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

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October 2024

Table of Contents

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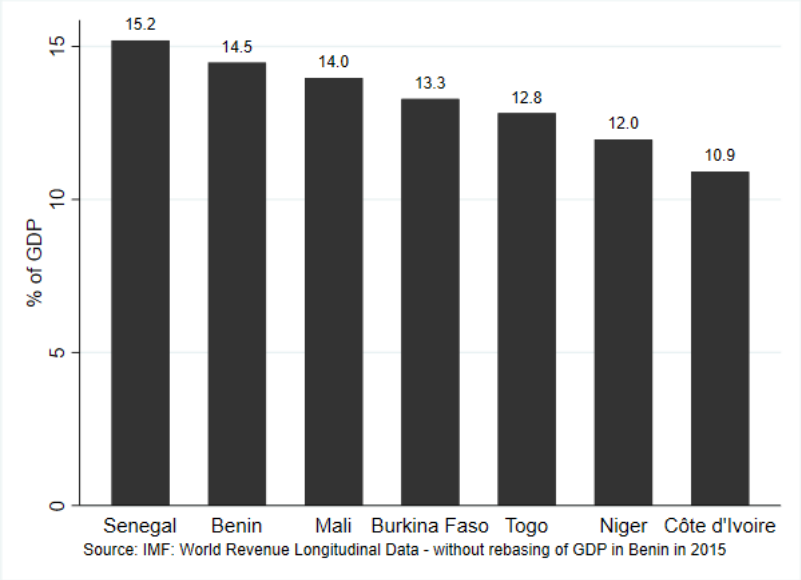
A VAT in WAEMU

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.

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-Buissau is available. On *rebasing* 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 Thorton's international Indirect Tax Guide: https://www.grantthornton.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:

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

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

$$\sum_l b_l(\mathbf{q}, y)\, \epsilon_{l,k}(\mathbf{q}, y) = -b_k(\mathbf{q}, y), \tag{A.2}$$

where $b_k(\mathbf{q}, y)$ is expenditure 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.

In the paper we distinguish between market and auto-consumed varieties of a each commodity g, indexed by g, m and g, a.

- Preferences are assumed to be characterised by the following utility function:

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

  where
  - $\rho_g = \frac{\sigma_g - 1}{\sigma_g}$, with $\sigma_g \in [0, \infty)$ being the elasticity of substitution between market and auto–consumed varieties of commodity g ($\rho_g < 1$). 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 then:

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

  where
  - $\mathbf{q}_g$ is the vector of consumer prices of the market and auto-consumed variety of commodity g: $\mathbf{q}_g = (q_{g,m}, q_{g,a})$. With producer prices normalised to one $\mathbf{q}_g = (1 + t_g, 1)$, where t_g is the tax rate on the market variety of commodity g;
  - $\phi_g(\mathbf{q}_g) = \left(\sum_s \delta_{g,s} q_{g,s}^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}$ is 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: $\delta_{g,a} = \left(1 + \frac{w_{g,m}}{w_{g,a}} \left(\frac{q_{g,a}}{q_{g,m}} \right)^{1-\sigma_g} \right)^{-1}$, with $w_{g,s}$ observed expenditures on commodity g, s, $s = m, a$;
  - σ_g cannot be immediately read off from the data. We assume it is not household specific and we will therefore denote it by σ. In the main analysis we use $\sigma = 0.5$, and we did a sensitivity analysis with $\sigma = 1.5$.
- The associated indirect utility function is:

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

– The corresponding expenditure function is:

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

A Money Metric Utility function (MMU) is the minimal amount of money needed at a set of reference price $\mathbf{q}^{\text{ref}}$ 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 $\mathbf{q}^{\text{ref}}$ and welfare level $U = v^{\text{CCD}}(\mathbf{q}, y)$, which gives:

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

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

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

B.2 Social welfare, government budget, optimal taxes

– Social welfare function:

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

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

– Government budget:

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

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

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

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

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

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 exogenously given incomes y_h, a uniform tax rate on all goods inclusive non-market goods, is equivalent to a lump sum tax on income. 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 an 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 14)[1]:

$$MC_{g,s}(\mathbf{t}) = \frac{\sum_h \beta_h(\mathbf{t})\, s_{g,s,h}(\mathbf{q};\mathbf{y})}{1+\sum_{j,r} t^*_{j,r} \sum_h \epsilon^h_{jr,gs}(\mathbf{q},y_h)\, \frac{b_{j,r,h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})}}, \tag{A.13}$$

where $s_{g,s,h}(\mathbf{q};\mathbf{y})$ is the share of household's consumption of commodity g,s in total consumption of commodity g,s, and $b_{j,r,h}(\mathbf{q};y_h)$ are expenditures of household h to commodity g,s.

