realizations between dates r and s, $\{\epsilon_t\}_{t=r}^{s}$, by ϵ_r^s. In the case of $r=0$, I write ϵ^s. Realizations of ϵ_t between dates r and s are distributed according to the distribution function $F_r^s(\epsilon_r^s)$, with density (or, if applicable, probability) $f_r^s(\epsilon_r^s)$. Contracts are written at time 0 after ϵ_0 has been observed. Households take the sequences of labor productivity, prices of the consumption good $\{p_t(\epsilon^t)\}_{t=0}^{T}$, and tax rates $\{\tau_t(\epsilon^t)\}_{t=0}^{T}$ as given and plan consumption and leisure $\{c_t^i(\epsilon^t), x_t^i(\epsilon^t)\}_{t=0}^{T}$, $i=a,b$, as well as the holdings of contingent claims in order to maximize expected utility. All endogenous variables at time t are functions of ϵ^t. To simplify the notation, I write these functions without their argument.

A solution to the utility maximization problems of a- and b-types is characterized by the first-order conditions[32]

[31] Variables associated with the income profile of the respondents influenced their attitude in the expected direction whereas the level of income had no effect.

[32] u_{ct} stands for $u_c(c_t^a, x_t^a)$, etc.

$$u_c(c_t^a, x_t^a)w_t^a(1-\tau_t) = u_x(c_t^a, x_t^a), \quad \forall\epsilon^t,\ t = 0, 1, 2, \ldots, T,$$

$$\beta^t \frac{u_c(c_t^a, x_t^a)}{u_c(c_0^a, x_0^a)} f_0^t(\epsilon^t|\epsilon_0) = \frac{p_t}{p_0}, \quad \forall\epsilon^t,\ t = 0, 1, 2, \ldots, T,$$

$$\sum_{t=0}^{T}\int p_t\big[c_t^a - w_t^a(1-\tau_t)\big(1-x_t^a\big)\big]\,\mathrm{d}\epsilon^t = 0,$$

$$v_c\big(c_t^b, x_t^b\big)w_t^b(1-\tau_t) = v_x\big(c_t^b, x_t^b\big), \quad \forall\epsilon^t,\ t = 0, 1, 2, \ldots, T,$$

$$\beta^t \frac{v_c(c_t^b, x_t^b)}{v_c(c_0^b, x_0^b)} f_0^t(\epsilon^t|\epsilon_0) = \frac{p_t}{p_0}, \quad \forall\epsilon^t,\ t = 0, 1, 2, \ldots, T,$$

$$\sum_{t=0}^{T}\int p_t\big[c_t^b - w_t^b(1-\tau_t)\big(1-x_t^b\big)\big]\,\mathrm{d}\epsilon^t = 0.$$

Substituting out prices and tax rates reduces these conditions to the implementability constraints:

$$\sum_{t=0}^{T}\beta^t \int u_c\big(c_t^a, x_t^a\big)c_t^a - u_x\big(c_t^a, x_t^a\big)\big[1-x_t^a\big]\,\mathrm{d}F_0^t\big(\epsilon^t|\epsilon_0\big) = 0, \tag{25}$$

$$\sum_{t=0}^{T}\beta^t \int v_c\big(c_t^b, x_t^b\big)c_t^b - v_x\big(c_t^b, x_t^b\big)\big[1-x_t^b\big]\,\mathrm{d}F_0^t\big(\epsilon^t|\epsilon_0\big) = 0, \tag{26}$$

$$\frac{u_c(c_t^a, x_t^a)}{v_c(c_t^b, x_t^b)} - \frac{u_c(c_0^a, x_0^a)}{v_c(c_0^b, x_0^b)} = 0, \quad \forall\epsilon^t,\ t = 1, 2, \ldots, T, \tag{27}$$

$$\frac{u_x(c_t^a, x_t^a)}{v_x(c_t^b, x_t^b)} - \frac{u_c(c_t^a, x_t^a)}{v_c(c_t^b, x_t^b)}\frac{w_t^a}{w_t^b} = 0, \quad \forall\epsilon^t,\ t = 0, 1, 2, \ldots, T. \tag{28}$$

