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Online Appendix to: Welfare effects of indirect tax policies in West Africa

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Online Appendix to “Welfare effects of indirect tax policies in West Africa”

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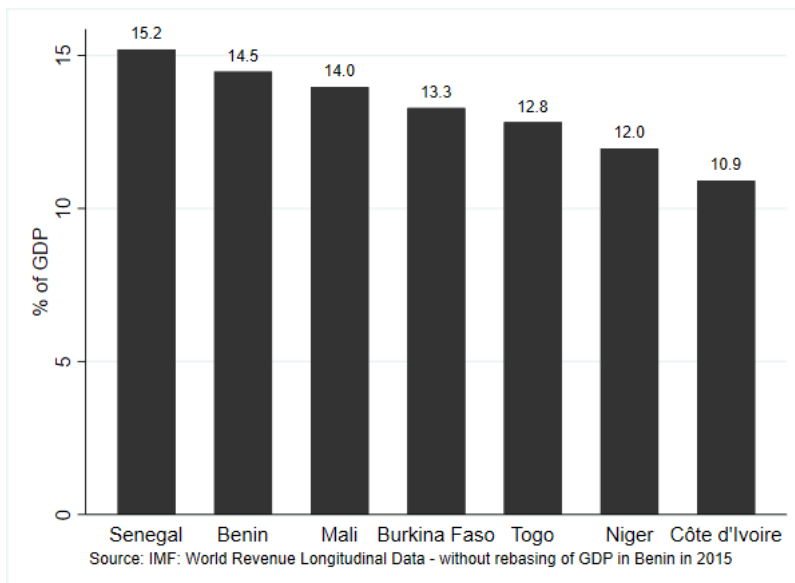
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A VAT in WAEMU

Figure A.1 displays tax revenue to GDP ratios across the WAEMU member states in 2015 and Table A.1 gives more information on the application of reduced rates, next to the standard rate, by WAEMU countries, after this has been allowed for since 2008.

Figure A.1: Tax revenue to GDP ratio in WAEMU countries, 2015 (%)



Note: Own calculations on the basis of <https://data.imf.org>. No information for Guinée-Bissau is available. On *rebasings* GDP, see note 10 of the main text.

Rebasing refers to the practice of the statistical authorities of many African countries, to revise retrospectively historic GDP figures on an attempt to include more items from mainly informal sectors, and coming this way closer to the standards of OECD countries.

Table A.1: Current VAT policy in WAEMU

Country	standard rate	exemption and zeros rates	reduced rate
Benin	18	yes	NO
Burkina Faso	18	yes	10
Côte d'Ivoire	18	yes	9
Mali	18	yes	5
Niger	19	yes	5 & 10
Senegal	18	yes	10
Togo	18	yes	10

Note: Data for all countries except Togo, stem from Thornton's international Indirect Tax Guide: <https://www.granthornton.global/en/insights/indirect-tax-guide/international-indirect-tax-guide/>; for Togo, we consulted: <https://www.lloydsbanktrade.com/en/market-potential/togo/taxes>. Guinée-Bissau only introduced VAT in 2023, replacing a sales tax.

B Additional methodology and theory

B.1 Individual household consumption behaviour

In general, a household is assumed to maximise a (strictly increasing) utility function $u(\mathbf{x})$, subject to a budget constraint, $\mathbf{q}'\mathbf{x} = y$, where \mathbf{q} is the vector collecting consumer prices q_k for commodity k , and y household's income. The solution is known as the set of Marshallian demand functions $d_k(\mathbf{q}, y)$.

Filling out these solutions in the budget equation and differentiating with respect to a commodity price q_k yields:

$$\sum_l q_l \frac{\partial d_l(\mathbf{q}, y)}{\partial q_k} = -d_k(\mathbf{q}, y). \quad (\text{A.1})$$

This equation is known as the *adding-up condition* of demand. In elasticity form this condition reads as:

$$\sum_l e_l(\mathbf{q}, y) \epsilon_{l,k}(\mathbf{q}, y) = -e_k(\mathbf{q}, y), \quad (\text{A.2})$$

where $e_k(\mathbf{q}, y)$ are the expenditures on commodity k at prices \mathbf{q} and income y , and $\epsilon_{l,k}$ is the uncompensated elasticity of demand for commodity k with respect to the price of commodity l .

We use the following functional specifications in the paper.

– Utility function:

$$u^{\text{CCD}}(\mathbf{x}) = \prod_g \left(\sum_s \delta_{g,s}^{1-r_g} x_{g,s}^{r_g} \right)^{\frac{\alpha_g}{r_g}}, \quad (\text{A.3})$$

where

- $r_g = \frac{\sigma_g - 1}{\sigma_g}$, with $\sigma_g \in [0, \infty)$ being the elasticity of substitution between market and auto-consumed types of the good g ($r_g < 1$). The elasticity of substitution is the percentage change of $x_{g,a}/x_{g,m}$ in response to a percentage change in the marginal rate of substitution between a and m ;
 - $\delta_{g,s}$ is a distribution parameter indicating the relative intensity of preference for the s variety (market versus auto) of good g , with $\sum_s \delta_{g,s} = 1$;
 - α_g is the Cobb–Douglas share parameter, and will turn out to be the expenditure share of good g (sum of expenditures on market and auto-consumption variety of a commodity g over the sum of expenditures on all commodities, market goods and auto-consumption).
- The Marshallian demand function for commodity g , s is:

$$d_{g,s}^{\text{CCD}}(\mathbf{q}_g; y) = \frac{\alpha_g \delta_{g,s} y}{\phi_g(\mathbf{q}_g)^{1-\sigma_g} q_{g,s}^{\sigma_g}}, \quad (\text{A.4})$$

where

- $\phi_g(\mathbf{q}_g) = \left(\sum_s \delta_{g,s} q_{g,s}^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}$, a CES price index;
 - α_g can be verified to be the expenditure share of good g and can be read off from the data;
 - for a given value of σ_g , $\delta_{g,s}$ can be read off from the data as follows: $\delta_{g,a} = \left(1 + \frac{e_{g,m}}{e_{g,a}} \left(\frac{q_{g,a}}{q_{g,m}} \right)^{1-\sigma_g} \right)^{-1}$;
 - σ_g cannot be immediately read off from the data, and should be fixed by the researcher. We assume it is not household specific and equal to 0.5 for all commodities g , and we will therefore denote it by σ .
- Indirect utility function:

$$v^{\text{CCD}}(\mathbf{q}, y) = y \prod_g \left(\frac{\alpha_g}{\phi_g(\mathbf{q}_g)} \right)^{\alpha_g}. \quad (\text{A.5})$$

– Expenditure function:

$$e^{\text{CCD}}(\mathbf{q}; U) = U \prod_g \left(\frac{\phi_g(\mathbf{q}_g)}{\alpha_g} \right)^{\alpha_g}. \quad (\text{A.6})$$

A Money Metric Utility function (MMU) is the minimal amount of money needed at a set of reference price \mathbf{q}^{ref} to obtain the same welfare level as in the situation where prices equal \mathbf{q} and income is y . This welfare level is given by the indirect utility function (A.5). Therefore, the MMU equals the expenditure function (A.6) evaluated at reference

prices \mathbf{q}^{ref} and welfare level $U = v^{\text{CCD}}(\mathbf{q}, y)$, which gives:

$$MMU^{\text{CCD}}(\mathbf{q}, y; \mathbf{q}_{\text{ref}}) = y \prod_g \left(\frac{\phi_g(\mathbf{q}_{\text{ref}}, g)}{\phi_g(\mathbf{q}_g)} \right)^{\alpha_g}. \quad (\text{A.7})$$

To arrive at an individual welfare metric we divide the MMU by a household equivalence scale θ :

$$m^{\text{CCD}}(\mathbf{q}, y; \mathbf{q}_{\text{ref}}) = \frac{MMU^{\text{CCD}}(\mathbf{q}, y; \mathbf{q}_{\text{ref}})}{\theta}. \quad (\text{A.8})$$

B.2 Social welfare, government budget, optimal taxes

– Social welfare function:

$$W(\mathbf{t}) = \sum_h n_h \frac{(m_h^{\text{CCD}}(\mathbf{q}, y_h; \mathbf{q}_{\text{ref}}))^{1-e}}{1-e}, \quad (\text{A.9})$$

with $e \geq 0$, the degree of inequality aversion.

– Government budget:

$$R(\mathbf{t}) = \sum_g t_g \sum_h \frac{\alpha_{g,h} \delta_{g,m,h} y_h}{\phi_{g,h}(\mathbf{q}_g)^{1-\sigma} q_{g,m}^\sigma} \geq \bar{R}. \quad (\text{A.10})$$

– Optimal taxes should satisfy (necessary) first order conditions of the maximisation problem (**max**) in the main text:

$$\lambda = - \frac{\partial W / \partial t_g}{\partial R / \partial t_g}, \text{ for all } g, \quad (\text{A.11})$$

with:

– λ : the Lagrange multiplier associated with the government budget restriction (A.10);

– $-\frac{\partial W}{\partial t_g} = \sum_h \beta_h(\mathbf{t}) d_{g,m,h}^{\text{CCD}}(\mathbf{q}_g, y_h) = \sum_h \beta_h(\mathbf{t}) \frac{\alpha_{g,h} \delta_{g,m,h} y_h}{\phi_{g,h}(\mathbf{q}_g)^{1-\sigma} q_{g,m}^\sigma}$, where

$$\begin{aligned} \beta_h(\mathbf{t}) = \frac{\partial W}{\partial y_h} &= \left(\frac{y_h}{\theta_h} \prod_g \left(\frac{\phi_{g,h}(\mathbf{q}_{\text{ref}}, g)}{\phi_{g,h}(\mathbf{q}_g)} \right)^{\alpha_{g,h}} \right)^{-e} \cdot \prod_g \left(\frac{\phi_{g,h}(\mathbf{q}_{\text{ref}}, g)}{\phi_{g,h}(\mathbf{q}_g)} \right)^{\alpha_{g,h}} \cdot \frac{n_h}{\theta_h} \\ &= \left(\frac{y_h}{\theta_h} \left(\frac{\Phi_h(\mathbf{q}_{\text{ref}})}{\Phi_h(\mathbf{q})} \right) \right)^{-e} \cdot \frac{\Phi_h(\mathbf{q}_{\text{ref}})}{\Phi_h(\mathbf{q})} \cdot \frac{n_h}{\theta_h}, \end{aligned} \quad (\text{A.12})$$

with $\Phi_h(\mathbf{q}) = \prod_g (\phi_{g,h}(\mathbf{q}_g))^{\alpha_{g,h}}$;

– $\frac{\partial R}{\partial t_g} = \sum_h \frac{d_{g,m,h}^{\text{CCD}}(\mathbf{q}_g, y_h)}{\phi_{g,h}(\mathbf{q}_g)^{1-\sigma} q_{g,m}^\sigma} \left(\phi_{g,h}(\mathbf{q}_g)^{1-\sigma} q_{g,m}^\sigma \left(1 - \sigma \frac{t_g}{q_{g,m}} \right) - (1 - \sigma) \delta_{g,m,h} t_g \right)$.

B.3 Optimal uniform rates

In our model, with exogeneously given incomes y_h , a uniform tax rate on all goods inclusive non-market goods, is equal to a lump sum tax. We investigate in this section when such a lump sum tax is optimal from a social welfare point of view. One might expect that a necessary condition for optimal uniform indirect taxation is that only efficiency considerations would matter, and thus that inequality aversion need to be absent. We will see that absence of inequality aversion is neither a sufficient, nor a necessary condition for uniform optimal taxation. To determine whether a uniform tax on all goods is optimal, we investigate whether such a uniform makes the marginal social welfare costs equal for all goods. We repeat here the marginal social welfare cost formula of the main text when all goods can be taxed (Equation 13)¹:

$$MC_{g,s}(\mathbf{t}) = \frac{\sum_h \beta_h(\mathbf{t}) s_{g,s,h}(\mathbf{q}; \mathbf{y})}{1 + \sum_{j,r} t_{j,r}^* \sum_h \epsilon_{j,r,gs}^h(\mathbf{q}, y_h) \frac{e_{j,r,h}(\mathbf{q}; y_h)}{\sum_{h'} e_{g,s,h'}(\mathbf{q}; y_{h'})}}. \quad (\text{A.13})$$

We first look at what happens with the denominator, when taxes are uniform. Denote the uniform rate by t . Then, $t_{j,r}^* = t / (1 + t)$ for all j, r and can be put in front of the summation over j, r . Since we study the case where all

¹Remember that in this case, and by a slight abuse of notation, the tax rate vector \mathbf{t} includes taxes for the nontaxable variety of each commodity g .

goods can be taxed, we can apply the adding-up condition (A.2), which implies

$$\begin{aligned} \sum_{j,r} t_{j,r}^* \sum_h \epsilon_{jr,gs}^h(\mathbf{q}, y_h) \frac{e_{j,r,h}(\mathbf{q}; y_h)}{\sum_{h'} e_{g,s,h'}(\mathbf{q}; y_{h'})} &= \frac{t}{1+t} \sum_h \sum_{j,r} \epsilon_{jr,gs}^h(\mathbf{q}, y_h) \frac{e_{j,r,h}(\mathbf{q}; y_h)}{\sum_{h'} e_{g,s,h'}(\mathbf{q}; y_{h'})} \\ &= -\frac{t}{1+t} \sum_h \frac{e_{g,s,h}(\mathbf{q}; y_h)}{\sum_{h'} e_{g,s,h'}(\mathbf{q}; y_{h'})} = -\frac{t}{1+t}, \end{aligned} \quad (\text{A.14})$$

and the denominator of Equation (A.13) reduces to $(1+t)^{-1}$, which is commodity independent. We want to stress that Equation (A.14) holds regardless of any assumption of preferences and their possible heterogeneity across persons.

So, let us concentrate on the numerator. In a more general formulation of the model, the social welfare function is a concave function of individual welfare indicators which are indirect utility functions, say $U_h = \nu_h(\mathbf{q}, y_h; \xi_h)$, where ξ_h captures how household characteristics may affect the welfare of individual household members:

$$SWF = W \left(\underbrace{\nu_h(\mathbf{q}, y_h; \xi_h)}_{n_h \text{ times}}; h = 1, \dots, H \right). \quad (\text{A.15})$$

The numerator of the marginal social welfare costs in Equation (A.13) then reads as:

$$\sum_h \underbrace{\frac{\partial W(\nu_h(\mathbf{q}, y_h; \xi_h); h = 1, \dots, H)}{\partial U_h}}_{\text{equity}} \underbrace{\frac{\partial \nu_h(\mathbf{q}, y_h; \xi_h)}{\partial \mathbf{y}}}_{\text{efficiency}} s_{g,s,h}(\mathbf{q}; \mathbf{y}). \quad (\text{A.16})$$

The first two terms equal the the marginal social welfare weight of a household

So, let us concentrate on the denominator of Equation (9), supposing the β_h 's are equal for all households h . The denominator contains the effect on government revenue of a marginal increase of the tax rate on commodity g . Now suppose that *all* goods can be taxed, market as well as auto-consumption varieties, and denote the tax rate on the s -variety of commodity g by $t_{g,s}$. Consumer prices are then equal to $q_{g,s} = 1 + t_{g,s}$, collected in the vector \mathbf{q} . In general, the government tax revenue equation then reads as:

$$R(\mathbf{q}; \mathbf{y}) = \sum_h \sum_{g,s} t_{g,s} d_{g,s,h}(\mathbf{q}; y_h), \quad (\text{A.17})$$

where $d_{g,s,h}$ denotes household h 's Marshallian demand function for the s -variety of commodity g .

The effect on tax revenues of increasing the tax on variety s of commodity g , then equals:

$$\frac{\partial R(\mathbf{q}; \mathbf{y})}{\partial t_{g,s}} = \sum_h d_{g,s,h}(\mathbf{q}; y_h) + \sum_h \sum_{g',s'} t_{g',s'} \frac{\partial d_{g',s',h}(\mathbf{q}; y_h)}{\partial t_{g,s}}. \quad (\text{A.18})$$

When taxes are uniform, the uniform tax rate being denoted by t , this reduces to:

$$\begin{aligned} \frac{\partial R(\mathbf{q}; \mathbf{y})}{\partial t_{g,s}} &= \sum_h d_{g,s,h}(\mathbf{q}; y_h) + t \sum_h \sum_{g',s'} \frac{\partial d_{g',s',h}(\mathbf{q}; y_h)}{\partial t_{g,s}} \\ &= \frac{\sum_h d_{g,s,h}(\mathbf{q}; y_h)}{1+t}, \end{aligned} \quad (\text{A.19})$$

where the second equality is obtained by using the adding-up condition of demand (see Equation (A.1) in Appendix B.1).