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

$$\begin{aligned} \sum_{j,r} t^*_{j,r} \sum_h \epsilon^h_{jr,gs}(\mathbf{q},y_h)\, \frac{b_{j,r,h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})} &= \frac{t}{1+t} \sum_h \sum_{j,r} \epsilon^h_{jr,gs}(\mathbf{q},y_h)\, \frac{b_{j,r,h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})} \\ &= -\frac{t}{1+t} \sum_h \frac{b_{g,s,h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})} = -\frac{t}{1+t}, \end{aligned} \tag{A.14}$$

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

So, let us concentrates on the numerator. In a more general formulation of the model, the social welfare function is an additively separable[2], anonymous, and 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[3]:

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

The numerator of the marginal social welfare costs[4] in Equation (A.13) then reads as:

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

The first two terms together compose the marginal social welfare weight of a household h, denoted earlier by $\beta_h(\mathbf{t})$ and reflect the impact on social welfare of giving an additional CFA to household h. These social welfare weights consist of an equity part (the A-component of the marginal social weights in the main text, Equation 13) and an efficiency part (the B- and C-component in the main text, Equation 13). Because of additive separability and anonymity, the equity part depends only on the welfare level U_h, and it is weakly decreasing in that individual welfare level, because of the concavity assumption. The efficiency component reflects how efficient a household is in producing welfare for its members out of money. This partly depends on preferences and partly on the presence of household composition. If household members prefer relatively more expensive goods, they will be less able to convert an additional CFA into welfare than persons relatively more intensely preferring cheaper goods.[5] On the other hand, the composition of the household may require expenditures on specific goods and/or engender joint consumption of the same good (economies of scale).[6] In case there is no inequality aversion the equity component of the marginal social weights

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

[2] The extension towards non-additively separable social welfare functions is beyond the scope of the present text.

[3] In our application the effect of household composition is captured by dividing the money metric utility which we chose as a welfare measure by an equivalence scale θ_h.

[4] Feldstein (1972) baptised the numerator as the distributional characteristic of a good, but, as we will see, it contains also some efficiency characteristics .

[5] Notice however that in an optimal tax problem, it is endogenously determined which goods are relatively cheap or expensive goods.

[6] Given that the marginal utility of money, $\partial\nu_h/\partial y_h$, is not invariant to positive monotone transformations of the utility function, many research subsume this efficiency aspect under the equity part of the social weights (e.g. Saez and Stantcheva, 2016, Bachas et al., 2023). Nevertheless the marginal utility of money is not completely independent of preferences. Therefore

is household independent.[7] However, the efficiency component can still play a role, even if preferences are identical, that is when the functional form of the individual welfare measure, ν_h, is household independent. Indeed, even in that case differences in household incomes and composition engendering different needs may make the value of efficiency component different across households. We come back to the conditions under which the efficiency part of the marginal social weights become household independent too.

First we turn to the third term of Equation (A.16), $s_{g,s,h}(\mathbf{q};\mathbf{y})$, which is the share of household's h consumption of a particular good g,s in total consumption of that good in society. When all persons in society have identical and homothetic preferences, demand functions are of the following form:

$$d_{g,m}(\mathbf{q}, y_h) = \frac{y_h}{P(\mathbf{q})}, \tag{A.17}$$

where $P(\mathbf{q})$ is a price index (a linearly homogeneous function which is equal to q if all prices in $\mathbf{q}$ are identically equal to q). In other words, expenditure shares of commodities are independent of household income and its consumption share of a commodity in total consumption of that commodity reduces to:

$$s_{g,s,h}(\mathbf{q};\mathbf{y}) = \frac{y_h}{\sum_{h'} y_{h'}}. \tag{A.18}$$

This term is therefore commodity independent. So, whatever the value of the marginal social weights, under identical and homothetic preferences, the numerators of the marginal social welfare costs are commodity independent, irrespective of the value of the tax rates:

$$\sum_h \beta_h(\mathbf{t})\, s_{g,s,h}(\mathbf{q};\mathbf{y}) = \sum_h \beta_h(\mathbf{t})\, \frac{y_h}{\sum_{h'} y_{h'}}. \tag{A.19}$$

Together with the fact that a uniform rate will make also the denominator commodity independent (Equation A.14), this implies that the marginal social welfare costs are equal for all commodities under a uniform rate. We can conclude that if all persons have identical and homothetic preferences and all goods can be taxed, a uniform rate is optimal irrespective of the value of the marginal social weights, that is irrespective of the degree of inequality aversion and differences due to household composition.