The government faces the intertemporal budget constraint

$$\sum_{t=0}^{T}\int p_t\big[g_t - \tau_t\big(\eta w_t^a\big(1-x_t^a\big) + (1-\eta)w_t^b\big(1-x_t^b\big)\big)\big]\,\mathrm{d}\epsilon^t = 0.$$

Substituting out prices and tax rates leads to the equivalent representation

$$\sum_{t=0}^{T}\beta^t \int v_c\big(c_t^b, x_t^b\big)[g_t - \varphi_t\Psi_t]\,\mathrm{d}F_0^t\big(\epsilon^t|\epsilon_0\big) = 0 \tag{29}$$

with

$$\varphi_t \equiv 1 - v_x\big(c_t^b, x_t^b\big)/\big(w_t^b v_c\big(c_t^b, x_t^b\big)\big),$$

$$\Psi_t \equiv \eta w_t^a\big(1-x_t^a\big) + (1-\eta)w_t^b\big(1-x_t^b\big).$$

The government maximizes the social welfare function subject to the implementability constraints and the aggregate resource constraints. (The government budget constraint is redundant.) This program reads (with multipliers in front of the restrictions)[33]

$$
\begin{aligned}
\max \sum_{t=0}^{T} \beta^t \int & \theta^a \eta u\left(c_t^a, x_t^a\right) + \theta^b (1-\eta) v\left(c_t^b, x_t^b\right) \mathrm{d}F_0^t\left(\epsilon^t \mid \epsilon_0\right) \\
\text{s.t.} \quad & \left[\mu_t\left(\epsilon^t\right)\beta^t f_0^t\left(\epsilon^t \mid \epsilon_0\right)\right], \quad (1), \\
& \left[\lambda^a \eta\right], \quad (25), \\
& \left[\lambda^b (1-\eta)\right], \quad (26), \\
& \left[\lambda_t^c\left(\epsilon^t\right)\beta^t f_0^t\left(\epsilon^t \mid \epsilon_0\right)\right], \quad (27), \\
& \left[\lambda_t^d\left(\epsilon^t\right)\beta^t f_0^t\left(\epsilon^t \mid \epsilon_0\right)\right], \quad (28).
\end{aligned} \tag{30}
$$

The policy instruments in this program are given by $c_t^i, x_t^i, i = a, b, \forall \epsilon^t, t = 0, 1, 2, \ldots, T$.

The constrained ex ante optimal tax plan satisfies (1), (25)–(28), and

$$
\begin{aligned}
& \eta\left\{u_{ct}\theta^a + \lambda^a\left[u_{ct} + u_{cct}c_t^a + u_{cxt}\left[x_t^a - 1\right]\right] - \mu_t\right\} \\
& \quad + \lambda_t^c[u_{cct}v_{c0}] + \lambda_t^d[u_{xct}v_{ct} - u_{cct}v_{xt}w_t] = 0, \quad \forall \epsilon^t,\ t = 1, 2, \ldots, T,
\end{aligned} \tag{31}
$$

$$
\begin{aligned}
& (1-\eta)\left\{v_{ct}\theta^b + \lambda^b\left[v_{ct} + v_{cct}c_t^b + v_{cxt}\left[x_t^b - 1\right]\right] - \mu_t\right\} \\
& \quad + \lambda_t^c[-u_{c0}v_{cct}] + \lambda_t^d[u_{xt}v_{cct} - u_{ct}v_{cxt}w_t] = 0, \quad \forall \epsilon^t,\ t = 1, 2, \ldots, T,
\end{aligned} \tag{32}
$$