B.4 Optimal deviations from uniform indirect taxes

In Section 3.2 on p.13 of the main text, we provided a set of jointly sufficient conditions to obtain uniform taxes. In Section 5.1, we then investigated the impact of relaxing two of these conditions, all goods can be taxed and no within-household economies of scale, either separately or jointly (see Table ??). However, in our model, relaxation of these conditions immediately brings into play our background assumption that preferences differ across agents. In

the present section we investigate what happens if we would relax only the assumption that all goods can be taxed, but suppose that agents have identical preferences. We show that a classical Ramsey indirect tax rule is obtained, in our case reducing to an inverse elasticity rule (Ramsey, 1927).

In case preferences are homothetic and identical across agents, the marginal social welfare weights would be identical across agents. To see this, let us repeat here the expression for the marginal social welfare weights (Equation 12):

$$\beta_h(\mathbf{q}) = \left(\frac{y_h/\theta_h}{\Phi_h(\mathbf{q})} \right)^{-e} \frac{1}{\Phi_h(\mathbf{q})} \frac{n_h}{\theta_h}. \quad (\text{A.20})$$

This expression is similar for the whole class of homothetic preferences. Under homotheticity, the money metric welfare is a real income concept: total expenditures divided by a price index Φ_h . When preferences are homothetic and identical for all agents, the functional form of the price index is household independent, and denoted by $\Phi(\mathbf{q})$. So, when everybody has identical, homothetic preferences, when there is no inequality aversion ($e = 0$), and when there are no within-household economies of scale ($n_h = \theta_h$), the marginal social welfare weights equal:

$$\beta_h(\mathbf{q}) = (\Phi(\mathbf{q}))^{-1}, \quad (\text{A.21})$$

and are therefore identical for all agents, denoted in the sequel by $\beta(\mathbf{q})$. Furthermore, also the demand function are household independent under identical preferences, and are denoted by $d_{g,m}(\mathbf{q}; y_h)$. The optimal tax rule, Equation (A.11), then reduces to:

$$\begin{aligned} \lambda &= \frac{\beta(\mathbf{q}) \sum_h d_{g,m}(\mathbf{q}; y_h)}{\sum_h d_{g,m}(\mathbf{q}; y_h) + \sum_k t_k \sum_h \frac{\partial d_{k,m}(\mathbf{q}; y_h)}{\partial q_{g,m}}} \\ &= \frac{\beta(\mathbf{q})}{1 + \sum_k \frac{t_k}{1+t_k} \epsilon_{km, gm} \frac{\sum_h d_{k,m}(\mathbf{q}; y_h) q_{k,m}}{\sum_h d_{g,m}(\mathbf{q}; y_h) q_{g,m}}} \quad \forall g \in \mathcal{G}, \end{aligned} \quad (\text{A.22})$$

where $\epsilon_{km, gm}$ is the cross price elasticity of market commodity k with respect to the price of market commodity g . Under the assumption of identical homothetic preferences, these elasticities are agent independent, and therefore not indexed by h . In fact this formula is Ramsey's indirect tax rule (Ramsey, 1927). This stands to reason as the Ramsey model for indirect taxes is derived under the assumption that not all goods can be taxed (typically leisure is assumed to be the non-taxable good).

It is worthwhile to compare this with the optimal tax rule under the same assumptions (homothetic preferences, no within household economies of scale, and no inequality aversion), except for identical preferences across all agents. From Equation (A.11), this can be seen to be equal to:

$$\begin{aligned} \lambda &= \frac{\sum_h d_{g,m,h}(\mathbf{q}; y_h) / \Phi_h(\mathbf{q})}{\sum_h (d_{g,m,h}(\mathbf{q}; y_h) / \Phi_h(\mathbf{q})) + \sum_h \sum_k t_k \partial d_{k,m,h}(\mathbf{q}; y_h) / \partial q_{g,m}} \\ &= \frac{\sum_h \beta_h(\mathbf{q}) d_{g,m,h}(\mathbf{q}; y_h) / \sum_h d_{g,m,h}(\mathbf{q}; y_h)}{1 + \sum_k \frac{t_k}{1+t_k} \sum_h \epsilon_{km, gm}^h \frac{d_{k,m,h}(\mathbf{q}; y_h) q_{k,m}}{\sum_{h'} d_{g,m,h'}(\mathbf{q}; y_{h'}) q_{g,m}}} \quad \forall g \in \mathcal{G}. \end{aligned} \quad (\text{A.23})$$

The crucial difference between Equation (A.22) and Equation (A.23) is in the numerator, where the former contains aggregate demand of commodity g , while the latter contains a weighted average of household demands for that same commodity. The weights, $\beta_h(\mathbf{q})$, are the inverse of the household specific price indices, $\Phi_h(\mathbf{q})^{-1}$. Therefore, *in the optimum* these weights are lower for households whose members particularly like relatively highly taxed goods. In a general setting, the numerator of the second line of Equation (A.23) is known as the distributional characteristic of a commodity g (Feldstein, 1972). The denominator contains the impact on the government revenue of marginally increasing the tax rate on a commodity g . While, theoretically, the denominators in Equations (A.22) and (A.23) differ, they refer to the same empirical content.

Table B.1: The impact of preference heterogeneity on the optimal tax structure

Commodity	Identical pref. %	Heterog. pref. %	Inequality aversion $e = 0, n_h = \theta_h$		Own price elast. (1)	Own price elast. (2)	Rank elas.(1)	Rank elas.(2)
			Rank (1)	Rank (2)				
Education e	12.78	13.62	23	10	-1.0000	-1.0000	23	23
Other services e	12.78	14.22	22	2	-1.0000	-1.0000	22	22
Health e	12.81	13.12	21	19	-0.9983	-0.9993	21	20
Communication t	12.82	13.55	20	11	-0.9974	-0.9993	20	19
Transport t	12.83	13.33	19	14	-0.9971	-0.9987	19	16
Others non serv. t	12.83	13.21	18	18	-0.9967	-0.9994	18	21
Transport e	12.84	13.69	17	9	-0.9960	-0.9984	17	15
Furnishings \& equipm. t	12.88	12.83	16	21	-0.9935	-0.9990	16	18
Housing utilities t	12.94	13.50	15	12	-0.9893	-0.9964	15	13
Other services t	12.95	12.15	14	23	-0.9886	-0.9988	14	17
Recreation, culture e	12.97	13.31	13	16	-0.9876	-0.9920	13	11
Recreation, culture t	13.08	13.42	12	13	-0.9801	-0.9899	12	8
Food poor t	13.08	12.87	11	20	-0.9798	-0.9909	11	10
Non alcoh. Bev. t	13.28	13.84	10	6	-0.9667	-0.9906	10	9
Catering and accomm. t	13.33	13.73	9	8	-0.9635	-0.9892	9	7
Food rich t	13.49	13.99	8	5	-0.9537	-0.9801	8	6
Alcoh. bev. \& tob. t	13.52	13.31	7	17	-0.9516	-0.9730	7	5
Alcoh. bev. \& tob. e	13.62	12.81	6	22	-0.9456	-0.9707	6	4
Clothing t	13.63	13.82	5	7	-0.9449	-0.9563	5	2
Housing utilities e	13.92	13.32	4	15	-0.9278	-0.9929	4	12
Food rich e	14.06	14.17	3	3	-0.9194	-0.9587	3	3
Food poor e	15.23	14.16	2	4	-0.8574	-0.9358	2	1
Housing rent e	20.06	14.61	1	1	-0.6785	-0.9972	1	14
Distance inverse elasticity rule (Spearman's Foot Rule (SFR) relative to max. value of SFR)							0.00	53.8

In our model cross price effects between market goods are zero, so that Equation (A.22) further reduces to:

$$\frac{t_g}{1+t_g} = \frac{1}{\epsilon_{gm,gm}^{\text{CCD}}} \frac{\beta(\mathbf{q}) - \lambda}{\lambda} = \frac{\gamma}{\epsilon_{gm,gm}^{\text{CCD}}}, \quad (\text{A.24})$$

which is the inverse elasticity rule: optimal taxes are inversely proportional to (own) price elasticities. We stress however that these elasticities depend on the tax rates and therefore are endogenous variables. The corresponding equation in case preferences are heterogeneous, equals:

$$\frac{t_g}{1+t_g} = \frac{1}{\sum_h \epsilon_{gm,gm}^{\text{CCD},h} \frac{d_{g,m,h}^{\text{CCD}}(\mathbf{q};y_h)}{\sum_{h'} d_{g,m,h'}^{\text{CCD}}(\mathbf{q};y_{h'})}} \frac{\sum_h \beta_h(\mathbf{q}) d_{g,m,h}^{\text{CCD}}(\mathbf{q};y_h) / \sum_{h'} d_{g,m,h'}^{\text{CCD}}(\mathbf{q};y_{h'}) - \lambda}{\lambda}. \quad (\text{A.25})$$

Again, the weighted average of household's own price elasticities of demand, $\sum_h \epsilon_{gm,gm}^{\text{CCD},h} \frac{d_{g,m,h}^{\text{CCD}}(\mathbf{q};y_h)}{\sum_{h'} d_{g,m,h'}^{\text{CCD}}(\mathbf{q};y_{h'})}$, and the market own price elasticity of demand, $\epsilon_{gm,gm}^{\text{CCD}}$, have the same empirical content. Consequently, preference heterogeneity would generally cause deviation from the inverse elasticity rule of demand.

In Table ?? of the main text, we provide some numerical calculations which illustrate the difference between optimal taxes when all goods can be taxed versus only market goods being taxable; with and without within household economies of scale; and with and without preference heterogeneity. Table B.2 gives more detail on the deviation from the inverse elasticity rule caused by preference heterogeneity. The first two columns reproduce Column (2) and (3) of Table ?? but we now rank commodities from lowly to highly taxed according to the inverse elasticity rule (Equation A.24), that is, assuming identical preferences. Market elasticities, which are shown in Column (6), are calculated as follows:

$$\begin{aligned} \epsilon_{gm,gm}^{\text{CCD}} &:= \sum_h \epsilon_{gm,gm}^{\text{CCD},h} \frac{D_{g,m,h}^{\text{CCD}}(\mathbf{q}_g; y_h)}{\sum_{h'} D_{g,m,h'}^{\text{CCD}}(\mathbf{q}_g; y_{h'})}, & g \in \mathcal{G}, \\ \epsilon_{gm,gm}^{\text{CCD},h} &= -\sigma - (1-\sigma) \frac{\delta_{g,m,h} (1+t_g)^{1-\sigma}}{(1-\delta_{g,m,h}) + \delta_{g,m,h} (1+t_g)^{1-\sigma}}, & h = 1, \dots, H; g \in \mathcal{G}, \\ D_{g,m,h}^{\text{CCD}}(\mathbf{q}_g; y_h) &= \frac{\alpha_{g,h} \delta_{g,m,h} y_h}{(\delta_{g,m,h} (1+t_g)^{1-\sigma} + (1-\delta_{g,m,h})) \cdot (1+t_g)^\sigma}, & h = 1, \dots, H; g \in \mathcal{G}, \end{aligned} \quad (\text{A.26})$$

where tax rates are evaluated at the optimum. Elasticities of 'Other services e' and 'Education e' are -1 as there are no auto-consumption varieties for those goods, and we are thus back in a simple Cobb-Douglas specification of preferences for those goods.

Column (5) shows the percentage point difference in optimal tax rates according to the inverse elasticity rule (A.24) (assuming identical preferences) and optimal taxes when preferences are heterogeneous, but maintaining the assumption that there is no inequality aversion, and that there are no within household economies of scale (Equation A.25).

Table B.2: The impact of preference heterogeneity on the optimal tax structure

Commodity	Inequality aversion $e = 0$, $n_h = \theta_h$					Own price elast.
	Identical pref. %	Heterog. pref. %	Rank (1)	Rank (2)	Diff. (2)-(1) $\times 10^2$	
Other services e	13.37	14.2	1	22	0.9	-1.000
Education e	13.37	13.6	2	14	0.2	-1.000
Others non serv. t	13.38	13.2	3	6	-0.2	-0.999
Health e	13.38	13.1	4	5	-0.3	-0.999
Communication t	13.38	13.5	5	13	0.2	-0.999
Furnishings & equipm. t	13.39	12.8	6	3	-0.6	-0.999
Other services t	13.39	12.1	7	1	-1.2	-0.999
Transport t	13.39	13.3	8	10	-0.1	-0.999
Transport e	13.40	13.7	9	15	0.3	-0.998
Housing rent e	13.41	14.6	10	23	1.2	-0.997
Housing utilities t	13.43	13.5	11	12	0.1	-0.996
Housing utilities e	13.48	13.3	12	9	-0.2	-0.993
Recreation, culture e	13.49	13.3	13	8	-0.2	-0.992
Food poor t	13.51	12.9	14	4	-0.6	-0.991
Non alcoh. bev. & tob. t	13.51	13.8	15	18	0.3	-0.991
Recreation, culture t	13.53	13.4	16	11	-0.1	-0.990
Catering and accomm. t	13.54	13.7	17	16	0.2	-0.989
Food rich t	13.68	14.0	18	19	0.3	-0.980
Alcoh. bev. & tob. t	13.79	13.3	19	7	-0.5	-0.973
Alcoh. bev. & tob. e	13.83	12.8	20	2	-1.0	-0.971
Food rich e	14.03	14.2	21	21	0.1	-0.959
Clothing t	14.07	13.8	22	17	-0.3	-0.956
Food poor e	14.42	14.2	23	20	-0.3	-0.936

Note: Column (1) contains the optimal tax rates according to the inverse elasticity rule (A.24), that is assuming identical preferences; Column (2) adds preference heterogeneity, as in Equation (A.25); Column (3) contains the ranks of the tax rate according to the inverse elasticity rule with identical preferences, from low to high, and Column (4) contains the corresponding ranks after having added preference heterogeneity (Column 2). Column (5) contains the difference in percentage points between the optimal rates with and without preference heterogeneity; Column (6), finally, contains the own price elasticities of demand. Commodities are ranked according to the optimal tax rates under identical preferences (Column 1), from low to high.

Differences are small (at most 1.2 percentage point), but they cause nevertheless serious re-ranking of optimal tax rates. ‘Alcoholic beverages and tobacco e’ bears for example the fourth highest tax rate under the assumption of identical preferences. The optimal tax rate when taking into account heterogeneous preferences falls with one percentage point, and it thus becomes the commodity with the second lowest tax rate. Notice that deviations from the inverse elasticity rule are not related to the height of the rates under identical preferences. The optimal rates of some relatively lowly taxed goods under the inverse elasticity rule (‘Education e’ or ‘Communication t’) go up, while others go down (‘Health e’ or ‘Furnishings and equipment t’), and *vice versa*. The interplay between elasticities and preferences heterogeneity thus displays no clear pattern.

B.5 Construction of quantiles, averages, and confidence intervals

Once individual welfare is calculated, we construct quantiles, that is, we divide the population in q equally sized groups, such that the first group consists of the poorest $q\%$ of the population, the next group contains the $q\%$ of the population which is better off than the first group but worse off than the other $100 - 2q\%$ of the population, and so forth. For individual welfare we construct deciles (groups of 10% of the population), though we sometimes use other quantile values. The q -th quantile value is the value below which $q\%$ of the population is situated.

Since our welfare measure (see Equation A.8) is an individual one, we consider mostly the population of individuals living in Benin at the moment of survey, as our reference population. This means that statistics will be drawn using weights which sum up to population size.²

For some concepts it might be more natural though, to draw statistics at the level of the population of households. For example, when one looks at the budget share of a good (the percentage of the budget spent to that good), it may make more sense to talk about the average household budget share spent on food, of the households to which the poorest 10% of individuals belong, rather than about the average household budget share spent on food, across all individuals belonging to that poorest decile. Average shares, for example budget shares of expenditures on a certain good, can either mean the average of that share over a number of observations, or the average of the numerator of the share, expenditures on that good, over the average of the denominator (the average budget), that is, the ratio of averages. The former is an outlier sensitive statistic. Especially when groups are not very big, the latter may therefore sometimes be preferred. When we talk below about quantiles and averages, we will always specify which quantile or average we mean: with respect to the population of individuals, or with respect to the population of households; and average shares or the ratio of averages.

Statistical inference is made by means of the bootstrap method. We create 500 new samples of the same size as the original one by drawing randomly with replacement from the original sample. The number of 500 replications was fixed by doing some robustness checks with 100, 200, 300, 400, and 500 draws, after which confidence intervals became rather stable. For each sample we first determine a new baseline by fixing the tax rate that raises the same government revenue as our baseline for the original sample. Remember that this baseline government revenue is determined such that the UN objective of tax revenues to attain 20% of GDP, is reached. Then we perform for each of the six values of inequality aversion optimal taxes and compare the resulting welfare levels with those of the corresponding baseline. The 95% confidence interval around the point estimates of a statistic is then fixed by selecting for twelfth lowest and thirteenth highest value of each of the 500 calculations of that statistic.

