Welfare effects of indirect tax policies in West Africa

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Abstract

In West Africa, the Value Added Tax (VAT) policy consists of a standard tax rate, but several items are exempted. We provide an optimal tax framework to evaluate the welfare effects of alternative tax structures in the context of current debates on domestic resource mobilisation in low-income countries. We show that a uniform tax rate is not optimal when taking into account that home-produced consumption goods cannot be taxed. An application with household data from Benin shows that generally optimal VAT rate structures are supported by a majority of the population. In comparison to the current VAT policy, optimal tax reforms yield higher average relative welfare gains for the lower deciles. Due to preferences heterogeneity, however, we find winners and losers in all welfare deciles.

Keywords: Africa, Auto-consumption, Value Added Tax (VAT), Optimal taxation, Taste heterogeneity, Domestic resource mobilisation, Tax reform, Welfare

JEL codes: O55, O23, H21, H23, H75

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1 Introduction

Developing countries face huge financing needs (*e.g.* infrastructure, education...), but their tax revenue collection remains relatively low (*e.g.* Garcia-Escribano et al., 2019). In 2019, the average total tax revenue to GDP ratio of about 15%[1] in low income countries (LICs) is still below the United Nations's (UN) minimal tax revenue threshold of 20% to achieve the Millennium Development Goals (UNDP, 2010).[2]

The overall objective of this paper is to understand the welfare effects of tax collection in the West African Economic and Monetary Union (WAEMU[3]), where the average tax revenue to GDP ratio is about 16% in 2019. We focus on the value-added tax (VAT) which contributes about 44% to total tax revenue. The current harmonised VAT policy in WAEMU consists of a unique rate but several goods and services are not subject to VAT.[4] For instance, many food products are exempted. While the list of exempted goods seems to be motivated by social objectives, a more thorough empirical analysis shows that for some of them, the budget share increases with income. WAEMU adopted the UN goal to raise tax revenues to 20% of GDP.[5] Maintaining the current policy requires to raise the standard tax rate. Little is known about the welfare implications of such a policy as compared to possible alternatives.

We study the welfare effects of alternative VAT rate structures in WAEMU using an optimal indirect tax framework. We use a fairly disaggregated commodity classification, designed to capture potential correlations between total expenditures and consumption of specific commodities. We develop a Ramsey-type model, assuming total expenditures to be exogenously given. It exhibits the following features. First, we use a money metric utility measure of individual welfare (*e.g.* Creedy et al., 2020). Individual welfare levels are aggregated by Atkinson-Kolm-Sen type of social welfare functions. The equity-efficiency trade-off is captured by the inequality aversion parameter of that class of welfare functions. Second, we allow for preference heterogeneity (*e.g.* Mirrlees, 1976, Saez, 2002, Kaplow, 2008, Blomquist and Christiansen, 2008, Gauthier and Henriet, 2018, Spiritus, 2022). This choice is guided by the empirical observation that expenditure patterns vary significantly even among households with similar structure and income. We assess the impact of preference heterogeneity on the optimal tax structure by comparing our results with those from the standard model that assumes identical preferences.

[1] Unless stated otherwise, data on tax revenue presented in this paper come from the UNU-WIDER Government Revenue Dataset, 2022: doi.org/10.35188/UNU-WIDER/GRD-2022.

[2] While the 20% threshold has not yet been met, LICs have increased tax collection from an average of 12% in 2000. This progress was the result of various initiatives. For instance, the Addis Tax Initiative (ATI), established in 2015, aims "to promote fair and effective domestic revenue mobilisation (DRM) ...". The ATI (UN, 2015) was the third international financing for development conference. The two earlier international agreements were respectively held in Monterrey in 2002 (UN, 2002) and in Doha in 2008 (UN, 2008).

[3] WAEMU includes eight countries: Benin, Burkina Faso, Côte d'Ivoire, Guinée-Bissau, Mali, Niger, Senegal, and Togo.

[4] This standard rate is 18% in all countries except in Niger where it is 19%. Guinée-Bissau introduced VAT only in 2023, replacing a sales tax.