$$
\begin{aligned}
& \eta\left\{u_{xt}\theta^a + \lambda^a\left[u_{cxt}c_t^a + u_{xxt}\left[x_t^a - 1\right] + u_{xt}\right] - \mu_t w_t^a\right\} \\
& \quad + \lambda_t^c[u_{cxt}v_{c0}] + \lambda_t^d[u_{xxt}v_{ct} - u_{cxt}v_{xt}w_t] = 0, \quad \forall \epsilon^t,\ t = 1, 2, \ldots, T,
\end{aligned} \tag{33}
$$

$$
\begin{aligned}
& (1-\eta)\left\{v_{xt}\theta^b + \lambda^b\left[v_{cxt}c_t^b + v_{xxt}\left[x_t^b - 1\right] + v_{xt}\right] - \mu_t w_t^b\right\} \\
& \quad + \lambda_t^c[-u_{c0}v_{cxt}] + \lambda_t^d[u_{xt}v_{cxt} - u_{ct}v_{xxt}w_t] = 0, \quad \forall \epsilon^t,\ t = 1, 2, \ldots, T.
\end{aligned} \tag{34}
$$

(31)–(34) only hold for $t > 0$. The first-order conditions with respect to c_0^a, c_0^b, x_0^a, and x_0^b involve modified expressions for the term multiplying $\lambda_t^c(\epsilon^t)$. The first-order condition with respect to c_0^a, for example, contains

$$
-u_{cc0} \sum_{t=1}^{T} \beta^t \int \lambda_t^c v_{ct} \, \mathrm{d}F_0^t
$$

instead of the λ_t^c term in (31). Parallel modifications apply in the other cases.

The first lines of (31) and (33) correspond with the first-order conditions in a setting with a representative agent, cf. Lucas and Stokey (1983, p. 62).[34] They summarize the marginal effect on social welfare due to the presence of the a-types: An increase in c_t^a or x_t^a benefits these households, affects their implementability constraint, and requires resources. The presence of heterogeneous households introduces additional considerations.

---

[33] In stating the government's program, I neglect the inequality constraints in (1). The multipliers are given in normalized form.

[34] If all households are identical, $\eta = 1$, the constraints (26)–(28) become obsolete.

Changes in c_t^b or x_t^b benefit the b-types, affect their implementability constraint, and require resources. Furthermore, the conditions of equal intertemporal marginal rates of substitution (multiplier λ_t^c) and marginal tax rates (multiplier λ_t^d) across types have to be satisfied.

A.2. Notes on the calibration

A.2.1. Sample

The simulation covers the years 1991–2050. To simplify the numerical procedures, this range is divided into six intervals of 10 years each. All variables in the simulation represent ten-year averages. I assume that the variables converge to their balanced growth path values throughout the first four intervals. From 2031, productivity, consumption, and government expenditure grow at constant positive rates whereas tax rates and labor supply remain constant.

A.2.2. Labor productivity

I set w_{1991}^a to 1. I approximate relative productivities by the ratio of West to East German per capita GDP.[35] I assume that productivity in the West grows at an annual rate of 1.5 percent, whereas productivity in the East converges to the Western one:

$$w_t^a = 1.015 w_{t-1}^a, \quad t = 1992, \ldots, 2030,$$

$$w_t = w_{t-1} \left(\frac{1}{w_{t-1}} \right)^{0.1}, \quad t = 2003, \ldots, 2030.$$

The path of w_t^b follows directly. In the simulation, I use ten year averages of these generated series. Relative productivity equals $w_{1990s} = 1.8920$, $w_{2000s} = 1.4050$, $w_{2010s} = 1.1266$, and $w_{2020s} = 1.0423$.

A.2.3. Government expenditure

In the model, g represents public consumption. In the data, transfers and investment outlays constitute an important component of public spending. For simplicity, I do not distinguish between these components. I assume that the utility function is additively separable in public consumption, investment, and/or transfers and that transfers are non-marketable (do not enter the household's budget constraint). These assumptions stress the fact that this paper as well as much of the relevant literature focus on the welfare effects of the *financing* side of fiscal policy.