When we drop the assumption of identical preferences but maintain the assumption of homotheticity, the uniform rate will remain optimal if the value of the marginal social weights is the same for all households, say $\beta_h(\mathbf{t}) = \beta(\mathbf{t})$ for all h. Indeed, the numerator of the marginal social welfare costs then becomes:

$$\sum_h \beta_h(\mathbf{t})\, s_{g,s,h}(\mathbf{q};\mathbf{y}) = \beta(\mathbf{t}). \tag{A.20}$$

We already mentioned that the value of the equity part of the marginal social welfare weights is household independent if inequality aversion is zero. Under homothetic preferences and with a money metric utility, the remaining (efficiency) part of the marginal social weights equals:

$$\beta_h(\mathbf{t}) = \frac{1}{P_h(\mathbf{q})}\frac{n_h}{\theta_h}. \tag{A.21}$$

While the price index P_h is now household specific, it still equals $1+t$ under a uniform rate t on all goods. Therefore, the only remaining household specific factor is n_h/θ_h, which reflects household economies of scale due to differences

we are quite explicit in our choice of the cardinal representation of preferences (using a money metric utility), and, in exchange, allow for preferences and preference heterogeneity to play their role in the determination of the value of the marginal social weights. By our assumption of homotheticity of preferences and the choice of a money metric utility measure for individual welfare, we impose the marginal utility of income to be independent of income. The efficiency part of the marginal social welfare weight then only contains preference related factors (the relative intensity of preference for cheaper or more expensive goods) and/or aspects relating to the way household composition affect the efficiency to convert money into welfare.

[7] To be more precise, in the more general formulation of the social welfare function (Equation A.15), absence of inequality aversion is defined as $\partial W/\partial U_h$ to be independent of the welfare level U_h and therefore having the same value for all households.

in household composition. So, putting the equivalence of scale equal to household size (no economies of scale) will make the marginal social weights household independent. We conclude that the optimal indirect taxes remain to be uniform when allowing for preference heterogeneity, if all goods can be taxed, preferences are homothetic, there is no inequality aversion, and there are no within household economies of scale.[8] Reversely, even when all goods can be taxed and preferences are homothetic, uniform indirect taxation may not be optimal due to preference heterogeneity and differences in household economies of scale. Remark however that under a non-uniform rate the impact on the government budget of an increase in a tax rate, reflected in the denominator of the marginal social welfare cost formula, will become commodity specific too and may thus affect the optimal tax rates. In the absence of the cross price effects between commodities g and g', the optimal tax rule becomes:

$$\lambda = \frac{\sum_h \beta_h(\mathbf{t})\, s_{g,s,h}(\mathbf{q};\mathbf{y})}{1+\sum_{s'} t^*_{g,s'} \sum_h \epsilon^h_{gs',gs}(\mathbf{q},y_h)\, \frac{b_{g,s',h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})}}. \tag{A.22}$$

When optimal rates are not uniform, also the B-component of the marginal social welfare weights (see Equation 13 of the main text) will be household specific and impact the optimal tax rates. We quantify the separate contribution of preference heterogeneity and household economies of scale to the deviation from uniformity in Section 5.1 (Table 2) and Section D.1 (Table D.1).

B.4 Optimal deviations from uniform indirect taxes

We now investigate what happens if we relax the assumption that all goods can be taxed. When some goods cannot be taxed, a uniform rate on market goods is not any more equivalent to a lump sum tax. This creates a differential wedge between producer and consumer prices for market varieties as compared to auto-consumed varieties, and makes indirect taxes distortive. So, generally speaking, we cannot expect a uniform tax rate for all market varieties to be optimal. To identify the impact of the presence of some nontaxable goods on optimal taxes, we start with the case where preferences are homothetic and identical across agents. Equation (A.18) which stipulates that the household shares in total consumption of a commodity are commodity independent, remains valid. So, the numerator of the marginal social welfare costs (Equation A.13) is commodity independent. However, since not all goods can be taxed, the adding-up condition for demand (Equation A.2) cannot be applied here. The denominator of the marginal welfare costs is, therefore, generally commodity specific. This denominator reflects the impact on the government budget of raising a tax rate $t_{g,m}$, expressed in terms of the demand elasticities of the market goods with respect to the price of that good. Under identical and homothetic preferences, these elasticities can be shown to be household independent. However, they do depend on the tax rates, and are therefore denoted by $\epsilon_{jr,gs}(\mathbf{t})$. Also the ratio of market expenditures on a commodity g,m and g,s only depends on consumer prices (or tax rates, given that producer prices are assumed to be fixed) and denoted by $E(\mathbf{t};jm,gm) := \sum_h b_{j,m,h}(\mathbf{q};y_h) / \sum_h b_{g,m,h}(\mathbf{q};y_h)$. Equating the marginal social welfare costs of market goods solely, yields a classical Ramsey indirect tax rule (Ramsey, 1927):

$$\lambda = \frac{B(\mathbf{t})}{1+\sum_k t^*_k \epsilon_{km,gm}(\mathbf{t})\, E(\mathbf{t};km,gm)} \qquad \forall\, g, \tag{A.23}$$

where $B(\mathbf{t}) = \sum_h \beta_h(\mathbf{t}) \frac{y_h}{\sum_{h'} y_{h'}}$. When there are no cross-price effects between market varieties (for $\epsilon_{km,gm} = 0$ for all $k \neq g$), Equation (A.23) can be rearranged to obtain the inverse elasticity rule, which says that optimal tax rates in the optimum should be inverse proportional to own price elasticities (use is made of the fact that $E(\mathbf{t};gm,gm) \equiv 1$):

$$\frac{t_g}{1+t_g} = \frac{\gamma}{\epsilon_{gm,gm}(\mathbf{t})}, \text{with } \gamma \in \mathbb{R} : \gamma \neq 0. \tag{A.24}$$