C Data

C.1 Composition of commodity aggregates

The present section gives detailed information of the composition of the different commodity aggregates we used at the most detailed level we have available in the data (COICOP 6 digits). The 23 aggregates are constructed using a somewhat finer grid than the COICOP 2 digit classification (for example housing is split into rents and utilities and maintenance). Moreover, as explained in the main text, we distinguish between commodities that are taxed according to the rules in vigour in 2015, and those that are exempt from VAT. For some categories, all its components are taxed (for example, ‘catering and accommodation’), or all are exempted (‘health’).

Finally, for food we distinguish between ‘food rich’ and ‘food poor’. This distinction was based on two pieces of information. First, we investigated for the market varieties of the food, the pattern of the budget shares across

² The dataset we use has as unit of observation a household. Weighting with individuals is then implemented by drawing statistics using household weights provided by INSAE (which can inflate statistics to the population of households) times the household size.

the welfare deciles, in the data.³ We took care that in the aggregate the budget share of the ‘food rich’ groups is increasing across the welfare distribution, and the other way around for ‘food poor’. One can verify that in Table C.2 below. Second, for each of the food aggregates we also investigated the share of total consumption of that good by different welfare groups (*cf.* the notion of *distributional characteristics* of a commodity, introduced by Feldstein, 1972). Of course the poor consume of (almost) all commodities less than the rich. But we verified that for the ‘food poor’ aggregates, the share in total consumption of these commodity groups of the lowest two welfare deciles is above their average of the shares in total consumption for all commodity groups, and, correspondingly, that the share in total consumption of ‘food poor’ for the highest two deciles is below the average share in total consumption of all goods for that group. For the ‘food rich’ aggregates, the share in total consumption of these commodity groups of the lowest two welfare deciles is below their average of the shares in total consumption for all commodity groups, and the share of richest two deciles above their average of the shares in total consumption for all commodities.

This brings us to 23 commodity groups, of which the composition is given in the next table. For the commodity names, we use the original labels of the survey, which are in French.

³ We stress again that budget shares of commodities might change with the tax structure and therefore are not necessarily the same in the optimum, as compared to what is observed in the data. The same holds true for the welfare deciles, the composition of which may change with tax rates. This is discussed further in Section D.5.

Table C.1: Detailed overview of the composition of the commodity groups

Food rich

Food rich taxed: Riz importé, Couscous de blé, Macaroni, Spaghetti, Autres pattes alimentaires, Biscuit industriel, Pâtisserie et viennoiserie, Biscuits, gâteaux, Poulet congelé, Canard congelé, Dinde congelé, Morceaux de poulet, Saucisson, Corned beef, Conserve de porc, Conserve de boeuf, Conserve de poulet, Conserves, autres viandes et préparatif, Maquereau et chinchard congelé, Crabes de lagune, Escargots de lagune, Crabes de mer, Escargots de mer, Homard et crevette, Langouste, Autres produits frais de la mer, Boite de sardine, Boite de thon, Autres conserves poissons, Lait entier pasteurisé, Lait entier concentré sucré ou non, Lait écrémé, Lait en poudre, Autres laits, Crème fraîche, Yaourt fabrication industrielle, Lait caillé, Margarine, Huile d'arachide, Huile de coton, Autres matières grasses, Orange, Mandarine, Citron, Ananas, Banane douce, Papaye, Avocat, Pomme, Pastèque melon, Datte, Concentré de tomate, Frites et chips, Farine d'igname, Sucre en morceaux, Bonbons, Miel raffiné, Glace, Sirop et mélasse, Chocolat à croquer ou en patte, Mayonnaise, Vinaigre, Lait infantile (Guiguoz), Cérélac, Farigallia, Nestum, Autres aliments pour bébé.

Food rich exempt: Maïs en épi frais, Mil, Riz local, Autres céréales non transformées, Maïs en patte, Farine de mil, Céréales grillées, Féculé de pomme de terre, Tapioca/gari, Autres farines et semoules, Patte alimentaire locale cuite (abolo), Pain de blé local artisanal, Pain de blé industriel en baguette, Autres pains, Bœuf sur pied (vivant), Viande de bœuf fraîche sans os, Viande de bœuf séchée, Abats et tripes de bœuf, Autres viandes de bœuf, Viande de mouton ou de chèvre fraîche, Abats et fripes de mouton ou de chèvre, Porc sur pied (vivant), Viande de porc fraîche, Volaille sur pied (vivante), Morceaux de volaille, Gibier, Capitaine, Bar frais, Sardinelles sardines et anchois fraîches, Poisson frais Appolo, Poisson frais Sosso, Carpe fraîche, Silure (silivi), Dorade, Autres poissons frais, Maquereau et chinchard fumé, Bar fumé, Sardinelles fumés, Sardinelles séchés, Silure fumée, Dorade fumée, Yaourt fabrication traditionnelle, Œuf frais de poule, Autres œufs, Patte d'arachide locale, Tomate fraîche, Aubergine verte, Carotte, Haricot vert, Courges, Autres légumes frais en fruits ou racines, Salade verte locale (laitue), Epinard, Choux vert, Ndolé (bitter-leaves ou feuilles amères), Feuille de manioc, Haricots secs, Pois secs, Arachide décortiquée, Sésame décortiqué, Banane plantain, Manioc, Igname, Pomme de terre tubercule, Patate douce, Taro, Macabo, Manioc râpé, Manioc déshydraté (en boules ou en mo), Autres tubercules, Canne à sucre, Miel naturel, Ail persil céleri et basilic, Gingembre.

Food poor

Food poor taxed: Jambon, Museau de porc, Autres charcuteries, Pilchard, Fromage, Autres produits laitiers, Beurre (alimentaire), Autres produits dérivés de beurre, Huile de palme, Huile de soja, Huile d'olive, Huile de karité, Autres huiles, Pamplémousse, Mangue, Goyave, Autres fruits frais, Noisettes, Noix de Coco, Noix de cajou, Autres fruits secs, Sucre en poudre, Autres sucres, Chewing-gum, Autres confiseries, Moutarde et ketchup, Bouillon alimentaire en cube (Maggi, Jumbo), Autres épices et condiments.

Food poor exempt: Maïs en grains crus, Sorgho, Fonio, Farine de maïs, Farine de sorgho, Farine de manioc (y compris Attiéké), Biscuit artisanal, Beignet à base de farine de blé, Beignet à base d'autres céréales, Viande de bœuf fraîche avec os, Mouton ou chèvre sur pied (vivant), Viande de mouton ou de chèvre sèche, Autres viandes de mouton ou de chèvre, Viande de porc séchée, Abats et tripes de porc, Autres viandes de porc, Autres volailles, Insectes ou chenilles, Serpent et reptiles, Maquereau et chinchard séché, Dorade séchée, Poissons salés, Autres poissons fumés ou séchés, Lait frais liquide non traité, Graines de palme traditionnelles, Oignon frais, Gombo frais, Feuille de gombo, Feuille de patate, Feuilles gluantes (adémè ou crincrin), Feuille de baobab, Autres légumes frais en feuille, Conserves de légumes secs, Autres oléagineux (arachide gri), Autres légumes secs, Autres tubercules, Bâton de manioc, Piment, Poivre et poivron, Sel.

Non alcoholic beverages

Non alcoholic beverages taxed: non existent.

Non alcoholic beverages exempt: Café, Thé, Milo, Ovaltine, Matinal, Autres produits cacaotés, Infusion (tisane), Autres cafés thés etc, Jus de fruit artisanal, Eau de source (potable), Glaçon, Autres boissons non alcoolisées artisanales, Eau gazeuse, Eau minérale en bouteille, Boisson gazeuse aromatisée (coca, fanta), Jus de fruit industriel, Autres boissons non alcoolisées industrielles.

Alcoholic beverages, tobacco and narcotics

Alcoholic beverages, tobacco and narcotics taxed: Whisky, Gin, Apéritifs non à base de vin, Eaux-de-vie ou liqueur locale, Autre liqueur industrielle, Vin industriel et vermouth, Apéritif à base de vin, Vins mousseux (champagne), Bière industrielle, Tabac local (à priser, à chiquer, etc), Cigarettes locales ou produites sous licence, Cigarettes importées, Cigares, Noix de cola, Autres stupéfiants.

Alcoholic beverages, tobacco and narcotics exempt: Vin de palme et de rafia, Autres boissons fermentées, Bière artisanale.

Clothing and footwear

Clothing and footwear taxed: Tissu pagne, Autres tissus en coton, Tissu synthétique, Autres tissus, Chemise homme (y compris chemisette), Gandoura, boubou et saharienne homme, Pantalon et culotte homme, Veste homme, Costume homme, Ensemble homme, Autres vêtements de dessus homme, Slip homme (toute forme de caleçon), Chaussette homme, Tee shirt homme, Vêtement de nuit homme, Autres sous-vêtements et bonneterie homme, Robe et jupe, Pantalon et culotte femme (culotte), Ensemble femme (tailleur, veste,), Gandoura, boubou et pagne femme, Chemise en tissu pour femme, Vêtement de sport (shorts, jogging), Autres vêtements de dessus femme, Slip et caleçon femme (string), Jupou et collants, Tee shirt femme, Soutien gorge, Vêtement de nuit (robe de chambre), Autres vêtements de dessous femme, Vêtements pour bébé (layette), Chemisette chemise tricot et pull-over, Robe et jupe fillette, Pantalon culotte et short garçon, Ensemble pour enfant (veste, costume), Gandoura boubou et enfant, Sous vêtement et vêtement de nuit enfant, Autres vêtements enfants, Tenues scolaires jeune homme, Tenues scolaires jeune fille, Tenues scolaires enfant (3 à 13 ans), Mouchoir et foulard en tissu, Ceinture, Couche bébé en tissu, Chapeau bonnet ou chéchia, Perruque, Cravate et noeud, Mercerie (fil à coudre, aiguilles, bou), Autres articles vestimentaires, Confection costume homme, Confection pantalon homme, Confection chemise homme, Réparation vêtement homme, Location de vêtement homme, Autre confection homme, Confection robe et jupe, Confection ensemble femme, Réparation vêtement femme, Location de vêtement femme, Autre confection femme, Confection chemise enfant, Confection pantalon enfant, Confection robe enfant, Confection jupe enfant, Confection ensemble garçon, Confection ensemble fille, Réparation vêtements enfant, Location vêtements enfant, Autres confection vêtements enfant, Nettoyage à sec de vêtement, Blanchissage, Pressing de vêtement, Teinture des vêtements et tissus, Chaussure en cuir homme, Chaussure synthétique homme (cahoutchouc), Chaussure de tennis basket ou football, Sandale pour homme, Autres chaussures et accessoires (languet), Chaussure en cuir femme, Chaussure synthétique femme (cahoutchouc), Chaussure de tennis basket ou football, Sandale pour femme, Autres chaussures et accessoires (languet), Sandale pour enfants, Chaussure en cuir enfant, Chaussure synthétique (cahoutchouc), Chaussure de tennis basket ou football, Autres chaussures accessoires et articles, Ressemelage complet, Cirage et nettoyage de chaussure, Autres réparations et locations.

Clothing and footwear exempt: non existent.

Housing rent

Housing rent taxed: non existent.

Housing rent exempt: Loyer de maison d'habitation, Loyer de terrain.

Housing utilities and maintenance

Housing utilities and maintenance taxed: Ciment, Tôle, Fer à béton, Peinture, Chaux vive, Sable, Carreaux, Robinet, Petites pièces de plomberie (tuyaux), Autres produits pour entretien et réparation, Main d'œuvre pour réparation courante, Main d'œuvre pour renouvellement, Main d'œuvre pour petits travaux de maintien, Autres services d'entretien du logement, Facture d'eau, Location de compteur, Eau achetée en bidon seau baril etc, Autres dépenses connexes (redevances), Enlèvement et traitement des ordures, Reprises des eaux usées, Vidange fosse septique, Gardiennage, Jardinage, Autres services payant liés au logement, Autres dépenses connexes, Pétrole lampant, Autres combustibles liquides, Charbon de bois, Autres combustibles.

Housing utilities and maintenance exempt: Consommation d'électricité, Gaz, Bois de chauffage, Sciure/copaux de bois.

Furnishings and household equipment

Furnishings and household equipment taxed: Nappes serviettes de table et serviettes, Draps couvertures couvrelit, Moustiquaires, Tissus pour rideau, Réparation d'articles de ménage, Autres articles de ménage en textile, Cafétières électriques, Ventilateur mobile, Plaques chauffantes, Fer à repasser, Moulinette (moulinex), Autres appareils électroménagers, Fer à repasser à charbon, Fourneau, Rechaud à pétrole ou à gaz, Réparation d'appareils électroménage, Réparation d'un groupe électrogène, Réparation d'un congélateur ou réfrigérateur, Réparation d'un ventilateur mobile, Réparation de fer à repasser, Réparation d'autres appareils ménager, Assiettes, Couverts (couteau, fourchette, cuiller), Verres, Bol et tasse, Réparation de vaisselle, Autres vaisselles, Casserole, Marmite, Poêle, Calebasses et jarres, Cocottes, Réparation d'ustensiles de cuisine, Autres ustensiles de cuisine, Lampe à pétrole pression ou à gaz, Seau ou cuvette, Poubelle, Bouteille thermos glacière, Autres ustensiles de ménage, Scies marteau tournevis etc, Pelle râteau brouette arrosoir etc, Machette et houe, Echelles et escabeaux, Gongs poignées et serrures, Ampoule tube fluorescent Lampes de poche et piles électriques, Autres petits accessoires électriques, Autres outillages, Eau de Javel, Savon de ménage en morceaux, Lessives en poudre ou liquides, Insecticide et tortillon anti-moustique, Articles en papier ou carton (mouchoirs), Produits de cirage (Kiwi), Désinfectant (Crésyl, raticide), Allumettes bougies ou mèches de lampe, Torchons et éponge de ménage serpiaire, Autres articles de ménage non durables, Boy bonne cuisinier, Jardinier, Chauffeur de véhicule personnel, Autre personnel domestique, Blanchisserie pressing de linge, Location de meubles et d'articles ménage, Services ménagers (désinfection), Autres services ménagers.

Furnishings and household equipment exempt: non existent.

Health

Health taxed: non existent.

Health exempt: Aspirine, Nivaquine, Quinimax, Vaccins, Bactrim, Chloroquine, Paracetamol, Autres médicaments modernes, Herbe pour paludisme, Anti hémoroïde, Antitussif, Vermifuge, Pansement gastrique, Antibiotiques, Autres médicaments traditionnels, Mercurochrome, Alcool ou teinture de pansement, Autres produits pour pansements, Seringue à jeter, Thermomètre médical, Préservatifs et autres contraceptifs, Autres produits pharmaceutiques, Consultation d'un généraliste, Consultation d'un gynécologue, Consultation d'un pédiatre, Consultation d'autres spécialistes, Autres services des médecins, Consultation d'un dentiste, Consultation d'un spécialiste ou auxil, Frais de pose des prothèses dentaires, Autres services des dentistes, Radiographie, Analyse de sang, Analyse d'urine, Analyse de celles, Autres analyses, Service d'un infirmier, Consultation d'un médecin traditionnel, Consultation d'un marabout, Autres services des auxiliaires médicales, Hospitalisation, Soins hospitaliers, Intervention chirurgicale, Frais de maternité, Autres services des hôpitaux.

Transport

Transport taxed: Pneu pour automobile, Chambre à air pour automobile, Batterie pour automobile, Bougie pour automobile, Pneu pour vélo ou moto, Chambre à air pour moto, Bougie pour moto, Autres pièces détachées, Essence super, Essence ordinaire, Essence mélange, Gas-oil, Huile à moteur, Autres carburants et lubrifiants, Vidange graissage d'une voiture, Vidange graissage d'une moto, Lavage, Réparation d'un pneu de voiture, Réparation d'un pneu de moto, Pose de pièces de rechange et d'access, Taillerie, Autres réparations et entretiens de véhicule, Frais de parking, Leçon auto-école, Examen de permis de conduire, Permis de conduire, Contrôle technique, Location de véhicule sans chauffeur, Autres services relatifs aux véhicules, Transport de passagers et de bagages passagers, Transport par train de tourisme, Taxi-auto course en ville, Télé-taxi, Transport en commun, Transport longue distance par route, Autres transports routiers, Transport par avion de tourisme, Transport transfrontaliers de passagers, Autre transport fluvial, Transport combiné de tourisme, Services de déménagement, Services de porteur, Consignation, Expédition de bagages, Autres services de transports.

Transport exempted: Peage, Taxi-moto.

Communication

Communication taxed: Achats de timbres, Envoi de colis personnels, Frais d'envoi de mandat postal, Achat de carte de téléphone fixe, Achat de carte de téléphone mobile, Autres achats de cartes téléphoniques, Communication téléphonique à l'unité, Frais d'abonnement téléphonique fixe, Frais d'abonnement téléphonique mobil, Facture téléphonique fixe, Facture téléphonique mobile, Frais d'installation de téléphone fix, Frais de télécopie ou fax, Autres services de téléphone et télé, Frais d'abonnement internet, Frais de connexion à internet, Utilisation de messagerie électronique, Autres frais divers de connexion internet.