[35] The data source for this ratio between 1991 and 2002 is `http://www.statistik-bw.de/VolkswPreise/ ArbeitskreisVGR/tab01.asp`.

I extrapolate the government expenditure-to-GDP ratio, R_t say (which reaches a maximum of 0.56 in 1995),[36] under the assumption that it converges to 40 percent, subject to the following law of motion:

$$R_t = R_{t-1}\left(\frac{0.4}{R_{t-1}}\right)^{0.1}, \quad t = 2002, \dots, 2030.$$

R_t times the model's production level under a BB policy represents government expenditure.[37] In the simulation, I use ten year averages of this generated series, namely: $g_{1990s} = 0.3217$, $g_{2000s} = 0.3553$, $g_{2010s} = 0.3931$, and $g_{2020s} = 0.4495$.

A.2.4. Parameters

$\eta = 0.82 \approx 65352/(65352 + 14632)$. $\beta = 0.985^{10}$, implying a risk free annual rate of return of 3 percent. $\gamma^a = \gamma^b = 0.5$, implying a steady state labor supply of 2/3.

A.3. Time consistency

(See the explanations in Appendix A.1.) At any point in time, the government's program is isomorphic to a static problem since financial markets are complete. A sequence of optimal policies over time, however, need not necessarily represent the continuation of the initial optimal policy (Kydland and Prescott, 1977). At the beginning of period 1, for example, the households' consumption, work, and savings decisions from period 0 as well as the government's choice of maturity structure for debt issued in period 0 are irrevocable. The government now takes these variables as given and might therefore want to revise its initial policy.

To keep track of the budget constraints over time, it is necessary to explicitly introduce the amounts of contingent claims held by the households. Following Lucas and Stokey (1983), I denote by $\{{}_s b_t^i\}_{t=s}^T$ the sequence of government issued contingent claims that are held by type i at the beginning of period s and promise payment in period t (and state $\epsilon^t|\epsilon^{s-1}$). Similarly, $\{{}_s d_t^i\}_{t=s}^T$ denotes the sequence of privately issued contingent claims. Consistency requires $\eta_s d_t^a + (1-\eta)_s d_t^b = 0$, $\forall \epsilon^t|\epsilon^{s-1}$, $t = s, s+1, \dots, T$.

The following discussion applies to general utility functions. It assumes, first, that the implementability constraints which state that all households face the same prices and tax rates,

$$\frac{u_c(c_t^a, x_t^a)}{v_c(c_t^b, x_t^b)} = \frac{u_c(c_0^a, x_0^a)}{v_c(c_0^b, x_0^b)} \equiv \frac{1}{c}, \quad \forall \epsilon^t,\ t = 1, 2, \dots, T,$$
$$\frac{u_x(c_t^a, x_t^a)}{v_x(c_t^b, x_t^b)} - \frac{u_c(c_t^a, x_t^a)}{v_c(c_t^b, x_t^b)} \frac{w_t^a}{w_t^b} = 0, \quad \forall \epsilon^t,\ t = 0, 1, 2, \dots, T,$$

[36] The data source for this ratio between 1991 and 2001 is `http://www.sachverstaendigenrat-wirtschaft.de/`.