Actually, γ is a shorthand for $(B(\mathbf{t}) - \lambda)/\lambda$, and is usually negative. The inverse elasticity rule says that commodities which exhibit larger own price elasticity –and therefore affect more intensely the government budget when their taxes

[8] These are the set of conditions identified in Section 3.2 (p.13) of the main text to be jointly sufficient for optimality of uniform taxation.

ore increased– should be taxed at a lower rate. For the CES-CD specification of preferences, own price elasticities of market demand only depend on the own tax rate:

$$\epsilon^{\text{CCD}}_{gm,gm}\left(t_g\right) = -\sigma - \left(1-\sigma\right)\frac{\delta_{g,m}\left(1+t_g\right)^{1-\sigma}}{\left(1-\delta_{g,m}\right)+\delta_{g,m}\left(1+t_g\right)^{1-\sigma}}. \tag{A.25}$$

When we allow for preference heterogeneity, the optimal tax rule in Equation (A.11) or (A.23), reads as:

$$\lambda \quad = \quad \frac{\sum_h \beta_h(\mathbf{q}) s_{g,m,h}(\mathbf{q},\mathbf{y})}{1+\sum_k t_k^* \sum_h \epsilon^h_{km,gm} \frac{b_{k,m,h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,m,h'}\left(\mathbf{q};y_{h'}\right)}} \qquad \forall\ g. \tag{A.26}$$

Equation (A.26) is an example of a many person Ramsey rule (Diamond, 1975). In case there are no cross price effects between market varieties, we get, after rearranging:

$$\begin{array}{ccc} \frac{t_g}{1+t_g} & = & \underbrace{\frac{1}{\sum_h \epsilon^h_{gm,gm}\left(\mathbf{t}\right) s_{g,m,h}\left(\mathbf{q},\mathbf{y}\right)}}_{\begin{array}{c}\text{inverse elasticity rule with}\\ \text{preference heterogneity}\end{array}} \quad \underbrace{\frac{\sum_h \beta_h\left(\mathbf{t}\right) s_{g,m,h}\left(\mathbf{q},\mathbf{y}\right)-\lambda}{\lambda}}_{\begin{array}{c}\text{deviation from inverse elasticity rule}\\ \text{due to preference heterogeneity}\end{array}}. \end{array} \tag{A.27}$$

The first factor of this expression is reminiscent of the inverse elasticity rule Equation (A.24). The second factor now also captures the differential impact of tax increases on social welfare. The latter effect is embodied in the term $\sum_h \beta_h\left(\mathbf{t}\right) s_{g,m,h}\left(\mathbf{q},\mathbf{y}\right)$, and we come back to it below. However, even in the absence of this factor, the inverse elasticity rule would generally not produce the same optimal tax rates as with identical preferences (Equation A.24). Indeed, behavioural reactions to a tax increase are here captured through an appropriate aggregation of individual elasticities, rather than through the behaviour of a representative agent. Using our CES-CD specification the following expressions for the individual elasticities and consumption shares are obtained:

$$\begin{array}{lcl} \epsilon^{\text{CCD},h}_{gm,gm}\left(t_g\right) & = & -\sigma-\left(1-\sigma\right)\frac{\delta_{g,m,h}\left(1+t_g\right)^{1-\sigma}}{\left(1-\delta_{g,m,h}\right)+\delta_{g,m,h}\left(1+t_g\right)^{1-\sigma}}, \\ s^{\text{CCD}}_{g,m,h}\left(\mathbf{q},\mathbf{y}\right) & = & \frac{d^{\text{CCD}}_{g,m,h}\left(\mathbf{q}_g,y_h\right)}{\sum_{h'} d^{\text{CCD}}_{g,m,h'}\left(\mathbf{q}_g,y_h\right)}, \\ d^{\text{CCD}}_{g,m,h}\left(\mathbf{q}_g,y_h\right) & = & \frac{\alpha_{g,h}\delta_{g,m,h}\, y_h}{\left(\delta_{g,m,h}\left(1+t_g\right)^{1-\sigma}+\left(1-\delta_{g,m,h}\right)\right)\cdot\left(1+t_g\right)^{\sigma}}. \end{array} \tag{A.28}$$