[5] The VAT revenue to GDP ratio can be decomposed into three main terms (Keen, 2013): the standard rate, the C-efficiency, and the consumption to GDP ratio. The C-efficiency, defined as actual VAT revenues over revenues if the standard rate would be applied to all consumption, can be further decomposed into the compliance gap (evasion from obliged VAT) and the policy gap (reductions on the standard rate). All these terms could be interrelated but this paper focuses on the tax rate structure and takes the other components as given.

Third, our model accounts for the welfare effects of items that cannot be taxed. In LICs a non-negligible part of consumption stems from own produce (*e.g.* agricultural products) and informal transactions. Taxation of such non-traded commodities is difficult. The survey data we use for our empirical analysis, show that households in Benin spend on average 87% of their budget on market goods in 2015, and thus 13% is informal and auto-consumption. For food items, the corresponding numbers are 82% and 18%. To capture substitutability between market and auto-consumption varieties of commodities, we employ individually specific nested Constant Elasticity of Substitution/Cobb-Douglas type of preferences (Keller, 1976).

Our theoretical analysis shows that, due to the home production, a uniform rate on market goods is not optimal. This result holds under identical preferences. Taxing market goods distorts relative prices of market goods and auto-consumption when the latter cannot be taxed. It might then be more efficient to impose higher tax on goods that are primarily bought on the market and less substitutable with auto-consumption varieties. We show that in the absence of inequality aversion the optimal tax structure obeys a classical Ramsey rule (Ramsey, 1927): goods for which a price increase causes a large (negative) impact on the government budget, should be taxed relatively lowly. We show that in our model this result boils down to an inverse elasticity rule: goods exhibiting a relatively large own price elasticity (in absolute value) are taxed relatively low in the optimum.

In addition to the presence of nontaxable goods, we examine the impact of preference heterogeneity and household composition on the optimal tax structure. We show that preference heterogeneity leads to a further diversification of the optimal tax rates, disturbing the inverse elasticity rule, even in the absence of inequality aversion. Commodities that are more preferred by households that are efficient in producing welfare for their members should be taxed less. Household composition generates within household economies of scales. Households exhibiting larger economies of scale are more efficient in producing welfare for their members. Commodities more intensely preferred by households exhibiting larger degrees of economies of scale should therefore be taxed less. When redistributive motives come into play, the correlation between preferences and individual welfare levels is an additional factor influencing the optimal tax structure. As inequality aversion increases, commodities more intensely preferred by people with lower welfare levels tend to be taxed less heavily, and this tendency is stronger when the correlation between preferences and welfare levels is higher.

We apply our model to the case of Benin, using a dataset of 19920 households to calibrate preference parameters. In the benchmark analysis we define 23 categories of goods for which we calculate optimal tax rates for six different values of the social welfare function's inequality aversion parameter (0; 0.5; 0.75; 1.25; 1.5; and 2). Our analysis focuses on the UN and WAEMU objective of 20% tax revenue to GDP ratio, but our framework is equally valid for an analysis of the tax structure by fixing the government budget to 14.5% of GDP, the value of 2015. We compare the individual welfare obtained in a baseline policy with that under optimal policies and provide a detailed distributional analysis of gains and losses. The baseline policy is defined using Benin's current tax policy structure, which includes a standard rate and a list of exempted goods. We construct 95%-confidence intervals by means of a bootstrap procedure.

Five empirical results stand out. First, when all goods can be taxed, we obtain a uniform tax rate of 11.7% with identical preferences as well as under preference heterogeneity with no inequality aversion and no within household economies of scale. Second, we quantify the effect of the presence of the non-taxable goods in isolation by applying the inverse elasticity rule. We find that starting from the uniform rate of 11.7%, the introduction of auto-consumption causes a tax differentiation ranging from 12.8 to 20% under identical preference. Third, the tax structure further changes significantly when we allow for preference heterogeneity. For instance, education which was taxed at the lowest rate under identical preferences is taxed at the tenth highest rate under preferences heterogeneity. Accounting in addition for the households economies of scale also affects the tax structure, but preference heterogeneity plays a dominant role on the optimal tax structure when inequality aversion increases. Fourth, we find that up to an inequality aversion level of 1.5, a statistically significant majority of the individuals would gain from switching to optimal taxes. On the contrary, optimal taxes for an inequality aversion level of 2 are rejected by a majority, though this result is not statistically significant at the 5% level. Fifth, we find winners and losers in all welfare deciles, due to preference heterogeneity within those deciles. Our results remain qualitatively unchanged when we restrict the number of possibly different tax rates.