Communication exempt: non existent

Recreation and culture

Recreation and culture taxed: Pellicule photo, Cassette enregistrée, Cassette vierge, Disquette vierge, Disquette enregistré, CD-ROM vierge, CD-ROM enregistré, Disque, Autres supports d'enregistrement, Réparation appareils réception enregistrement, Réparations d'équipement photographique, Réparation du matériel de traitement, Ludo echec dame carte etc., Jeux video, Jouets, Feux d'artifice, Guirlandes et décorations pour arbre, Autres jeux et jouets, Ballon, Raquette, Boules, Tente et accessoires connexes, Chaussures spéciales, Autres articles de sport, Fleurs et feuillages naturels ou artifices, Plantes arbustes arbrisseaux, Engrais compost, Terreaux, Frais de livraison des fleurs et plantes, Autres produits pour jardins, Chat, Oiseau, Achat d'aliments de produits vétérin, Collier du chien et du chat, Niche cage à oiseau ou litière du chat, Toilettage des animaux de compagnie, Dressage, Vaccination et traitement des animaux, Droit d'entrée au stade, Droit d'entree dans une piscine, Salle de gymnase, Service de guide de montagne touristique, Autres services récréatifs et sportif, Droit d'entrée dans une salle de ciné, Droit d'entrée au théâtre, Droit d'entrée au concert, Droit d'entrée en boîte de nuit, Droit d'entrée à une bibliothèque, Abonnement et redevance à des chaînes, Services de photographe, Locations de cassettes à but culturel, Autres services culturels, Billet de loterie nationale, Billet de PMU, Autres jeux de hasard, Journal quotidien privé local, Journal hebdomadaire privé local, Autres presses et périodiques, Catalogues, Imprimé publicitaires, Affiches publicitaires, Carte postale, Calendrier, Carte de vœux cartes de visite, Cartes géographiques et globes, Autres presse et imprimés divers, Cahier, Cartable, Agenda, Enveloppes, Bloc-notes carnets de note, Livres comptables, Autres articles de papeterie, Trousse, Autres fournitures de bureau, Pélérinages, Excursions et circuits touristiques.

Recreation and culture exempt: Livres scolaires enseignement maternelle, Livres scolaires enseignement primaire, Livres scolaires enseignement secondaire, Livres scolaires enseignement supérieure, Autres livres scolaires, Atlas, Dictionnaire, Album pour photo, Bande dessinée, Reliure des ouvrages, Autres livres, Journal quotidien

officiel, Journal hebdomadaire officiel, Journal mensuel, Crayons, Stylos, Ardoise locale, Craies, Instruments de géométrie, Articles de dessin, Colles à papier et adhésifs, Cartouche d'encre pour imprimante.

Education

Education taxed: non existent.

Education exempted: Frais de scolarité jardin d' enfants, Frais de scolarité dans une école primaire, Cours d'alphabétisation, Frais de répétition des élèves en primaire, Autres frais liés à l'enseignement primaire, Frais de scolarité dans une école secondaire, Frais de répétition des élèves en secondaire, Enseignement secondaire extrascolaire, Autres frais liés à l'enseignement secondaire, Frais de scolarité dans un institut post-secondaire, Autres frais d'enseignement post-secondaire, Frais de scolarité dans le supérieur, Autres frais liés l'enseignement supérieur, Cours particuliers non récréatifs, Formation professionnelle, Autres services d'enseignement.

Catering and accommodation

Catering and accommodation taxed: Bière artisanale dans un bar, Bière industrielle dans un bar, Sucrierie dans un bar, Liqueur dans un bar, Petit déjeuner pris à l'extérieur, Déjeuner pris à l'extérieur, Dîner pris à l'extérieur, Autres consommations à l'extérieur, Autres consommations à l'extérieur, Services de restauration des cantines, Chambre d'hôtel motel auberge, Pensionnats, Résidences universitaires, Autres services d'hébergement.

Catering and accommodation exempt: non existent.

Other non services

Other non services taxed: Coupe homme, Coupe dame, Défrisage des cheveux, Tresse, Manucure ou pédicure, Massage à des fins non thérapeutiques, Autres services de coiffure, Autres services de beauté et soins, Rasoir électrique, Tondeuse électrique, Séchoir à main, Casque séchoir, Réparation des appareils électriques, Autres appareils électriques pour soins, Rasoir non électrique, Tondeuse non électrique, Lame de rasoir et de tondeuse, Ciseaux, Peigne brosse (à cheveux et à dents), Bigoudis, Réparations et autres articles pour les soin de cheveux, Savon de toilette, Savon médicinal, Lait et huile de toilette, Dentifrice, Parfums et eaux de toilette, Déodorants corporels, Produits de beauté (vernis rouge à lèvres), Couches jetables pour bébé, Papier hygiénique, Autres articles pour les soins corporel, Valise, Sac de voyage, Sac à main, Lunettes solaires, Parapluies, Porte-monnaie et portefeuilles, Articles pour fumeurs, Articles pour bébés (poussettes sié), Réparation des effets personnels, Autres effets personnels.

Other non services exempt:

Other services

Other services taxed: Frais de crèche, Autre frais de protection sociale du ménage, Prime d'assurance éducation, Assurance vol, Assurance dégâts des eaux, Assurance maladie, Assurance d'accident privé, Autres assurances maladie, Assurance Automobile, Assurance motocyclette, Autres assurances transport, Frais effectivement facturés par les b Autres services d'intermédiation, Frais de mouture de céréales, Autres frais de mouture, Montant versé à des conseillers juridiques, Montant versé à des services de pompe, Montant versé à des agences immobilières, Autres frais divers sur prestations, Légalisation d'une pièce, Frais de photocopie et de reprographie, Autres services.

Other services exempt: Frais d'établissement des actes d'établissement, Autres frais d'établissement d'autres, Frais de parution d'annonce.

For most of these commodity aggregates, an auto-consumed variety exists. Exceptions are *education* and *other services*. For 'Housing rents' the auto-consumption variety consists of the imputed rents of owner-occupied dwellings.

C.2 Budget shares

Tables C.2 and C.3 contain the budget shares of different commodities by deciles of individual welfare and overall, as constructed from the original data, given the policy in vigour at that time (2015), that is a basic VAT-tariff of 18% while some goods are exempt. Section C.1 contains the definitions of our commodity aggregates.

For auto-consumption and gifts received, the reported monetary amounts are assumed to be exclusive of VAT, and are thus evaluated at producer prices. The idea is that these goods can, if wanted, be sold on the market at producer price, and therefore should be included as part of the global budget of the households. The budget shares are calculated as the sum of expenditures on a particular commodity g, s of households whose members belong to a particular decile or overall, divided by total expenditures on market goods and auto-consumption of those households (whose members belong to a particular decile or overall).

Tables C.4 and C.5 contain the budget shares of different commodities by deciles of individual welfare and overall, for the baseline with which we will compare results from the optimal taxation exercises. This baseline retains the structure of indirect taxation as is, with a basic tariff and a number of commodities that are exempt. The basic tariff is increased from 18 to 25.56% in order to meet the UN objective to raise total tax revenues to 20% of GDP. The budget shares are calculated as the sum of expenditures on a particular commodity g, s of households whose members belong to a particular decile or overall, divided by total expenditures on market goods and auto-consumption of those households (whose members belong to a particular decile or overall).

Overall budget shares on varieties who belong to the exempt categories are not changing as compared to the corresponding budget shares calculated from the data as reported in Tables C.2 and C.3. The differences across deciles for those goods are solely due to the fact that the deciles are differently composed in both cases (individual welfare with 18% tariff for market varieties of taxed commodities in the data case *versus* 25.56% in the baseline simulation). The budget shares of the market variety of the taxed good categories increase, while those of the corresponding auto-consumption varieties decreases, when compared to the original data. The reverse holds for quantities consumed (decreases for the market variety of taxed commodities, and increases for corresponding auto-consumption variety). This corresponds to what is to be expected from the demand equations (see Equation A.4).

Table C.2: Budget share market by decile and total (% of total expenditures: market + auto) – Data

Commodity	Decile										Total
	1	2	3	4	5	6	7	8	9	10	
Food rich t	3.59	4.01	4.62	5.21	5.81	6.30	6.65	7.45	8.06	10.27	7.80
Food rich e	9.35	10.63	12.95	14.11	16.32	17.38	17.31	17.92	18.04	18.82	17.27
Food poor t	8.84	6.82	6.32	6.18	5.51	5.41	5.00	4.76	4.25	3.32	4.59
Food poor e	10.78	12.57	12.98	13.00	11.59	10.61	9.79	8.72	7.99	7.65	9.24
Non alcoh. bev. t	0.62	0.58	0.61	0.54	0.65	0.48	0.51	0.62	0.53	1.07	0.73
Alcoh. bev. & tob. t	1.37	1.30	1.15	0.74	0.74	0.65	0.56	0.53	0.60	0.92	0.77
Alcoh. bev. & tob. e	0.25	0.19	0.20	0.10	0.15	0.10	0.11	0.13	0.06	0.12	0.12
Clothing t	4.79	4.27	4.07	3.81	3.89	3.85	3.88	3.72	3.60	4.17	3.94
Housing rent e	0.28	0.70	0.69	0.64	0.91	1.02	1.28	1.73	1.60	1.73	1.40
Housing: utilities t	2.28	2.76	3.11	3.30	3.13	3.43	3.15	3.04	2.75	2.25	2.78
Housing utilities e	0.99	1.86	1.58	1.68	1.89	1.52	1.74	1.66	1.77	1.80	1.73
Furnishings & equipm. t	1.58	1.71	1.74	1.56	1.59	1.51	1.30	1.26	1.18	1.32	1.37
Health e	3.16	3.47	3.25	2.84	3.18	2.94	3.19	3.00	2.89	2.70	2.93
Transport t	5.97	5.28	6.15	6.38	6.18	6.37	6.63	6.77	7.27	8.09	7.10
Transport e	0.44	0.61	0.76	0.77	0.76	0.75	0.89	0.88	1.03	0.97	0.89
Communication t	2.63	2.56	2.97	3.28	3.88	4.09	4.16	4.81	4.97	5.15	4.51
Recreation, culture t	0.56	0.38	0.40	0.33	0.34	0.38	0.38	0.37	0.37	0.39	0.38
Recreation, culture e	0.11	0.17	0.21	0.25	0.23	0.28	0.29	0.31	0.31	0.25	0.27
Education e	2.88	2.09	1.87	1.80	2.03	2.28	2.65	2.48	3.01	3.88	2.93
Catering and accomm. t	7.65	8.50	8.63	10.77	11.03	11.41	12.74	13.10	13.70	13.68	12.56
Others non serv. t	1.95	1.69	1.87	1.89	1.88	1.91	1.82	1.82	1.78	1.88	1.85
Other services t	3.29	3.37	3.28	2.65	2.24	1.90	1.60	1.25	1.05	0.84	1.49
Other services e	0.00	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.01
Total market	73.39	75.52	79.40	81.82	83.94	84.58	85.65	86.33	86.84	91.28	86.63

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the observed situation. Each decile contains 10% of the population of individuals (see Section B.5). Averages are calculated as mean household expenditures on a commodity g , s over mean total household expenditures on auto-consumption plus market goods (see Section B.5). Commodities followed by a 't' are currently taxed at 18%. Those followed by an 'e' are currently exempt.

Table C.3: Budget share auto-consumption by decile and total (% of total expenditures: market + auto) – Data

Commodity	Decile										Total
	1	2	3	4	5	6	7	8	9	10	
Food rich t	0.93	0.70	0.53	0.79	0.69	0.81	0.84	0.79	1.05	0.66	0.78
Food rich e	3.12	3.56	3.05	2.98	3.82	4.03	4.08	4.39	4.28	2.69	3.54
Food poor t	0.31	0.39	0.46	0.35	0.39	0.27	0.25	0.14	0.13	0.07	0.19
Food poor e	12.91	12.51	9.83	7.69	5.34	4.71	4.02	3.49	3.06	1.57	3.96
Non alc. bev. t	0.05	0.03	0.03	0.02	0.04	0.04	0.04	0.09	0.07	0.04	0.05
Alcoh. bev. & tob. t	0.12	0.07	0.08	0.06	0.07	0.07	0.09	0.09	0.08	0.08	0.08
Alcoh. bev. & tob. e	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02
Clothing t	0.64	0.82	0.76	0.71	0.69	0.62	0.54	0.53	0.40	0.29	0.48
Housing rent e	4.20	3.72	3.68	4.16	3.76	3.38	2.89	2.55	2.30	2.21	2.77
Housing utilities t	0.06	0.13	0.11	0.09	0.09	0.08	0.07	0.05	0.04	0.04	0.06
Housing utilities e	0.36	0.81	1.10	0.78	0.64	0.58	0.46	0.22	0.12	0.05	0.31
Furnishings & equipm. t	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.03	0.02
Health e	0.00	0.01	0.01	0.02	0.00	0.00	0.01	0.00	0.01	0.02	0.01
Transport t	0.03	0.01	0.02	0.03	0.00	0.03	0.02	0.08	0.03	0.06	0.04
Transport e	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Communication t	0.00	0.08	0.01	0.02	0.01	0.03	0.02	0.03	0.03	0.02	0.02
Recreation, culture t	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.02
Recreation, culture e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Education e						non existent					
Catering and accomm. t	3.68	1.52	0.80	0.35	0.44	0.62	0.92	1.14	1.44	0.81	0.97
Other non serv. t	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01
Other services t	0.16	0.08	0.09	0.07	0.03	0.06	0.03	0.01	0.03	0.01	0.03
Other services e						non existent					
Total auto	26.61	24.48	20.60	18.18	16.06	15.42	14.35	13.67	13.16	8.72	13.37

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the observed situation. Each decile contains 10% of the population of individuals (Section B.5). Averages are calculated as mean household expenditures on a commodity g , s over mean total household expenditures on auto-consumption plus market goods (see Section B.5). Commodities followed by a 't' are those for which the corresponding market variety is taxed at 18%. Those followed by an 'e' are those for which the corresponding market variety is exempt.

Table C.4: Budget share market by decile and total (% of total expenditures: market + auto) – Baseline

Commodity	Decile										Total
	1	2	3	4	5	6	7	8	9	10	
Food rich t	3.63	4.07	4.73	5.24	5.78	6.32	6.66	7.55	8.04	10.25	7.81
Food rich e	9.18	10.63	12.67	14.11	16.37	17.17	17.14	18.02	17.90	18.99	17.27
Food poor t	9.02	6.83	6.72	5.94	5.48	5.49	4.93	4.76	4.23	3.33	4.60
Food poor e	10.80	12.42	12.74	13.06	11.65	10.51	9.85	8.68	8.03	7.67	9.24
Non alcoh. bev. t	0.60	0.62	0.60	0.55	0.64	0.49	0.52	0.61	0.54	1.06	0.73
Alcoh. bev. & tob. t	1.43	1.31	1.15	0.73	0.75	0.63	0.59	0.53	0.60	0.92	0.77
Alcoh. bev. & tob. e	0.25	0.19	0.19	0.09	0.16	0.09	0.12	0.13	0.07	0.12	0.12
Clothing t	4.80	4.31	4.12	3.84	3.88	3.84	3.93	3.78	3.61	4.16	3.95
Housing rent e	0.28	0.63	0.72	0.64	0.93	1.01	1.27	1.76	1.60	1.72	1.40
Housing: utilities t	2.32	2.74	3.14	3.25	3.19	3.41	3.14	3.05	2.77	2.24	2.78
Housing utilities e	0.98	1.80	1.58	1.71	1.88	1.59	1.69	1.66	1.77	1.80	1.73
Furnishings & equipm. t	1.58	1.73	1.75	1.54	1.60	1.50	1.34	1.25	1.17	1.32	1.37
Health e	3.17	3.37	3.32	2.83	3.20	2.89	3.16	3.02	2.89	2.71	2.93
Transport t	6.02	5.64	6.15	6.45	6.24	6.32	6.71	6.79	7.29	8.01	7.10
Transport e	0.45	0.60	0.77	0.75	0.72	0.75	0.95	0.89	0.98	0.98	0.89
Communication t	2.70	2.54	2.98	3.39	3.95	4.09	4.37	4.64	5.01	5.10	4.51
Recreation, culture t	0.56	0.38	0.39	0.33	0.33	0.39	0.39	0.38	0.37	0.39	0.38
Recreation, culture e	0.11	0.16	0.20	0.24	0.24	0.27	0.30	0.31	0.31	0.25	0.27
Education e	2.88	2.11	1.82	1.83	2.01	2.26	2.63	2.49	3.01	3.89	2.93
Catering and accomm. t	7.99	8.73	8.66	11.17	10.75	11.74	12.84	12.96	13.79	13.55	12.57
Others non serv. t	1.93	1.73	1.85	1.89	1.93	1.90	1.79	1.85	1.80	1.86	1.85
Other services t	3.36	3.34	3.26	2.64	2.25	1.89	1.60	1.26	1.05	0.84	1.49
Other services e	0.00	0.01	0.01	0.00	0.00	0.02	0.01	0.00	0.02	0.00	0.01
Total market	74.04	75.90	79.50	82.21	83.94	84.57	85.92	86.39	86.85	91.16	86.67

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the simulated baseline (basic tariff 25.56%, exempt goods as in legacy of 2015). Each decile contains 10% of the population of individuals (Section B.5). Averages are calculated as mean household expenditures on a commodity g, s over mean total household expenditures on auto-consumption plus market goods (see Section B.5). Commodities followed by a 't' are taxed at 25.56%. Those followed by an 'e' are exempt.