The term $\sum_h \beta_h\left(\mathbf{t}\right) s_{g,m,h}\left(\mathbf{q},\mathbf{y}\right)$ is generally commodity specific, even with homothetic preferences, and in the absence of inequality aversion or any household composition effects. The marginal social weights for homothetic preferences, using a money metric utility with reference prices all equal (to one for simplicity), and employing an Atkinson-Kolm-Sen specification for the social welfare function (Equation A.9), and an equivalence scale approach to capture the impact of household composition, reduce to:

$$\beta_h\left(\mathbf{t}\right) = \left(\frac{y_h}{P_h\left(\mathbf{q}\right)\theta_h}\right)^{-e}\frac{1}{P_h\left(\mathbf{q}\right)}\frac{n_h}{\theta_h}. \tag{A.29}$$

In Table B.1, we concentrate on the comparison between the inverse elasticity rule and optimal taxes under preference heterogeneity in the absence of inequality aversion and household economies of scale (that is when $\beta_h\left(\mathbf{t}\right) = \left(\Phi_h\left(\mathbf{q}\right)\right)^{-1}$). The optimal tax rates for the cases of identical and heterogeneous preferences are shown in columns (1) and (2) of Table B.1, respectively. They are ranked from low to high under the assumption of identical preferences (that is, obeying the inverse elasticity rule). The corresponding ranks numbered from high to low, are shown in columns (3) and (4) of Table B.1.[9] The next two columns, (5) and (6), contain the own price elasticities for both scenario's. Finally, the last two columns, (7) and (8), contain the ranks of the price elasticties (from low to high).

[9] Tables 3 and D.1 report the change in optimal tax rates and their mutual rankings respectively, by gradually introducing preference heterogeneity, inequality aversion and within household economies of scale. Therefore, the first two columns of 3 correspond to the first to columns of Table B.1 and the first two columns of Table D.1 correspond to columns (3) and (4) of

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

	Inequality aversion $e = 0$, $n_h = \theta_h$							
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Commodity	Identical pref. %	Heterog. pref. %	Rank (1)	Rank (2)	Own price elast. (1)	Own price elast. (2)	Rank elas.(1)	Rank elas.(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

Elasticities reported in column (5), are highest (in absolute value) for 'Education e' and 'Other services e'. These are the two goods for which there is no auto-consumption variety. Preferences over these commodities reduce then to a pure Cobb-Douglas specification and elastcities equal -1. That the other elasticities are smaller in absolute value reveals that part of a tax increase on market commodities will be absorbed by a reduction in the consumption of the auto-consumed variety. They are complements to the market goods. This is due to our assumption of a value for σ smaller than one. The reason that we show the elasticities for both, the case with identical preferences and the one with heterogeneous preferences, is that to study whether the case of heterogeneous preferences really deviates from an inverse elasticity rule, we have to compare the ranking of the optimal tax rates with the ranking of the elasticities calculated under the assumption of heterogeneous preferences evaluated in the optimum for that case, and not with the elasticities of the representative agent (identical preferences) evaluated in the optimum for that case. A few exceptions notwithstanding ('Housing rent e', 'Other services e', and 'food poor t') differences in percentage points are less than 1 percentage point. Nevertheless the ranking of the tax rates is quite different (compare columns (3) and (4)), despite the ranks of the representative agent elasticities and the aggregated micro-elasticities being quite close (columns (7) and (8)) except for 'Housing utilities e' and 'Housing rent e'. The bottom line of Table B.1 gives for both, the case with identical preferences and the one with preference heterogeneity, a measure for the deviation of tax ranks and elasticity ranks. For identical preference both rankings coincide. With heterogeneous preferences, the deviation between both rankings is almost 54% of the maximal difference both rankings can exhibit.[10] We can conclude that in the absence of inequality aversion and economies of scale, preference heterogeneity plays a minor role in the level of the optimal tax rates but does affect their ranking substantially. When inequality aversion is increased the deviation from the inverse elasticity rule becomes even larger. For a given value of (positive) inequality aversion, though, the deviation from the inverse elastcity rule in simulations with and without within household economies of scale are quite similar though.

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 of 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

Table B.1.

[10] We measure the distance between two rankings by the sum of the absolute difference of the tax rate rank of each of the commodities (Spearman's foot rule) divided by the maximum difference the can be obtained between two rankings of the tax rates, when measured in this way.

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.[11] 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 the welfare deciles, in the data.[12] 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

[11] 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.

[12] 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.

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.

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, Pattisserie 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 écremé, Lait en poudre, Autres laits, Crême fraiche, 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 transformes, Maïs en patte, Farine de mil, Céréales grillés, Fécule 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 fraiches, Poisson frais Appolo, Poisson frais Sosso, Carpe fraiche, 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, Aïl 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, Pamplemousse, 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 Attiékè), 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 sêche, 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), Jupon 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 synthêtique 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 couvre-lit, 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 electroménagers, 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 réfrigerateur, 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, Poèle, 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 hospitaux.