Our paper is related to Bachas et al. (2023) who find that goods bought on the informal market are necessities while those bought on the formal market are luxuries.[6] As a result, they argue that formal market goods should be taxed highly if the government has redistributive preferences.[7] We contribute to this literature by characterising theoretically and quantitatively other channels to motivate indirect tax rate differentiation and their welfare impact. First, our theoretical result shows that, due to home production, optimal tax rates should differ across goods even if there is no desire for redistribution. Second, empirical observations motivate us to use heterogeneity in preferences rather than non-homotheticity to explain differences in expenditure behaviour. Not all expenditure shares of foods bought on the market are increasing with income. Moreover, we find that this preference heterogeneity has a larger impact on the optimal tax structure as inequality aversion increases.

The remainder of the paper is structured as follows. Section 2 provides background on the study. Section 3 contains our framework for optimal indirect tax analysis and Section 4 describes the data, the model calibration and the baseline policy. Section 5 discusses our theoretical and empirical results. The last section concludes. Additional data documentation, methodology, and further theoretical and empirical results are collected in the online Appendix.

[6] They assume that indirect taxation in developing countries is levied only in big shops and supermarkets, and not in small scale local shops, street stalls, at local markets, or on own production. As we do not have information on the place of transaction, we consider goods to be nontaxable only if they are not bought on the market (that is, received as gift or stemming from own production). In that sense we consider our figures for the share of nontaxable goods as a lower bound.

[7] de Quatrebarbes et al. (2016) provide a tax incidence analysis of VAT for Niger (one of the eight WAEMU countries) using a linkage between a Computable General Equilibrium model and a micro-simulation tool. This allows them to consider variable producer prices (generating incomplete pass-through of changes in the VAT-structure). However, such a modelling strategy only allows to capture the consequences of different arbitrarily predetermined tax scenario's. Our normative framework, on the contrary, allows to provide principles of optimal tax design.

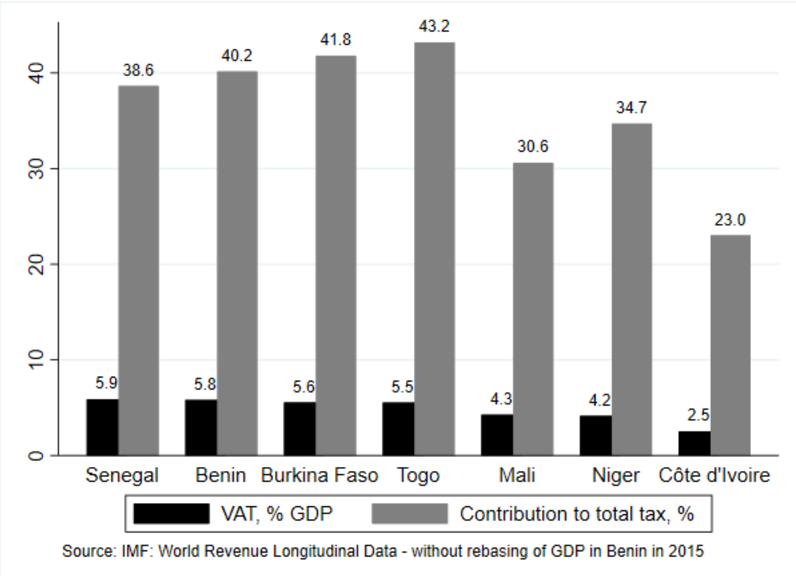
2 Background

We start with some background information on tax revenue and VAT policy in WAEMU (Section 2.1). Subsequently, we provide specific information on tax revenues in Benin (Section 2.2).

2.1 Tax policy and tax revenues in West Africa

In 2015, the ratio of tax revenues to GDP differs widely across WAEMU countries, from 11% in Côte d'Ivoire to 15% Senegal (See Figure A.1 in Appendix A). In most of the WAEMU member states, VAT was only established in the nineties with the exception of three countries (Côte d'Ivoire introduced VAT already in 1960; Senegal in 1980, and Niger in 1986).[8] After its introduction, VAT began to form a substantial part of total tax revenues in these countries. In 2015 VAT contributes between 23% (Côte d'Ivoire) to over 43% (Togo) of total tax revenue (see Figure 1).