Table C.5: Budget share auto-consumption by decile and total (% of total expenditures: market + auto) – Baseline

Commodity	Decile										Total
	1	2	3	4	5	6	7	8	9	10	
Food rich t	0.94	0.69	0.52	0.77	0.63	0.82	0.81	0.79	1.03	0.66	0.77
Food rich e	2.92	3.48	3.14	2.89	3.66	4.13	3.94	4.37	4.24	2.77	3.54
Food poor t	0.27	0.40	0.46	0.33	0.38	0.27	0.25	0.14	0.13	0.07	0.19
Food poor e	12.89	12.16	9.70	7.49	5.64	4.55	4.03	3.48	3.13	1.59	3.96
Non alc. bev. t	0.04	0.03	0.02	0.02	0.04	0.04	0.04	0.09	0.06	0.05	0.05
Alcoh. bev. & tob. t	0.12	0.07	0.08	0.06	0.07	0.07	0.09	0.08	0.08	0.08	0.08
Alcoh. bev. & tob. e	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.02
Clothing t	0.64	0.79	0.75	0.68	0.68	0.61	0.53	0.52	0.39	0.28	0.47
Housing rent e	4.14	3.75	3.60	4.11	3.76	3.46	2.81	2.60	2.28	2.22	2.77
Housing utilities t	0.06	0.12	0.12	0.09	0.08	0.08	0.06	0.05	0.04	0.04	0.06
Housing utilities e	0.38	0.78	1.11	0.76	0.65	0.58	0.45	0.23	0.10	0.06	0.31
Furnishings & equipm. t	0.01	0.00	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.03	0.02
Health e	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.01	0.00	0.02	0.01
Transport t	0.03	0.01	0.02	0.03	0.00	0.03	0.03	0.08	0.03	0.06	0.04
Transport e	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Communication t	0.00	0.08	0.01	0.02	0.01	0.03	0.02	0.03	0.03	0.02	0.02
Recreation, culture t	0.00	0.01	0.01	0.00	0.01	0.02	0.02	0.02	0.02	0.01	0.02
Recreation, culture e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Education e						non existent					
Catering and accomm. t	3.34	1.62	0.81	0.38	0.39	0.62	0.93	1.05	1.49	0.80	0.96
Other non serv. t	0.00	0.00	0.01	0.02	0.01	0.02	0.01	0.01	0.00	0.02	0.01
Other services t	0.16	0.09	0.08	0.07	0.03	0.06	0.03	0.01	0.03	0.01	0.03
Other services e						non existent					
Total auto	25.96	24.10	20.50	17.79	16.06	15.43	14.08	13.61	13.15	8.84	13.33

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the simulated baseline (basic tariff 25.56%, exempt goods as in legacy of 2015). Each decile contains 10% of the population of individuals (Section B.5). Averages are calculated as mean household expenditures on a commodity g, s over mean total household expenditures on auto-consumption plus market goods (see Section B.5). Commodities followed by a 't' are those for which the corresponding market variety is taxed at 25.56%. Those followed by an 'e' are those for which the corresponding market variety is exempt.

D Additional results

D.1 Optimal tax structure

Tables D.1 and D.2 contain the ranks of the commodities' tax rates for each of the cases reported in Tables 2 and 3 of the main text. For example, for the case with heterogeneous preferences and household of economies of scale (Columns (8) to (13) of Table D.2) 'Other services e' turns the commodity bearing the lowest tax rate in absence of any inequality aversion (4.2%), while it is taxed at the third highest rate (55.3%) when inequality aversion is high ($e = 2$). Columns (8) to (13) of Table D.2 contains the values to construct Figure 3 of the main text. The optimal tax rates are reported in Table D.3. An increase or decrease in the tax rank of a commodity, when inequality aversion rises, does not necessary imply that the corresponding tax rate increases or decreases. For example, the tax rate on 'Other services e' decreases from 4.2% when $e = 0$ (Column (8) of Table 3) to 0.2% when $e = 0.5$ (Column (9) of Table 3). The former tax rate is the lowest tax rate when $e = 0$ (Column (8) of Table D.2), while the latter tax rate is only the third lowest when $e = 0.5$ (Column (9) of Table D.2).

Table D.1: Rank of optimal taxes when *all* goods can be taxed

Preferences	Heterogeneous												
	Identical						Household economies of scale: $\theta_h = \text{OECD-scale}$						
	Uniform rule	No household economies of scale: $\theta_h = n_h$					Inequality aversion						
Commodity	(1) and (2)	$e=0.5$	$e=0.75$	$e=1.25$	$e=1.5$	$e=2$	$e=0$	$e=0.5$	$e=0.75$	$e=1.25$	$e=1.5$	$e=2$	
	(1) and (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
Other services e	uniform	5	5	9	12	19	1	4	5	12	12	21	
Other services t	uniform	1	1	1	1	3	2	1	1	1	1	3	
Food poor t	uniform	2	2	2	2	1	3	2	2	2	2	1	
Recreation, culture e	uniform	12	14	16	17	22	4	11	13	16	18	22	
Recreation, culture t	uniform	10	9	8	7	11	5	8	9	8	9	11	
Education e	uniform	18	17	15	13	10	6	17	17	15	14	10	
Food poor e	uniform	4	4	4	4	5	7	5	4	4	4	5	
Furnishings & equipm. t	uniform	6	6	7	8	12	8	6	6	7	7	12	
Transport t	uniform	15	15	14	16	15	9	15	15	14	16	16	
Health e	uniform	7	8	6	6	2	10	7	8	6	6	2	
Alcoh. bev. & tob. e	uniform	3	3	3	3	4	11	3	3	3	3	4	
Clothing t	uniform	13	12	11	10	9	12	13	12	10	10	9	
Food rich e	uniform	16	16	18	19	20	13	16	16	18	19	19	
Others non serv. t	uniform	11	11	10	9	6	14	12	11	9	8	6	
Housing utilities e	uniform	14	13	13	14	16	15	14	14	13	15	15	
Food rich t	uniform	21	22	22	22	18	16	21	21	22	22	17	
Housing utilities t	uniform	8	10	12	11	14	17	10	10	11	11	14	
Alcoh. bev. & tob. t	uniform	9	7	5	5	7	18	9	7	5	5	8	
Communication t	uniform	20	20	19	18	13	19	19	20	19	17	13	
Catering and accomm. t	uniform	17	19	20	20	21	20	18	18	20	20	20	
Transport e	uniform	19	18	17	15	8	21	20	19	17	13	7	
Non alcoh. bev. t	uniform	22	21	21	21	17	22	22	22	21	21	18	
Housing rent e	uniform	23	23	23	23	23	23	23	23	23	23	23	

Note: The identical preference parameters, α_g and $\delta_{m,g}$ ($s = m, s, g = 1, 2, \dots, G$), are calibrated on the basis of the aggregate demand function as observed in the data, using the same procedure as for the calibration of the household specific parameters. Goods are sorted from low to high tax rates according to column 8 (heterogeneous preferences, household economies of scale, no inequality aversion). Only tax rates of market goods are reported.

When all goods can be taxed, there are no within household economies of scale, and there is no inequality aversion, indirect taxes are uniform. This continues to hold irrespective of the degree of inequality aversion and/or the presence of within household economies of scale when preferences are *identical* and homothetic. With heterogeneous preferences, both inequality aversion and the presence of economies of scale have an impact on the level and structure of optimal taxes. When there is no inequality aversion, economies of scale cause deviation from uniform tax rates (compare column 2 and 8). Preference heterogeneity plays a major role, resulting in a similar tax structure of each of the columns 3 till 7 when compared with the corresponding columns 9 to 13.

Table D.2: Rank of optimal taxes when *only market goods* can be taxed

Commodity	Heterogeneous												
	Identical			No household economies of scale: $\theta_h = n_h$			Household economies of scale: $\theta_h = \text{OECD-scale}$			Inequality aversion			
Inverse elasticity rule	$e=0$	$e=0.5$	$e=0.75$	$e=1.25$	$e=1.5$	$e=2$	$e=0$	$e=0.5$	$e=0.75$	$e=1.25$	$e=1.5$	$e=2$	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(13)
Education e	1	14	18	17	15	13	10	6	17	17	15	14	10
Other services e	2	22	5	5	11	12	18	1	3	5	12	13	21
Health e	3	5	7	7	6	6	2	10	7	7	6	6	2
Communication t	4	13	20	20	19	17	13	18	19	20	19	17	13
Transport t	5	10	15	15	14	16	14	9	15	15	14	16	16
Others non serv. t	6	6	11	12	10	10	7	13	13	12	10	9	7
Transport e	7	15	19	18	17	15	8	21	20	19	17	15	8
Furnishings & equipm. t	8	3	6	6	7	7	12	8	6	6	7	7	12
Housing utilities t	9	12	8	9	12	11	15	16	9	10	11	11	14
Other services t	10	1	1	1	1	1	3	2	1	1	1	1	3
Recreation, culture e	11	8	13	14	16	18	22	4	11	14	16	18	22
Recreation, culture t	12	11	9	10	8	9	11	5	8	9	8	10	11
Food poor t	13	4	2	2	2	2	1	3	2	2	2	2	1
Non alcoh. bev. t	14	18	22	22	21	21	17	22	22	22	21	21	18
Catering and accomm. t	15	16	17	19	20	20	20	20	18	18	20	20	19
Food rich t	16	19	21	21	22	22	19	17	21	21	22	22	17
Alcoh. bev. & tob. t	17	7	10	8	5	5	6	19	10	8	5	5	6
Alcoh. bev. & tob. e	18	2	3	3	3	3	4	14	4	3	3	3	4
Clothing t	19	17	12	11	9	8	9	12	12	11	9	8	9
Housing utilities e	20	9	14	13	13	14	16	15	14	13	13	12	15
Food rich e	21	21	16	16	18	19	21	11	16	16	18	19	20
Food poor e	22	20	4	4	4	4	5	7	5	4	4	4	5
Housing rent e	23	23	23	23	23	23	23	23	23	23	23	23	23

Note: The identical preference parameters, α_g and $\delta_{m,g}$ ($s = m, s, g = 1, 2, \dots, G$), are calibrated on the basis of the aggregate demand function as observed in the data, using the same procedure as for the calibration of the household specific parameters. Goods are sorted from low to high taxes according to column 1 (inverse elasticity rule).

When not all goods can be taxed, preferences are identical and homothetic, and there are no cross price effects, taxes are inverse proportional to the own price elasticity of aggregate demand, irrespective of the degree of inequality aversion and/or the presence of within household economies of scale. With heterogeneous preferences, both inequality aversion and the presence of economies of scale have an impact on the level and structure of optimal taxes, on top of the own price elasticities. When there is no inequality aversion, economies of scale play a major role, what results in big deviations between column 2 and 8 of the table. In the presence of inequality aversion, however, preference heterogeneity plays a major role, resulting in a similar tax structure of each of the columns 3 till 7 when compared with the corresponding columns 9 to 13.

Table D.3: Optimal indirect tax rates (%) – the role of inequality aversion

Commodity	Inequality aversion					
	$e = 0$	$e = 0.50$	$e = 0.75$	$e = 1.25$	$e = 1.50$	$e = 2.0$
Housing rent e	26.2	38.9	46.1	62.9	73.8	111.4
Non alcoh. bev. t	20.6	31.0	33.5	35.3	36.5	47.9
Transport e	20.1	23.2	24.2	22.2	16.7	-1.9
Catering and accomm. t	16.0	20.8	23.6	30.3	34.7	50.3
Alcoh. bev. & tob. t	15.9	10.0	5.4	-4.3	-7.7	-4.7
Communication t	15.4	21.3	24.4	28.7	28.3	21.0
Food rich t	14.9	26.9	32.8	43.0	46.3	46.9
Housing utilities t	14.8	8.8	7.1	6.7	9.1	27.7
Housing utilities e	14.4	13.5	13.2	14.1	16.1	30.0
Alcoh. bev. & tob. e	14.0	0.6	-5.5	-15.7	-18.9	-15.4
Others non serv. t	13.9	11.7	10.2	5.9	2.7	-4.7
Clothing t	13.8	11.6	9.5	4.5	2.3	3.5
Food rich e	13.6	17.2	19.8	27.4	33.2	51.2
Health e	13.1	7.2	4.5	-1.4	-6.7	-34.4
Transport t	12.5	15.2	16.4	18.5	20.2	31.4
Furnishings & equipm. t	12.5	6.7	4.0	0.7	1.5	17.2
Food poor e	11.8	1.2	-2.9	-8.9	-11.0	-14.8
Education e	11.5	19.1	21.1	19.4	16.1	11.9
Recreation, culture t	10.6	7.9	6.2	3.3	3.5	16.4
Recreation, culture e	10.0	11.4	13.4	21.7	30.1	71.2
Food poor t	9.0	-3.3	-8.6	-20.0	-27.1	-45.0
Other services t	6.0	-13.7	-20.8	-29.9	-31.4	-23.1
Other services e	4.2	0.2	1.1	8.3	16.1	55.3

Note: The numbers in the table represent the optimal tax rates for the corresponding commodities. Commodities are ranked from high to low tax rates according to the simulation in the first column ($e = 0$) which coincides with the results reported in column (8) of Table 3.

D.2 Average welfare gains

Tables D.4 and D.5 contain the values underlying the blue lines of Figures 4 and 5 of the main text.

Table D.4: Inequality aversion and average welfare gain: overall and by decile (CFA)

Decile	Average change in welfare: CFA					
	Inequality aversion					
	e=0	e=0.5	e=0.75	e=1.25	e=1.5	e=2
1	1297	2740	3410	4684	5313	6144
2	1369	3919	5019	6841	7524	7468
3	1648	4740	5997	7920	8535	7787
4	1799	4563	5541	6695	6769	4123
5	1132	3320	3946	4288	3884	-159
6	1790	3193	3342	2636	1627	-4464
7	1878	2134	1670	-256	-1882	-9780
8	2083	518	-959	-5023	-7812	-19058
9	3316	-1017	-3969	-10969	-15283	-31471
10	5289	-9838	-18086	-35408	-45352	-80617
All	2160	1426	590	-1862	-3671	-12008

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the baseline (two tariffs: exempt and 25.56%, thus reaching the UN tax revenue objective of 20% of GDP). Each decile contains 10% of the population of individuals (Section B.5). Averages are calculated at the individual level. Boldface figures are significantly positive at the 5% level; italics are significantly negative. Significance levels are calculated by means of a 500 replications bootstrap.