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, Vaccinnation 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 secondair, 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 artsanale dans un bar, Bière industrielle dans un bar, Sucrerie dans un bar, Liqueur dans un bar, Petit déjeuner pris à l'extérieur, Dèjeuner pris à l'extérieur, Diner 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 apparels 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 lèvre), 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 crêche, 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 motcyclette, 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 exempted 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**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
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**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
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**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
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**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
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 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 respectively. 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	Identical	Heterogeneous										
	Uniform rule	No household economies of scale: $\theta_h = n_h$ Inequality aversion					Household economies of scale: θ_h =OECD-scale Inequality aversion					
Commodity		**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) 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 $\delta_{m,g}$ ($s = m, s$, $g = 1, 2, \ldots, G$), 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

Preferences	Identical	Heterogeneous											
	Inverse elasticity	No household economies of scale: $\theta_h = n_h$ Inequality aversion						Household economies of scale: θ_h =OECD-scale Inequality aversion					
Commodity	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)
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 $\delta_{m,g}$ ($s = m, s$, $g = 1, 2, \ldots, G$), 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

	Inequality aversion					
Commodity	$e = 0$	$e = 0.50$	$e = 0.75$	$e = 1.25$	$e = 1.50$	$e = 2.0$
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)

	Average change in welfare: CFA					
	Inequality aversion					
Decile	**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

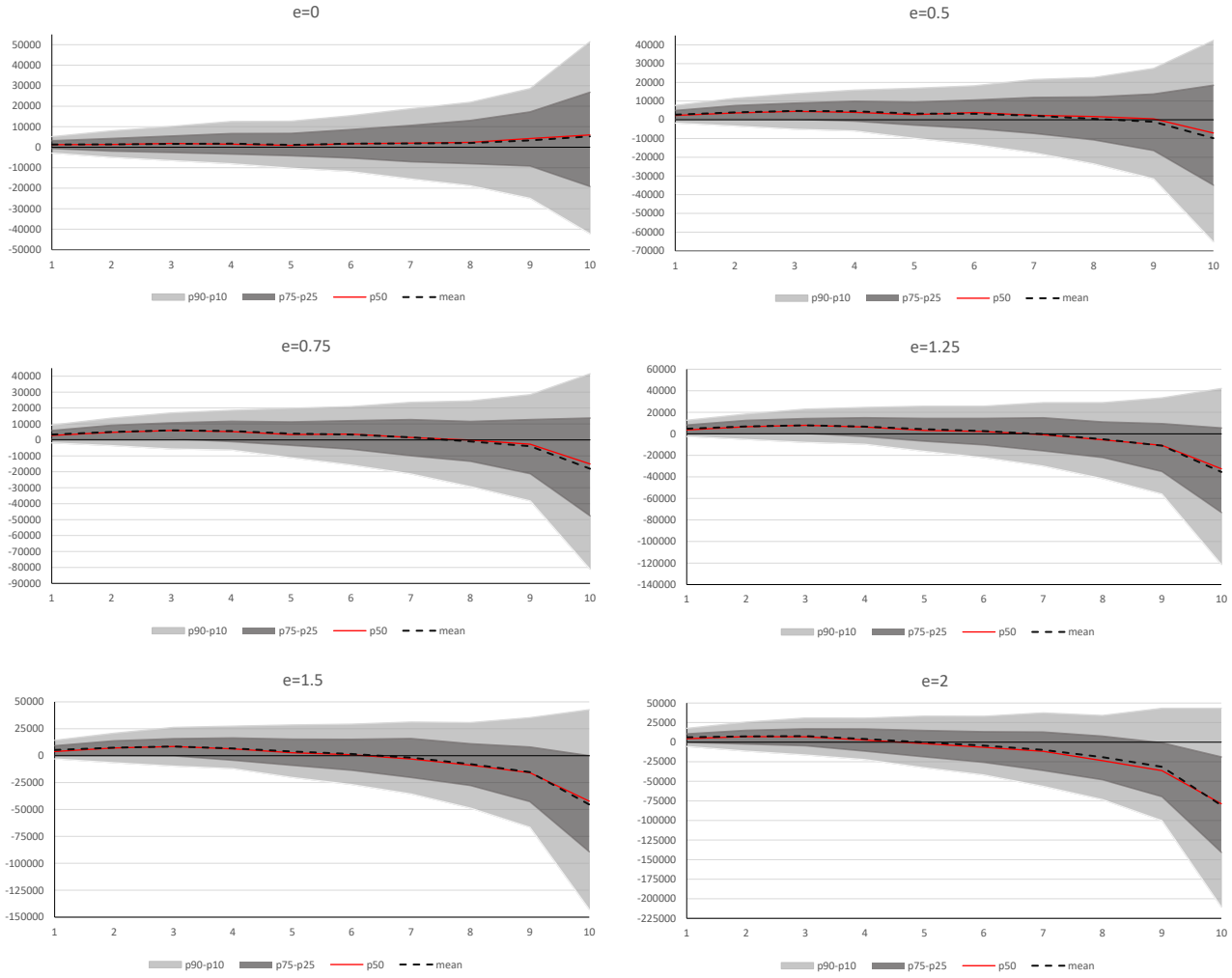
	Average change in welfare: %					
	Inequality aversion					
Decile	**e=0**	**e=0.5**	**e=0.75**	**e=1.25**	**e=1.5**	**e=2**
1	**1.8**	**3.9**	**4.9**	**6.7**	**7.6**	**8.8**
2	**1.0**	**2.9**	**3.7**	**5.0**	**5.5**	**5.5**
3	**0.9**	**2.6**	**3.3**	**4.4**	**4.7**	**4.3**
4	**0.8**	**2.0**	**2.4**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