[37] The government expenditure-to-GDP ratio in the data is not generated under a BB policy but, supposedly, under a policy of initial deficits and subsequent surpluses, corresponding to initially higher and subsequently lower labor supply than under a BB. The calibrated values for g thus are slightly too low in the beginning and slightly too high towards the end. Robustness checks show that the effect on the simulation is negligible.

can be solved for functions $\tilde{c}^a(c_t^b, x_t^b, c; w_t)$ and $\tilde{x}^a(c_t^b, x_t^b, c; w_t)$, $\forall \epsilon^t$, $t = 0, 1, 2, \ldots, T$. Second, it assumes that these functions allow for solving the resource constraint

$$e_t = \eta\big(\tilde{c}^a(\cdot) + w_t^a \tilde{x}^a(\cdot)\big) + (1-\eta)\big(c_t^b + w_t^b x_t^b\big), \quad \forall \epsilon^t,\ t = 0, 1, 2, \ldots, T,$$

for functions $c^a(h_t)$, $c^b(h_t)$, $x^a(h_t)$, $\forall \epsilon^t$, $t = 0, 1, 2, \ldots, T$, where $h_t \equiv (x_t^b, c; w_t^a, w_t^b, g_t, \eta)$. (In the main model, these conditions were trivially satisfied.) Consequently, utilities and marginal utilities are also functions of h_t. I denote these functions by $u(h_t)$, $v(h_t)$, etc.

I first derive the equations characterizing an interior optimal solution to the government's program as of time r. I compare them to the optimality conditions from the subsequent program at time $s = r + 1$. The policy is time consistent between r and s, if the government can issue debt in period r with a maturity and ownership structure $\{{}_sb_t^a, {}_sb_t^b\}_{t=s}^T$, such that the optimal policy as of time s, given this structure, is a continuation of the one chosen in period r. If this is the case, the government can, by induction, always commit to its ex ante optimal policy.

The constraints of the government's program as of time r are given by the reduced form implementability constraints that—in contrast to the earlier representation—now incorporate the resource constraint:

$$\sum_{t=r}^T \beta^t \int u_c(h_t)\big(c^a(h_t) - {}_rb_t^a - {}_rd_t^a\big) - u_x(h_t)\big[1 - x^a(h_t)\big]\,\mathrm{d}F_r^t\big(\epsilon^t|\epsilon^r\big) = 0, \tag{35}$$

$$\sum_{t=r}^T \beta^t \int v_c(h_t)\big(c^b(h_t) - {}_rb_t^b + {}_rd_t^a\big) - v_x(h_t)\big[1 - x_t^b\big]\,\mathrm{d}F_r^t\big(\epsilon^t|\epsilon^r\big) = 0. \tag{36}$$

(For convenience, I here assume that $\eta = 0.5$.) The government's problem,

$$\max_{\{x_t^b\}_{t=r}^T, c} \sum_{t=r}^T \beta^t \int \theta^a \eta u(h_t) + \theta^b (1-\eta) v(h_t)\,\mathrm{d}F_r^t\big(\epsilon^t|\epsilon^r\big)$$
$$\text{s.t.} \quad [\lambda^a] \quad (35), \quad [\lambda^b] \quad (36),$$

implies the first-order conditions (35), (36), and

$$\begin{aligned} &m_1(h_t) + \lambda^a\big[m_2(h_t) + m_3(h_t)\big({}_rb_t^a + {}_rd_t^a\big)\big] \\ &\quad + \lambda^b\big[m_4(h_t) + m_5(h_t)\big({}_rb_t^b - {}_rd_t^a\big)\big] = 0, \quad \forall \epsilon^t|\epsilon^r,\ t = r, r+1, \ldots, T, \end{aligned} \tag{37}$$

$$\begin{aligned} &\sum_{t=r}^T \beta^t \int m_6(h_t)\,\mathrm{d}F_r^t\big(\epsilon^t|\epsilon^r\big) + \lambda^a \sum_{t=r}^T \beta^t \int m_7(h_t) + m_8(h_t)\big({}_rb_t^a + {}_rd_t^a\big)\,\mathrm{d}F_r^t\big(\epsilon^t|\epsilon^r\big) \\ &\quad + \lambda^b \sum_{t=r}^T \beta^t \int m_9(h_t) + m_{10}(h_t)\big({}_rb_t^b - {}_rd_t^a\big)\,\mathrm{d}F_r^t\big(\epsilon^t|\epsilon^r\big) = 0, \end{aligned} \tag{38}$$