Table D.5: Inequality aversion and average welfare gain (%): overall and by decile

Decile	Average change in welfare: %					
	Inequality aversion					
	e=0	e=0.5	e=0.75	e=1.25	e=1.5	e=2
1	1.8	3.9	4.9	6.7	7.6	8.8
2	1.0	2.9	3.7	5.0	5.5	5.5
3	0.9	2.6	3.3	4.4	4.7	4.3
4	0.8	2.0	2.4	2.9	3.0	1.8
5	0.4	1.2	1.4	1.5	1.4	-0.1
6	0.5	1.0	1.0	0.8	0.5	-1.3
7	0.5	0.5	0.4	-0.1	<i>-0.5</i>	<i>-2.4</i>
8	0.4	0.1	-0.2	<i>-1.0</i>	<i>-1.5</i>	<i>-3.7</i>
9	0.5	-0.1	<i>-0.6</i>	<i>-1.6</i>	<i>-2.2</i>	<i>-4.6</i>
10	0.4	<i>-0.8</i>	<i>-1.4</i>	<i>-2.8</i>	<i>-3.6</i>	<i>-6.4</i>
All	0.5	0.3	0.1	<i>-0.5</i>	<i>-0.9</i>	<i>-2.9</i>

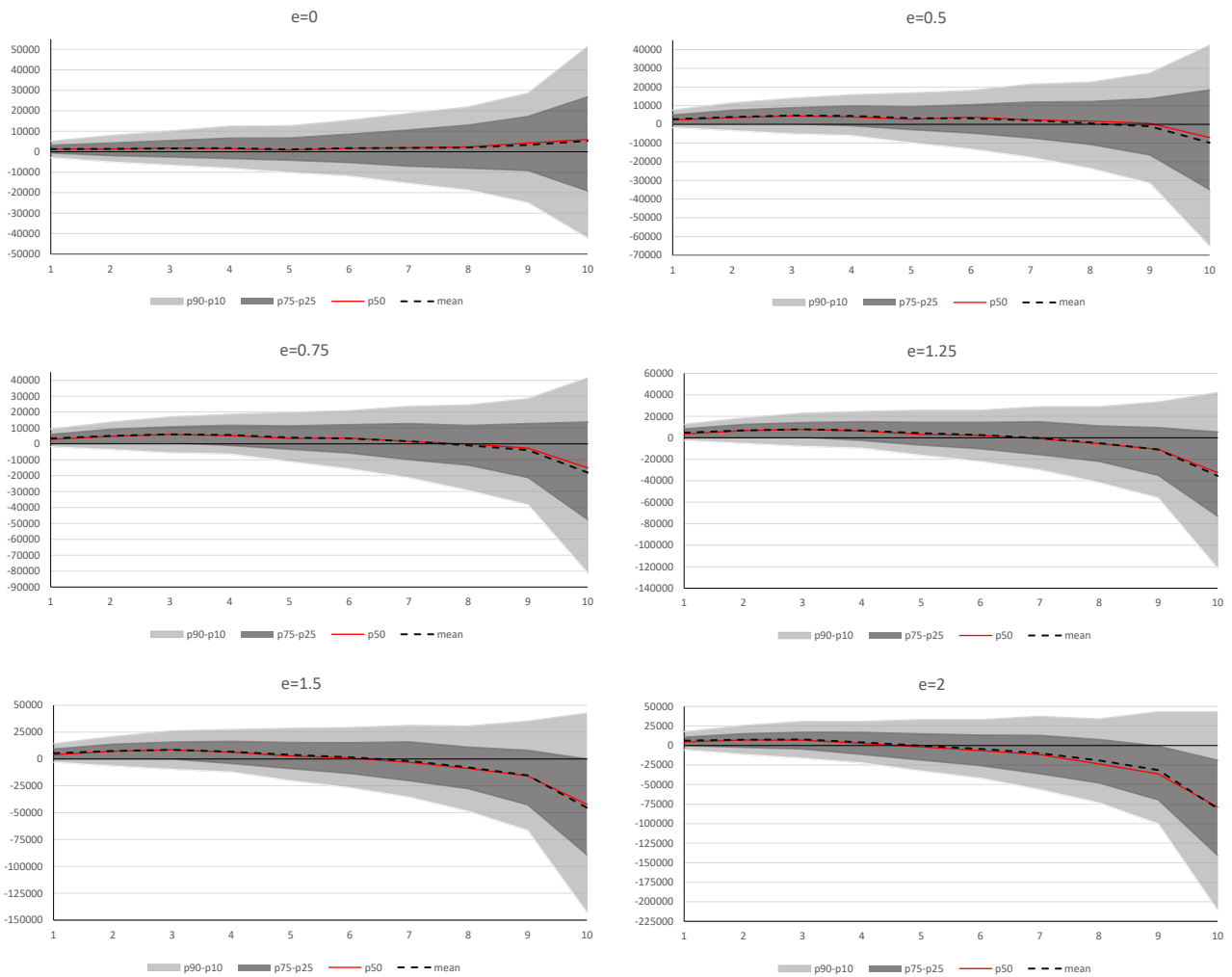
Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the baseline (two tariffs: exempt and 25.56%, thus reaching the UN tax revenue objective of 20% of GDP). Each decile contains 10% of the population of individuals (Section B.5). Averages are calculated as average gain over average baseline welfare (see Section B.5) and these averages are calculated at the individual level.

Boldface figures are significantly positive at the 5% level; italics are significantly negative. Significance levels are calculated by means of a 500 replications bootstrap.

D.3 Heterogeneity of welfare gains within deciles

Figure D.1 is the counterpart for welfare changes in levels of Figure 6 in the main text which contains the relative welfare gains (see Section 5.2). These figures illustrate the within decile distribution of welfare gains and losses from a switch of the baseline (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP) to the optimal tax structure. Generally, the medians follow a similar course as the means, and we refer to the discussion of Figure 4 in the main text for a discussion of the results. For lower values of inequality aversion the within decile distribution is skewed toward higher values than the median (the mean tends to be somewhat higher than the median), and reversely for higher deciles (mean lower than median). Contrary to the corresponding figure for the relative changes (Figure 6), within decile diversity is increasing in baseline decile ranks: the gap between the biggest losers and winners is widening across deciles for all values of inequality aversion.

Figure D.1: Within decile quantile values of welfare changes



Note: The vertical axis reports the, within each baseline welfare decile, quantile values and means of welfare changes (CFA) from a switch of the baseline (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP) to the optimal tax structure. Each panel is for a different value of inequality aversion. The dashed lines connect the mean welfare change within each decile and correspond to the blue lines of Figure 4 of the main text. The red lines connect the median value of the welfare change within each baseline decile. The dark grey areas are bounded by the first and third quartile value within each baseline decile. The light grey areas are bound by the first and ninth decile of the welfare differences within each baseline.

D.4 Winners and losers

Table D.6 contains the percentage of losers with respect to the baseline (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP) per decile of baseline welfare, for different values of inequality aversion. The blue lines of Figure 7 report the corresponding percentages of winners (that is 100 *minus* the values reported in the table).

Table D.6: Inequality aversion and percentage of losers: overall and by decile

Decile	Percentage of losers					
	Inequality aversion					
	e=0	e=0.5	e=0.75	e=1.25	e=1.5	e=2
1	32.2	22.6	21.3	23.5	23.2	25.7
2	38.6	22.6	21.8	23.1	24.5	31.1
3	38.4	23.5	22.4	23.6	25.3	34.2
4	42.1	29.5	29.1	32.9	34.6	44.0
5	44.9	35.9	37.1	39.9	44.1	53.2
6	42.8	37.4	39.1	46.1	48.4	59.1
7	43.7	43.6	46.1	52.0	54.9	63.1
8	44.0	46.2	50.2	58.1	62.4	69.5
9	41.5	49.6	54.9	65.0	67.9	75.3
10	43.1	58.3	64.2	71.1	75.0	80.6
All	41.1	36.9	38.6	43.5	46.0	53.6

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the baseline (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP). Each decile contains 10% of the population of individuals (Section B.5). A cell shows the percentage of the population belonging to that decile (or overall) losing from applying the optimal indirect tax tariff for a given degree of inequality aversion (columns) compared to their baseline individual welfare level.

Boldface figures are significantly higher than 50% at the 5% significance level; italics are significantly lower than 50%. Significance levels are calculated by means of a 500 replications bootstrap.

D.5 Transition matrices

Tables D.7–D.8 show for each decile in the baseline, the percentage of persons in deciles 1 to 10 for each of the six optimal indirect tax simulations (each panel is corresponding to a different value of inequality aversion). More people tend to jump from one decile to another when inequality aversion increases. People are predominantly jumping to neighbouring deciles, and decile movements occur more in the middle of the distribution than at the outer deciles.

Table D.7: Transition matrices

Welfare decile baseline	Optimal indirect tax simulation									
	1	2	3	4	5	6	7	8	9	10
$e = 0$										
1	9.70	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.29	9.14	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.58	8.76	0.65	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.65	8.66	0.69	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.70	8.70	0.61	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.61	8.67	0.73	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.72	8.70	0.58	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.58	9.02	0.40	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	9.25	0.35
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	9.65
$e = 0.5$										
1	9.59	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.41	8.96	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.63	8.50	0.85	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.87	8.32	0.82	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.82	8.44	0.75	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.75	8.45	0.80	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.80	8.54	0.66	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.66	8.88	0.46	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	9.16	0.37
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	9.63
$e = 0.75$										
1	9.52	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.48	8.81	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.71	8.31	0.97	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.98	8.06	0.98	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.98	8.18	0.85	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.84	8.22	0.93	0.01	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.93	8.33	0.75	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.76	8.72	0.52	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	9.09	0.39
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	9.61

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5). Rows are deciles in the baseline (two tariffs: exempt and 25.56%, guaranteeing the UN tax revenue objective of 20% of GDP); columns are deciles when applying the optimal indirect taxes. Each panel refers to a different degree of inequality aversion. Cells show the percentage of people belonging to decile k (row) in the baseline and to decile l in the indirect tax simulation.

Table D.8: Transition matrices

Welfare decile baseline	Optimal indirect tax simulation									
	1	2	3	4	5	6	7	8	9	10
$e = 1.25$										
1	9.40	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.60	8.46	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.94	7.82	1.19	0.04	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	1.23	7.52	1.25	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	1.28	7.47	1.24	0.01	0.00	0.00	0.00
6	0.00	0.00	0.00	0.01	1.24	7.49	1.25	0.01	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	1.27	7.68	1.05	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	1.06	8.24	0.69	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	8.79	0.51
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	9.49
$e = 1.5$										
1	9.35	0.63	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.65	8.29	1.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	1.07	7.53	1.32	0.07	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	1.40	7.17	1.43	0.01	0.00	0.00	0.00	0.00
5	0.00	0.00	0.01	1.48	7.06	1.42	0.03	0.00	0.00	0.00
6	0.00	0.00	0.00	0.01	1.44	7.09	1.42	0.03	0.01	0.00
7	0.00	0.00	0.00	0.00	0.01	1.47	7.33	1.19	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.01	1.22	7.98	0.79	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	8.59	0.60
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	9.41
$e = 2$										
1	9.15	0.80	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2	0.82	7.77	1.35	0.06	0.01	0.00	0.00	0.00	0.00	0.00
3	0.03	1.40	6.72	1.65	0.14	0.06	0.00	0.00	0.00	0.00
4	0.00	0.02	1.83	6.23	1.76	0.16	0.01	0.00	0.00	0.00
5	0.00	0.00	0.08	1.92	6.07	1.81	0.12	0.00	0.01	0.00
6	0.00	0.00	0.00	0.13	1.95	6.04	1.81	0.06	0.01	0.00
7	0.00	0.00	0.00	0.00	0.07	1.90	6.45	1.52	0.06	0.00
8	0.00	0.00	0.00	0.00	0.00	0.03	1.62	7.20	1.14	0.01
9	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.22	7.91	0.85
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	9.14

Note: Deciles are constructed on the basis of the individual welfare measure (equivalised money metric utility, Equation 5). Rows are deciles in the baseline (two tariffs: exempt and 25.56%, guaranteeing the UN tax revenue objective of 20% of GDP); columns are deciles when applying the optimal indirect taxes. Each panel refers to a different degree of inequality aversion. Cells show the percentage of people belonging to decile k (row) in the baseline and to decile l in the indirect tax simulation.

E Extended analyses

E.1 Restricted optimal tax rates

Many results in optimal indirect taxation (among others, Ramsey, 1927, Corlett and Hague, 1953, Diamond and Mirrlees, 1971, Feldstein, 1972, Diamond, 1975, Atkinson and Stiglitz, 1976, and Kaplow, 2010) depend on preference characteristics of commodities (for example, necessities versus luxuries, substitutability with leisure, and/or price elasticities). Goods exhibiting different price elasticities or different degrees of substitutability may therefore be taxed differently in the optimum and this requires a detailed level of commodity disaggregation. In theory, this poses no problem as one could always disaggregate commodities at the finest level necessary from a theoretical point of view. In practice, a classification of commodities into groups will always be necessary, and even a coarse approximation of theoretical prerequisites would lead to a number of goods (and potentially different tax rates) which is far beyond what is administratively manageable. Moreover, increasing the number of tax rates would open up the door for tax evasion opportunities and/or lobbying to obtain a favourable tax tariff. For example, in our application, we arrive at 23 commodity groups, while this is far beyond current tax diversification in countries with a well established tax administration, where the number of VAT rates rarely exceeds four.

There is, however, little theoretical guidance on how to optimally group commodities. Belan and Gauthier (2006) provide some theoretical results when only efficiency matters (in a Ramsey model with one representative agent). These results are extended to allow for distributional concerns by Belan et al. (2008), but their results crucially depend on the assumption of a continuum of goods, and therefore cannot easily be applied in practice. We therefore propose the following alternative. Once optimal taxes for our finer classification into 23 groups are derived for a specific simulation, we order these tax rates and break them up into four broader groups (low tax rate, middle low, middle high, and high).⁴ Next we re-run our optimal taxation program imposing that commodities belonging to the same group in this broader classification should bear the same tax rate. If a policy maker would consider the highest tariffs resulting from such an exercise to be too high, in addition, an upper bound on taxes could be imposed in such an exercise (as well as a lower bound, if subsidies are considered to be too high).

We ran simulations imposing restricted optimal taxation for inequality aversion $e = 0$ and $e = 2$. After running the unrestricted optimal tax program, we ranked goods from high to low optimal tariffs, and subdivided them into four categories: those with high, middle high, middle low, and low tariffs. The groups are separated by a horizontal bar in Table E.1. The grouping of cases $e = 0$ and $e = 2$ differ. Next, we re-ran the optimal tax program under the additional constraint that the tax rates for commodities belonging to the same group should be identical. We did not impose however any order on these tax rates. That is, we allowed that goods belonging to the group with highest tax rates in the unrestricted program, would bear a lower tax rate than the other groups. But it turns out that the unrestricted hierarchy is respected in the optimum, as one could expect.

Table E.2 compares the average welfare gain and percentage of winners per decile with respect to the baseline policy, for both, the unrestricted and restricted optimal taxes. The first two columns show the results for the gain in levels (CFA franc).⁵

The figures for the gains and losses in levels from a switch from the baseline policy to the unrestricted versus restricted optimal policies are close to each other in case of absence of inequality aversion (see first two columns in the upper panel of Table E.2). The differences never exceed 240 CFA franc per year. The same holds true for high inequality aversion $e = 2$, except for the first and last decile (see the first two columns of the lower panel of Table E.2). But we saw that the gains and losses per decile under high inequality aversion are much larger too. Differences in relative

⁴ Admittedly, the determination of the breaks determining the division in four groups is somewhat arbitrarily, but where possible, we choose them such that there are clear jumps in the more granular optimal rates.

⁵ The figures in the first column of the upper panel of Table E.2 correspond to the first columns of Table D.4 in Appendix D.2; those of first column in the lower panel of Table E.2 correspond to the last column of Table D.4 in Appendix D.2.

Table E.1: Restricted *versus* unrestricted optimal tax rates (%)

Commodity	e=0		Commodity	e=2	
	23 rates	4 rates		23 rates	4 rates
Housing rent e	26.2	22.9	Housing rent e	111.4	55.2
Non alcoh. bev. t	20.6	22.9	Recreation, culture e	71.2	55.2
Transport e	20.1	22.9	Other services e	55.3	55.2
Catering and accomm. t	16.0	15.4	Food rich e	51.2	55.2
Alcoh. bev. & tob. t	15.9	15.4	Catering and accomm. t	50.3	55.2
Communication t	15.4	15.4	Non alcoh. bev. t	47.9	35.4
Food rich t	14.9	15.4	Food rich t	46.9	35.4
Housing utilities t	14.8	15.4	Transport t	31.4	35.4
Housing utilities e	14.4	15.4	Housing utilities e	30.0	35.4
Alcoh. bev. & tob. e	14.0	15.4	Housing utilities t	27.7	35.4
Others non serv. t	13.9	12.9	Communication t	21.0	35.4
Clothing t	13.8	12.9	Furnishings & equipm. t	17.2	15.3
Food rich e	13.6	12.9	Recreation, culture t	16.4	15.3
Health e	13.1	12.9	Education e	11.9	15.3
Transport t	12.5	12.9	Clothing t	3.5	-23.7
Furnishings & equipm. t	12.5	12.9	Transport e	-1.9	-23.7
Food poor e	11.8	12.9	Others non serv. t	-4.7	-23.7
Education e	11.5	12.9	Alcoh. bev. & tob. t	-4.7	-23.7
Recreation, culture t	10.6	8.5	Food poor e	-14.8	-23.7
Recreation, culture e	10.0	8.5	Alcoh. bev. & tob.e	-15.4	-23.7
Food poor t	9.0	8.5	Other services t	-23.1	-23.7
Other services t	6.0	8.5	Health e	-34.4	-23.7
Other services e	4.2	8.5	Food poor t	-45.0	-23.7

Note: The 23 rates cases are the optimal tax rates for inequality aversion $e = 0$ and $e = 2$, and correspond to the first and last column of Table D.3. Commodities are ordered such that they are ranked from high to low optimal tax rates for the cases with 23 rates. The columns for the cases of 4 rates contain the optimal taxes obtained by regrouping commodities into 4 classes on the basis of the corresponding results for the 23 rates cases.