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 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

	Percentage of losers					
	Inequality aversion					
Decile	**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	**Optimal indirect tax simulation**									
baseline	**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).[13] 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 focusing on 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).[14] 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 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

[13] 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.

[14] 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 (%)

e=0			e=2		
Commodity	23 rates	4 rates	Commodity	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

	Inequality aversion $e = 0$					
	Welfare change level (CFA)		Relative welfare change(%)		Winners (%)	
Decile	unrestricted	restricted	unrestricted	restricted	unrestricted	restricted
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
	Inequality aversion $e = 2$					
	Welfare change level (CFA)		Relative welfare change(%)		Winners (%)	
Decile	unrestricted	restricted	unrestricted	restricted	unrestricted	restricted
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 $e = 2$.

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 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

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.

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

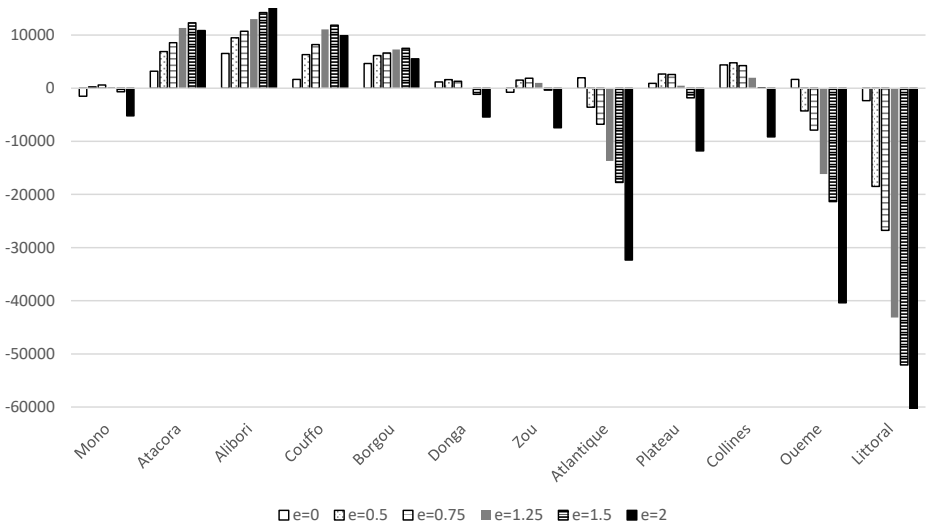
Department	Population	Welfare rank	Auto-consumption
Alibori	9.3	3	24.4
Atacora	7.6	2	27.2
Atlantique	13.7	8	8.6
Borgou	13.4	5	23.8
Collines	7.6	10	15.3
Couffo	8.1	4	14.4
Donga	5.1	6	23.6
Littoral	6.6	12	4.5
Mono	5.2	1	8.0
Oueme	8.5	11	6.3
Plateau	5.6	9	13.0
Zou	9.4	7	13.7
All	100	–	13.4

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)

	Inequality aversion					
Departement	**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

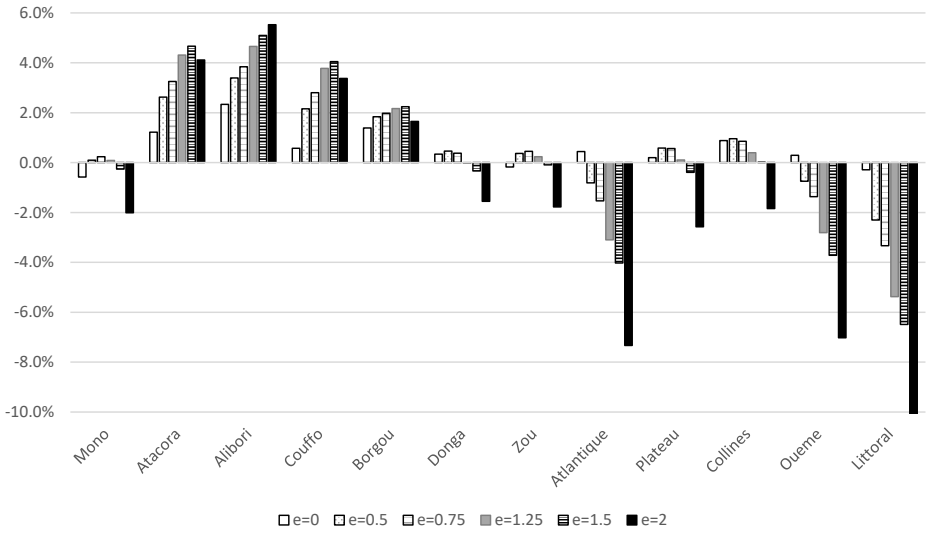
Note: The figures represent the average welfare differences in levels (CFA) between the application of the optimal tax and the baseline simulation (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP). Rows represent average gains of a given department for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