where $m_j(\cdot)$, $j = 1, 2, \ldots, 10$, are some functions of h_t. Denote the system of equations (35)–(38) that holds as of time r by ${}_rE$. Given $\{{}_rb_t^a, {}_rb_t^b, {}_rd_t^a\}_{t=r}^T$, ${}_rE$ determines $(\{{}_rx_t^b\}_{t=r}^T, {}_rc, {}_r\lambda^a, {}_r\lambda^b)$ say. Subject to these values and an updated maturity structure of privately issued claims, $\{{}_sd_t^a\}_{t=s}^T$, the government chooses the maturity structure $\{{}_sb_t^a, {}_sb_t^b\}_{t=s}^T$. Given $\{{}_sb_t^a, {}_sb_t^b, {}_sd_t^a\}_{t=s}^T$, ${}_sE$ determines in the next period

$(\{{}_s x_t^b\}_{t=s}^T, {}_s c, {}_s\lambda^a, {}_s\lambda^b)$. The government can commit to the optimal policy as of time r, if there exists $\{{}_s b_t^a, {}_s b_t^b\}_{t=s}^T$, such that $(\{{}_s x_t^b\}_{t=s}^T, {}_s c) = (\{{}_r x_t^b\}_{t=s}^T, {}_r c)$.

Under the assumption of a representative agent, $u = v$, $c = 1$, $\{{}_r d_t^a\}_{t=r}^T = \{0\}$, the only constraint in the government program is (36), and the first-order conditions reduce to (36) and (37) with $\lambda^a = {}_r d_t^a = 0$. Denote this simpler system of equations by ${}_r E^{\mathrm{RA}}$. Lucas and Stokey (1983) subtract (37) in ${}_r E^{\mathrm{RA}}$ from (37) in ${}_s E^{\mathrm{RA}}$. If the policy is time consistent, the values of m_j, $j = 1, 4, 5$, are identical in the two expressions for each state and period $t \geqslant s$. This implies a restriction that defines, for each state in each period $t \geqslant s$, ${}_s b_t^b$ as a function of ${}_s\lambda^b$ and the predetermined or fixed (by time consistency) values of ${}_r\lambda^b$, ${}_r b_t^b$, and h_t. It follows that there exists a specific value for ${}_s\lambda^b$ and a corresponding new maturity structure $\{{}_s b_t^b\}_{t=s}^T$ that satisfies (36) in ${}_s E^{\mathrm{RA}}$. The government can therefore commit to its optimal policy.[38]

With heterogeneous agents, the maturity structure of government debt needs to counterbalance the differential incentives along the tax smoothing and the tax shifting margin. Moreover, it must take into account that $\{{}_s d_t^a\}_{t=s}^T$ no longer equals $\{0\}$. Assume, for example, that $\{{}_s b_t^a\}_{t=s}^T = \{0\}$ and that privately issued debt (satisfying (35) as of $t = s$) is given by a particular sequence $\{{}_s d_t^a\}_{t=s}^T$. (37) in ${}_s E$ can then be solved for ${}_s b_t^b({}_s\lambda^a, {}_s\lambda^b; h_t, {}_s d_t^a)$, $\forall \epsilon^t | \epsilon^r$, $t = s, s+1, \ldots, T$. Substituting these functions into (36) and (38) in ${}_s E$ results in two equations in the two unknowns ${}_s\lambda^a$, ${}_s\lambda^b$. A solution to these equations implicitly defines the maturity structure $\{{}_s b_t^b\}_{t=s}^T$ that allows the government to commit to its optimal tax plan as of time r.

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[38] If the government could costlessly appropriate resources, the resource constraints (incorporated in $v(h_t)$) would be the only constraints to bind and $\lambda^b = 0$. Time consistency would then be guaranteed independent of the maturity structure.

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