Table E.2: Welfare gains and winners with respect to baseline: restricted vs. unrestricted optima

Decile	Welfare change level (CFA)		Inequality aversion $e = 0$		Winners (%)	
	unrestricted	restricted	unrestricted	restricted	unrestricted	restricted
			Relative welfare change(%)			
1	1297	1234	1.85	1.76	67.8	67.0
2	1369	1220	1.01	0.90	61.4	60.5
3	1648	1473	0.91	0.81	61.6	60.5
4	1799	1619	0.79	0.71	57.9	57.1
5	1132	1018	0.41	0.37	55.1	53.2
6	1790	1752	0.53	0.52	57.2	56.1
7	1878	1889	0.46	0.46	56.3	55.8
8	2083	2251	0.41	0.44	56.0	56.6
9	3316	3508	0.48	0.51	58.5	58.6
10	5289	5527	0.42	0.44	56.9	57.2
All	2160	2149	0.53	0.52	58.9	58.3

Decile	Welfare change level (CFA)		Inequality aversion $e = 2$		Winners (%)	
	unrestricted	restricted	unrestricted	restricted	unrestricted	restricted
			Relative welfare change(%)			
1	6144	5454	8.76	7.78	74.3	73.5
2	7468	7534	5.49	5.54	68.9	70.5
3	7787	7732	4.29	4.25	65.8	68.6
4	4123	4259	1.82	1.88	56.0	56.7
5	-159	59	-0.06	0.02	46.8	48.4
6	-4464	-4782	-1.33	-1.43	40.9	42.2
7	-9780	-9675	-2.40	-2.37	36.9	37.5
8	-19058	-18978	-3.72	-3.70	30.5	30.2
9	-31471	-31507	-4.57	-4.57	24.7	25.9
10	-80617	-70912	-6.37	-5.60	19.4	22.0
All	-12003	-11086	-2.93	-2.70	46.4	47.5

Note: The first two columns denote the average welfare gain (positive) or loss (negative) in CFA franc per *baseline* welfare decile (standard rate of 25.56%, thus guaranteeing to reach the UN tax revenue objective of 20% of GDP, with the list of exempted goods as in 2015) and overall, from a switch from the baseline policy to the optimal policy, with and without restriction. The next two columns show the relative welfare gain compared to the baseline (%) per *baseline* welfare decile and overall, in the unrestricted and restricted case. Average relative welfare gains are calculated as mean gain (per decile and overall) over mean baseline policy level of welfare (see Appendix B.5). The last two columns compare the percentage of winners from a switch from the baseline policy to the optimal policy under the unrestricted and restricted optimal taxes. The upper panel concerns the case of absence of inequality aversion ($e = 0$), the lower panel is for $e = 2$.

gains or losses are less than 0.1 percentage points for all cases, except for the first and last decile under high inequality aversion (third and fourth columns of Table E.2). Even for the first and tenth decile under high inequality aversion the difference is less than 1 percentage point. Qualitatively, the picture of losses and gains is the same for the unrestricted and restricted optimum, except for the fifth decile under high inequality aversion. The differences for the fifth decile are, however, so close to zero, that this result will hardly be statistically significant. Also the number of losers and winners are close to each other.

Whereas we concentrated up to now on differences with the baseline policy for both the restricted and unrestricted optima, Table E.3 compares the restricted (maximum 4 rates) optimum with the corresponding unrestricted cases directly. Deciles remain, however, constructed on the basis of the baseline policy simulation. The first two columns of the table represent the change in average welfare level for each baseline decile, when switching from the unrestricted (maximum 23 tariffs) to the restricted case (maximum 4 rates) for $e = 0$ (first column) and $e = 2$ (second column). These columns correspond to the differences between the first two columns of Table E.2. The next two columns contain the relative gains or losses from a switch from the unrestricted to the restricted optimum, expressed as the

Table E.3: Welfare gains and winners: restricted versus unrestricted

Baseline decile	Welfare change (CFA)		Relative welfare change (%)		Winners (%)	
	e=0	e=2	e=0	e=2	e=0	e=2
1	-63	-690	-0.09	-0.90	40.7	46.9
2	-148	66	-0.11	0.05	29.8	54.8
3	-174	-56	-0.09	-0.03	30.4	56.8
4	-180	136	-0.08	0.06	32.4	53.9
5	-114	218	-0.04	0.08	40.7	53.6
6	-38	-318	-0.01	-0.10	46.0	51.6
7	11	105	0.00	0.03	49.7	53.6
8	168	80	0.03	0.02	57.7	52.7
9	192	-35	0.03	-0.01	56.7	48.0
10	237	9706	0.02	0.82	53.9	55.5
All	-11	922	0.00	0.23	43.8	52.8

Note: The first two columns denote the difference in average welfare gain between the restricted optimal taxation (4 tariffs) and the unrestricted optimal taxation (23 tariffs), per *baseline* welfare decile (standard rate of 25.56%, thus guaranteeing to reach the UN tax revenue objective of 20% of GDP, with the list of exempted goods as in 2015) and overall. The next two columns contain the corresponding average relative gains or losses from a switch from the unrestricted to the restricted optimum, calculated as the average gain over the mean welfare levels in the unrestricted optimum (see Appendix B.5). The last two columns contain the percentage of winners in each decile and overall, for the same switch from unrestricted to restricted taxation.

average gain or loss divided by average welfare in the unrestricted optimum. These figures numerically slightly deviate from the differences between the third and fourth columns of Table E.2, because the denominator there is the baseline policy average welfare. Qualitatively both give the same information though. The last two columns represent the percentage of winners when switching from the unrestricted to the restricted optimum. Notice that is not equal to the difference between the last two columns of Table E.2, which contains the percentage of winners of the unrestricted and restricted case with respect to the baseline policy. One can, for example, win with respect to baseline in both, the restricted and unrestricted case, but one is either a winner or a loser when comparing the unrestricted with the restricted optimum.

In absence of inequality aversion there is an average loss of welfare of only 11 CFA. Limiting the diversification of the tax rates to a tractable number of at most four rates, allows to come reasonably close to the welfare optimum without restrictions. A closer look at the distribution of this small loss across deciles learns that the losses are primarily born by people belonging to the lower deciles. There are both, more people loosing in the lower six deciles than in the highest three deciles (see column 5 of the table), and welfare changes with respect to unrestricted optimal taxation are on average negative within those deciles. But not everybody loses from such a restriction. On the contrary, a considerable majority in the highest three deciles is even gaining under the restricted policy, as compared to the unrestricted one. This might be explained by the fact that smaller losses are caused when designing the tax such that goods on average more intensely preferred by the people with initially lower levels of welfare, become more expensive, than when one makes goods on average more intensely preferred by the originally better off more expensive. Given that correlation between welfare and preferences is not perfect, there will be losers and winners everywhere in the welfare distribution. But as losses and gains in levels are usually bigger among the better off, it is more efficient to put the burden of the overall loss on the persons with preferences shared more commonly among the poorer persons. However, given that the differences in welfare between restricted and unrestricted optima are small, it is not clear whether the percentages of winners and losers from switching from the unrestricted to the restricted optimum are very stable.

Potentially even more surprisingly, the switch to a more restricted tax structure in presence of high inequality aversion ($e = 2$) causes an average *gain* in welfare of more than 900 CFA. Even more so, a majority of persons is gaining from the switch from unrestricted to restricted taxation in this case. If we look at the impact across the initial welfare distribution, we see that losses are on average largest for the persons belonging to the lowest decile in the baseline, and average gains for those in the baseline top decile are no less than 9706 CFA. When inequality aversion is high, one wants to give up average welfare in exchange for a transfer of welfare from those with high welfare to poorer persons in terms of welfare. When one restricts the number of tax rates such an objective becomes more difficult to obtain. But then this loss in redistributive power can only be minimised by overcompensating the richer ones as they have a lower weight in the welfare function. Given the small differences in welfare gains and losses between the restricted and unrestricted case, we should again warn that, also in the case of high inequality aversion, these results might not be statistically significant.

E.2 Welfare analysis by department

In the present section, we redo the analyses of Sections 5.2–5.3 in the main text, but now from the point of view of regional inequalities rather than across the welfare distribution. Indeed, both consumption patterns (reflecting preferences) and availability of goods may differ across departments. This might result in differences in the redistributive patterns across regions (departments). We, however, do not investigate redistribution within departments, and/or its contribution to overall redistribution of optimal taxation, but simply study how welfare gains and winners and losers from the switch to optimal taxation are distributed across departments.

Table E.4 presents the pattern of the share of auto-consumption across the twelve departments of the country. Compared to the overall share of expenditure on market goods in aggregate expenditures (86.6%), a relatively larger part of the budget is spent on these goods in Littoral (95.5%), Oueme (93.7%) and Mono (92.0%). In Atacora, Alibori, Borgou and Donga auto-consumption exceeds one fifth of total expenditures. These regions belong the north of Benin, where more poverty occurs and inequality is higher than in the rest of the country (INSAE, 2016). In that respect, Mono, the poorest of all departments, forms an exception, as auto-consumption is low there (8%).

Table E.4: Population shares (%), welfare rank, and auto-consumption shares (%) by region

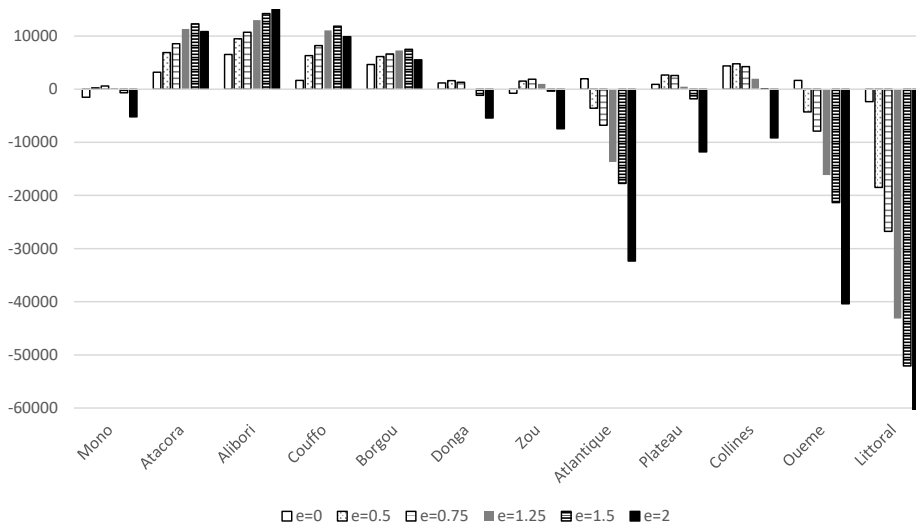
Department	Population	Welfare rank	Auto-consumption
Alibori	9.3	3	24.4
Atacora	7.6	2	27.2
Atlantique	13.7	8	8.6
Borgou	13.4	5	23.8
Collines	7.6	10	15.3
Couffo	8.1	4	14.4
Donga	5.1	6	23.6
Littoral	6.6	12	4.5
Mono	5.2	1	8.0
Oueme	8.5	11	6.3
Plateau	5.6	9	13.0
Zou	9.4	7	13.7
All	100	–	13.4

Note: The first column shows the percentage of the population living in each department in 2015. The second column reports the welfare rank of each department, from poorest to richest, where the ranking is based on the average individual welfare (measured by the equivalised money metric utility, Equation 5) evaluated in the observed situation. Auto-consumption shares are calculated as mean household expenditures on auto-consumption over mean total household expenditures on auto-consumption plus market goods (see Section B.5).

In Figures E.1 and E.2, each group of six connected, differently patterned bars represents results of different levels of inequality aversion for a given department. White bars refer to no inequality aversion, grey dotted ones to $e = 0.5$, grey striped to $e = .75$, full grey to $e = 1.25$, black striped to $e = 1.5$, and black ones to $e = 2$. Departments on the horizontal axes are ranked according to their average baseline welfare level (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, and list of exempted goods as in 2015), from lowest to highest. This ranking coincides well with welfare rankings of departments from other sources (e.g. INSAE, 2016).

Figure E.1 reports average welfare gains per department in levels, and Figure E.2 reports average welfare gains relative to baseline welfare. *Grosso modo* the figures reveal that poorer departments are gaining on average while richer ones are losing, the more so, when inequality aversion increases. The correlation is far from perfect though. And when inequality aversion becomes very high ($e = 2$), some poorer departments tend to gain less on average, both in levels and relatively speaking, than for a lower value of inequality aversion (Atacora and Couffo). There is one big exception though to this picture: the poorest department, Mono, loses on average both in the absence of

Figure E.1: Average welfare gain by department – levels (CFA)



Note: The vertical axis reports average welfare differences in levels (CFA) between the application of the optimal tax and the baseline simulation (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015). Each set of equally patterned bars is for a different level of inequality aversion. Each group of differently patterned bars is for a particular department. Departments are ranked from poorest to richest according to average baseline welfare level. The vertical axes is truncated below at -60 000 CFA. The underlying values of the figure can be found in Table E.5.

inequality aversion and in presence of high inequality aversion, and only gains modestly for intermediate values of inequality aversion. Mono is the department with the third lowest share of auto-consumption in total expenditures (see Table E.4). As far as it is optimal to tax market substitutes for auto-consumption, as these are more preferred by persons with a lower welfare level, the poor in Mono might not benefit as much from such a policy.

Finally, Figure E.3 represents the percentage of winners for each department and for different levels of inequality aversion. The number of winners is inversely U-shaped in inequality aversion for poorer departments, and uniformly decreasing for the richer departments. Even in the absence of inequality aversion a majority of residents in three departments (Mono, Zou, and Littoral) are losing. Interestingly, not always the same departments face a majority of losers for different values of inequality aversion. From a political economy perspective these observations are relevant, as it might reveal that representatives of different departments may favour different kind of optimal policies.

Tables E.5–E.7 report the values underlying Figure E.1–E.3.

Table E.5: Average welfare gain by department (CFA)

Departement	Inequality aversion					
	e=0	e=0.5	e=0.75	e=1.25	e=1.5	e=2
Mono	-1508	242	600	214	-685	-5195
Atacora	3219	6911	8556	11332	12284	10837
Alibori	6522	9477	10717	13002	14226	15418
Couffo	1676	6327	8231	11087	11869	9903
Borgou	4665	6162	6624	7268	7504	5530
Donga	1179	1625	1319	-100	-1169	-5443
Zou	-754	1542	1881	1005	-370	-7445
Atlantique	1958	-3583	-6770	-13680	-17755	-32324
Plateau	899	2663	2578	480	-1807	-11778
Collines	4377	4781	4258	1969	39	-9164
Oueme	1677	-4276	-7875	-16155	-21356	-40403
Littoral	-2324	-18486	-26738	-43152	-52077	-81496

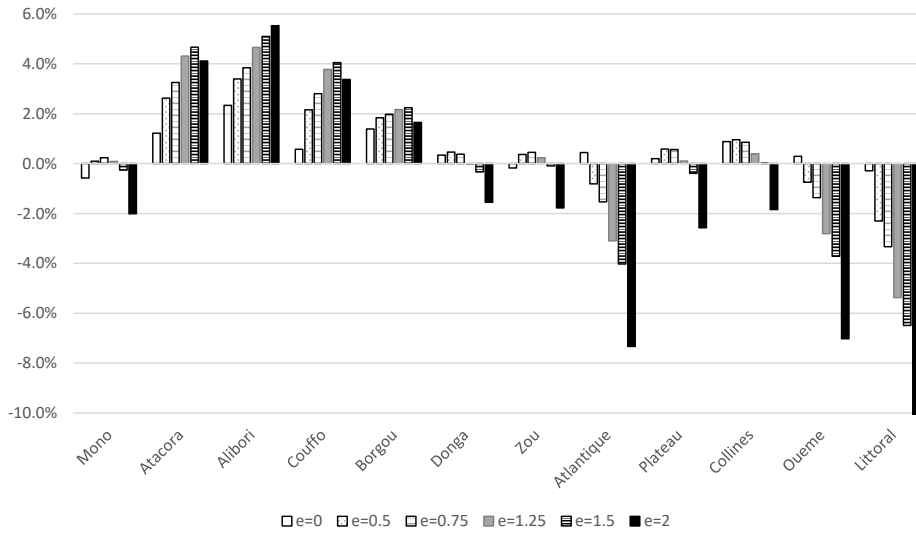
Note: The figures represent the average welfare differences in levels (CFA) between the application of the optimal tax and the baseline simulation (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP). Rows represent average gains of a given department for different levels of inequality aversion (columns).