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

	Inequality aversion					
Departement	**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

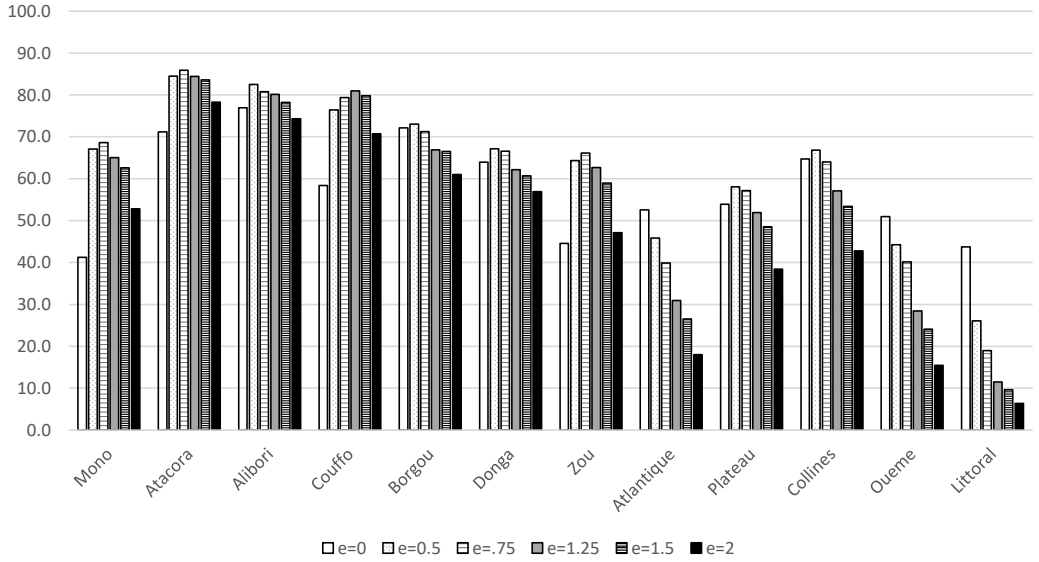
Note: The figures represent the relative average welfare differences in levels (CFA) between the application of the optimal tax and the baseline simulation (two tariffs: exempt and 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP). Relative average welfare differences are calculated 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

	Inequality aversion					
Departement	**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.[15] We more in particular investigate which patterns may arise if we vary the government budget.[16] 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

[15] 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.

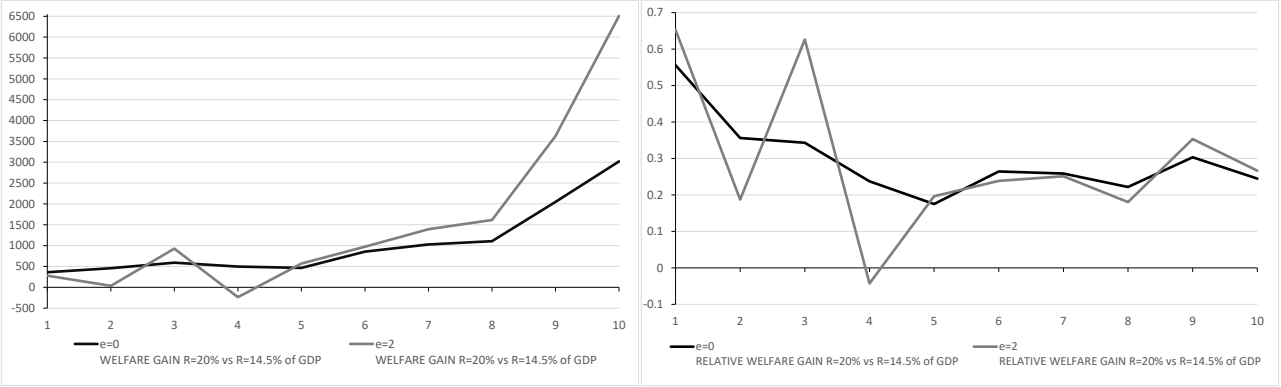
[16] We also did some analyses with an intermediate level of tax revenues equalling 18% of GDP, but do not report them here, as all qualitative results remained unaltered.

Table E.8: Optimal tax 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

Distribution of the sample across different classes (%)		
	Inequality aversion	
Class	$e = 0$	$e = 2$
(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 ($e = 2$).[17] 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.

[17] 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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