Table E.6: Relative average welfare gain by department (%)

Departement	Inequality aversion					
	e=0	e=0.5	e=0.75	e=1.25	e=1.5	e=2
Mono	-0.6	0.1	0.2	0.1	-0.3	-2.0
Atacora	1.2	2.6	3.3	4.3	4.7	4.1
Alibori	2.3	3.4	3.8	4.7	5.1	5.5
Couffo	0.6	2.2	2.8	3.8	4.0	3.4
Borgou	1.4	1.8	2.0	2.2	2.2	1.6
Donga	0.3	0.5	0.4	0.0	-0.3	-1.6
Zou	-0.2	0.4	0.4	0.2	-0.1	-1.8
Atlantique	0.4	-0.8	-1.5	-3.1	-4.0	-7.3
Plateau	0.2	0.6	0.6	0.1	-0.4	-2.6
Collines	0.9	1.0	0.9	0.4	0.0	-1.8
Oueme	0.3	-0.7	-1.4	-2.8	-3.7	-7.0
Littoral	-0.3	-2.3	-3.3	-5.4	-6.5	-10.2

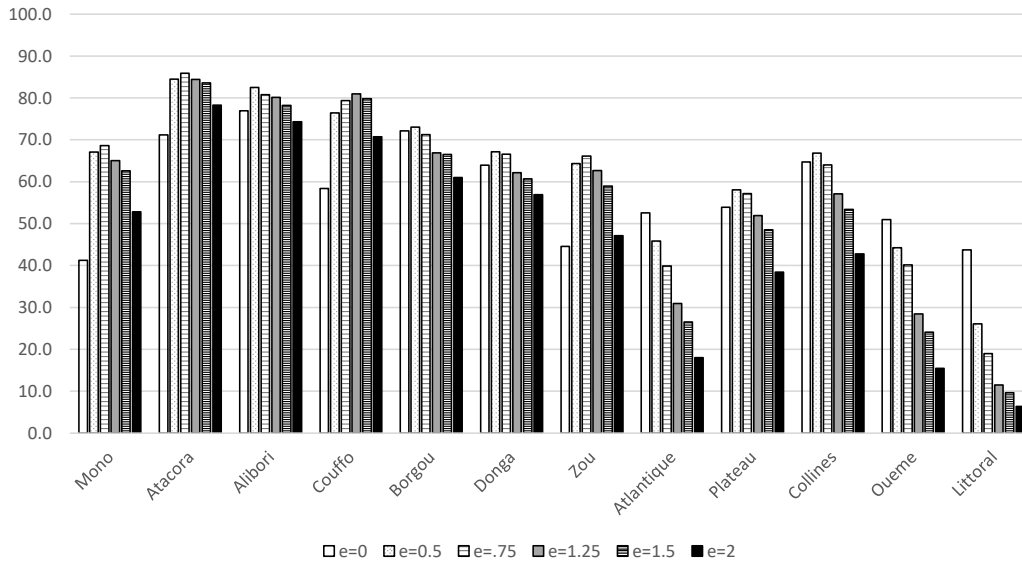
Note: The figures represent the relative average welfare differences in levels (CFA) between the application of the optimal tax and the baseline simulation (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP). Relative average welfare differences are calculated as average welfare differences over baseline average welfare levels. Rows represent relative average gains of a given department for different levels of inequality aversion (columns).

Figure E.2: Average welfare gain by department – relative (%)



Note: The vertical axis reports relative average welfare differences between the application of the optimal tax and the baseline simulation (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015). Averages are calculated as average welfare gain over baseline average welfare level. Each set of equally patterned bars is for a different level of inequality aversion. Each group of differently patterned bars is for a particular department. Departments are ranked from poorest to richest according to average baseline welfare level. The vertical axes is truncated below at -10%. The underlying values of the figure can be found in Table E.6.

Figure E.3: Percentage of winners by department



Note: The vertical axis contains the percentage of winners from a switch of the baseline simulation (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015) to the optimal taxes. Each set of equally patterned bars is for a different level of inequality aversion. Each group of differently patterned bars is for a particular department. Departments are ranked from poorest to richest according to average baseline welfare level. The underlying values of the figure can be found in Table E.7.

Table E.7: Percentage of winners by department

Departement	Inequality aversion					
	e=0	e=0.5	e=0.75	e=1.25	e=1.5	e=2
Mono	41.2	67.1	68.6	65.1	62.6	52.8
Atacora	71.2	84.5	85.9	84.4	83.6	78.3
Alibori	76.9	82.5	80.8	80.1	78.2	74.3
Couffo	58.4	76.4	79.3	81.0	79.8	70.7
Borgou	72.2	73.0	71.2	66.9	66.5	61.0
Donga	64.0	67.1	66.6	62.2	60.7	56.9
Zou	44.6	64.4	66.1	62.6	58.9	47.2
Atlantique	52.6	45.9	39.9	30.9	26.5	18.0
Plateau	53.9	58.0	57.1	51.9	48.5	38.4
Collines	64.7	66.8	64.0	57.1	53.4	42.8
Oueme	51.0	44.2	40.2	28.5	24.1	15.5
Littoral	43.8	26.1	19.0	11.5	9.7	6.4

Note: The figures represent the percentage of winners from a switch of the baseline simulation (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP) to the optimal taxes. Rows represent percentage of winners in a given department for different levels of inequality aversion (columns).

E.3 The role of the government budget level

As was noted in Section 2.2, tax revenues in Benin were not on the rise the last few years. We therefore illustrate which insights our model provides on the tax structure and level of government revenues at the moment of the data collection.⁶ We more in particular investigate which patterns may arise if we vary the government budget.⁷ Given that we do not integrate the public goods financed through taxes in our analysis, it makes no sense to compare welfare levels obtained under different government budget constraints. Actually, all individuals lose, both in the baseline and in the optimum, when the government budget is increased. Alternatively, we compare gains and losses arising from a switch of the existing tax structure (one VAT tariff, 18% under the low budget, and 26.56% under the high one, and an unaltered list of exempted goods) to optimal taxes, under the low (14.5% of GDP, coinciding with the tax revenues in 2015 and 2019) and the high (20% of GDP) government budget. We limit our comparison for the cases of absence of inequality aversion ($e = 0$) and ‘extreme’ inequality aversion ($e = 2$).

We start by comparing the optimal taxes of low (tax revenues to GDP ratio equal to 14.5%) versus high government budget (20% of GDP) for the cases $e = 0$ and $e = 2$ (Table E.8). All optimal tax rates increase when the government budget constraint tightens. The ranks of the tax rates are however unaffected when $e = 2$, and the taxes of only three pairs of goods switch rank in the case where $e = 0$ (‘furnishings and equipment t’ and ‘transport t’; ‘food rich t’ and ‘housing utilities t’; and ‘alcoholic beverages and tobacco t’ and ‘catering and accommodation t’). Rank switches only occur between originally adherent pairs of goods. The optimal tax structure turns out to be fairly robust with respect to the required government budget level.

We now turn to the welfare analysis. Figure E.4 shows the differences in welfare changes between baseline and optimum for both government budget constraints, across the initial welfare distribution. Deciles are (slightly) differently composed under the low and high government budget (see the discussion on the budget shares in both cases in Appendix C.2). For each decile, the difference in the average change in welfare from a switch to the optimum is given. Black lines refer the case of no inequality aversion, and grey lines to the case where $e = 2$. The left hand panel contain the figures in levels, the right panel contain relative differences (percentage gain or loss with respect to baseline level).

The black lines reveal that the average gain (loss) is in(de)creasing in the height of the government budget. In levels, this higher gain is relatively flat for the first five deciles, and increases for higher deciles. In relative terms, though, it is decreasing up to the fifth decile, and relatively flat afterwards. It is still overall positive. This means that the loss incurred by raising the government budget is higher under the baseline tax structure (one rate and exempted goods) than under the optimal policy. It might be tempting to conclude that a higher government budget allows for larger gains from a switch the current tax structure with one rate, and a number of exempted goods, to an optimal tax structure. A look at the results for higher inequality aversion (the grey lines) gives a more versatile picture for the lower deciles, with even a negative average for the fourth decile, meaning that gains from switching to the optimum are on average larger for the lower budget, or losses smaller. Notice that even under high inequality aversion, the individuals who gain more or lose less in levels (CFA) from a switch to the optimum under a high than under a low government budget belong to the higher deciles.

A closer look at the results learns that also here, these average differences in welfare changes per decile hide quite a lot of heterogeneity throughout. Table E.9 divides the sample into seven groups: (1) those who win from the switch under a low budget, but lose from the switch under the high budget; (2) those who lose under both government budget constraints, but lose more under the high budget; (3) those who lose under both government budget constraints, but lose less under the high budget; (4) those who are unaffected; (5) those who gain under both government budget

⁶ This amounts to VAT revenues from the household sector equalling 172.6 billion CFA, or 3.5% of GDP, and total tax revenue equalling 14.5% of GDP, which is about the same level as in 2019, see Section 2.2.

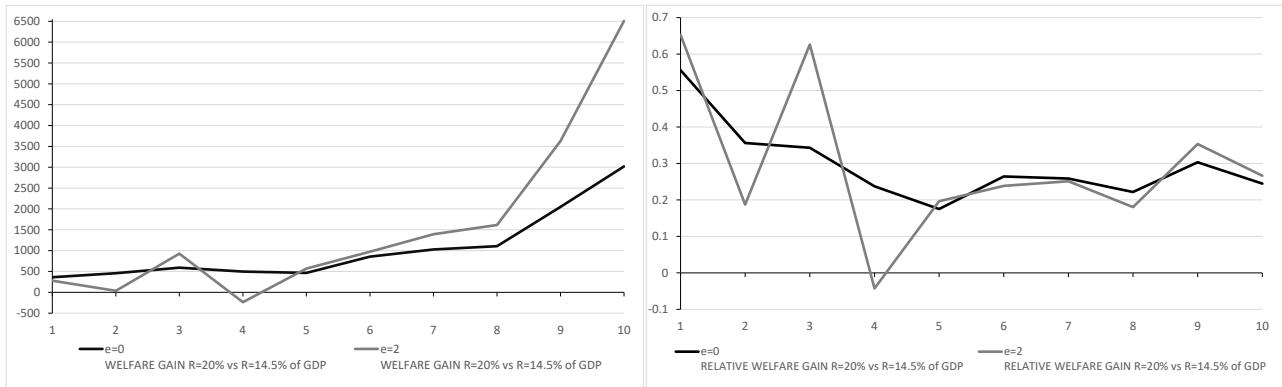
⁷ We also did some analyses with an intermediate level of tax revenues equalling 18% of GDP, but do not report them here, as all qualitative results remained unaltered.

Table E.8: Optimal taxes rates and global government budget

Inequality aversion	$e = 0$		$e = 2$		
	Government budget		Government budget		
Commodity	20.0% of GDP	14.5% of GDP	Commodity	20.0% of GDP	14.5% of GDP
Other services e	4.2	0.3	Food poor t	-45.0	-46.9
Other services t	6.0	2.6	Health e	-34.4	-36.7
Food poor t	9.0	5.3	Other services t	-23.1	-26.2
Recreation, culture e	10.0	6.1	Alcoh. bev. & tob. e	-15.4	-18.6
Recreation, culture t	10.6	6.7	Food poor e	-14.8	-17.9
Education e	11.5	7.5	Alcoh. bev. & tob. t	-4.7	-8.4
Food poor e	11.8	7.7	Others non serv. t	-4.7	-8.1
Furnishings & equipm. t	12.5	8.6	Transport e	-1.9	-5.2
Transport t	12.5	8.5	Clothing t	3.5	-0.4
Health e	13.1	9.2	Education e	11.9	8.0
Food rich e	13.6	9.4	Recreation, culture t	16.4	12.1
Clothing t	13.8	9.7	Furnishings & equipm. t	17.2	12.8
Others non serv. t	13.9	9.9	Communication t	21.0	16.8
Alcoh. bev. & tob. e	14.0	10.2	Housing utilities t	27.7	23.2
Housing utilities e	14.4	10.3	Housing utilities e	30.0	25.2
Housing utilities t	14.8	10.7	Transport t	31.4	26.7
Food rich t	14.9	10.7	Food rich t	46.9	41.8
Communication t	15.4	11.3	Non alcoh. bev. & tob. t	47.9	42.6
Alcoh. bev. & tob. t	15.9	11.9	Catering and accomm. t	50.3	44.9
Catering and accomm. t	16.0	11.8	Food rich e	51.2	45.6
Transport e	20.1	15.8	Other services e	55.3	49.8
Non alcoh. bev. & tob.t	20.6	16.2	Recreation, culture e	71.2	64.8
Housing rent e	26.2	21.3	Housing rent e	111.4	104.4

Note: Optimal tax rates (%) for $e = 0$ under high and low government budget (columns 2 and 3), and, similarly, for inequality aversion $e = 2$ (columns 5 and 6). Goods are ranked from low to high taxes under the higher budget, for each level of inequality aversion separately. Grey background coloured rates are those that cause a rank reversal in the optimal tax structure between low and high government budget. The optimal tax rates in columns 2 and 5 are the same as those in columns 2 and 7 of Table D.3.

Figure E.4: Difference in average welfare gain w.r.t. level of government revenues



(a) difference in avg. welfare gain per decile (CFA)

(b) Difference in relative welfare gain per decile (%)

Note: The figures show for each decile the difference in the average welfare change from the baseline tax structure to optimal tariffs for low (total tax revenues GDP ratio equal to 14.5%) and high (total tax revenue GDP ratio equal to 20%). The left hand panel contains the differences in levels (CFA). The right hand panel contains the differences in welfare changes relative to the respective baselines. Black lines are for absence of inequality aversion ($e = 0$), grey lines apply to $e = 2$.

Averages and deciles are calculated for the population of individuals. Deciles are constructed on the basis of baseline welfare, and are therefore not necessarily composed of the same persons in both the low and high tax revenue case. The averages of relative gains (right hand panel) are calculated as the average gain of all individuals within a decile divided by the average welfare level of individuals within that decile (Section B.5).

Table E.9: Government budget and heterogeneity in amount of welfare gain/loss

Class	Distribution of the sample across different classes (%)	
	Inequality aversion	
	$e = 0$	$e = 2$
(1) Winner under 14.5 -loser under 20% of GDP	0.7	1.0
(2) Loser under 14.5, loss increases under 20	38.0	19.3
(3) Loser under both 14.5 and 20% of GDP but loss smaller under 20%	4.4	34.6
(4) Unaffected in both 14.5 and 20% of gdp	0.1	0.1
(5) Winner under both 14.5 and 20% GDP but gain decreases under 20%	1.7	19.4
(6) Winner under both 14.5 and 20% GDP, gain increases under 20%	53.4	24.0
(7) Loser under 14.5, winner under 20% of GDP	1.6	1.7

Note: Each individual in the sample is subdivided into one of seven classes according to her loss or gain pattern from a switch of the baseline structure to optimal taxes : (1) those who win from the switch under a low budget, but lose under the high budget; (2) those who lose under both government budget constraints, but lose more under the high budget; (3) those who lose under both government budget constraints, but lose less under the high budget; (4) those who are unaffected; (5) those who gain under both government budget constraints, but gain less under the high budget; (6) those who gain under both government budget constraints, but gain more under the high budget; and (7) those who lose under the low budget, but win under the high budget. The figures in the table represent the *sample* distribution across the seven classes.

constraints, but gain less under the high budget; (6) those who gain under both government budget constraints, but gain more under the high budget; and (7) those who lose under the low budget, but win under the high budget. The table reproduces some results from the earlier analysis (see Table 5), and shows that these results continue to hold at a lower government budget. Adding the classes (5), (6), and (7), we obtain the percentage of winners from a switch from existing policy to optimal rates to be equal to a majority of 56.8% when there is no inequality aversion, and a minority of 45.1% when inequality aversion is high ($e = 2$).⁸ For the low budget (total tax revenues equal to 14.5% of GDP) the corresponding figures are 55.9% and 44.3% respectively, obtained by adding the classes (5), (6), and (1). So, a majority is gaining when there is no inequality aversion, while the reverse holds when inequality aversion is high, and this results seems to be unrelated to the size of the government budget. Nevertheless, the percentage of winners slinks when the budget is lower. Actually, Table E.9 shows that in absence of inequality aversion, 53% of the individuals in the sample gain more from a switch of existing to optimal taxes under the high budget than under the low budget. But, no less than 38% loses under both government budgets, and even more so under the higher budget. Under high inequality aversion, the largest group is the one composed of those who lose under both government budgets, but lose less under the higher government budget. Almost 40% of the sample experiences either a loss from the switch from baseline to optimal taxes that is higher under the high government budget than under the low one, or they experience a smaller gain from that switch with a larger budget than with a low.

We conclude that the level of the budget constraint has almost no effect on structure of optimal indirect taxes. We reaffirm the conclusions of the analysis with the higher budget: optimal indirect taxes entails winners and losers when compared with the existing tax structure. The amount of winners and the average gain tend to increase slightly with government budget, though at the decile level this not a general result.

⁸ The deviation with the 58.9% and 46.4%, respectively, reported in Table 5 is due to the fact that the figures in Table E.9 are at the sample level. No inference for the population as whole is aimed at here. Qualitatively the conclusions are the same anyhow.

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