Figure 1: VAT 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.

WAEMU is one of the economic areas in the world where fiscal coordination is the most advanced (Mansour and Rota-Graziosi, 2012). WAEMU countries also share a common currency, the CFA franc. The VAT coordination reform began in 1998 with a directive aiming to harmonise the VAT systems and tax policies in the area. According to the reform, each country must define a standard tax rate between 15% and 20%. All WAEMU countries adopted a standard rate of 18%, except for Niger where it is fixed at 19%. The use of a single rate combined with a list of exempted goods is a common feature of indirect tax policies in developing countries in Africa and Latin-America.[9]

[8] In Guinée-Bissau VAT was only introduced in 2023, replacing a sales tax.

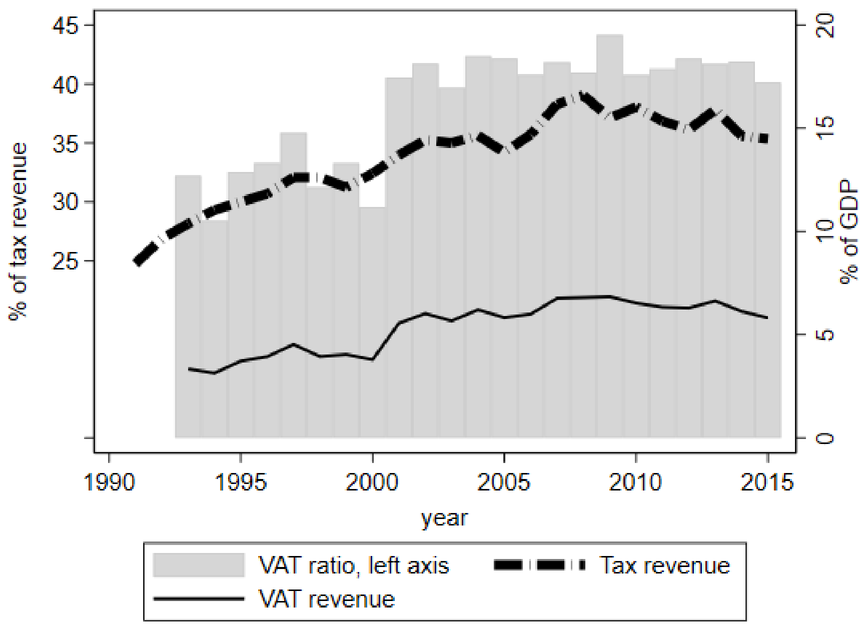
[9] In response to energy and food price shocks that hit the region in 2006-2008, WAEMU introduced in 2009 a reform that allowed countries that wish, to apply reduced rates between 5 and 10% on a restricted list of goods and services (Directive N° 02/2009/CM/UEMOA). Thus the following countries applied reduced rates: Burkina Faso (2020), Côte d'Ivoire (2021), Mali (2011), Niger (2018), and Senegal (2011), whereas Benin continues to apply a single rate (Table A.1 of Appendix A). See Thorton's international Indirect Tax Guide:
https://www.grantthornton.global/en/insights/indirect-tax-guide/international-indirect-tax-guide/.

The WAEMU fiscal directives composed a list of goods that should be exempted from VAT for reasons of equity and poverty alleviation (Mansour and Rota-Graziosi, 2012). At the national level, other goods and services were added to this list.

2.2 Tax revenue and VAT policy in Benin

Figure 2 shows that tax revenue has increased in Benin from less than 10% in 1990 to 14.5% in 2015.[10] The improvement of tax collection in Benin coincided with the introduction of VAT in 1991. The introduction of VAT took place in the context of the structural adjustment program following financial and political crises that the country experienced in the late 1980s. Next to the international coordination of VAT policies, also the weak capacity of the tax administration motivated the choice for one standard rate, fixed at 18%. Its scope covers services such as telecommunication, large part of housing utilities and maintenance, housing furnishings and equipment, clothing and footwear, and a number of food items. The list of exempted goods in Benin includes: education and health services, domestic consumption of electricity and gas, books, mainly non-manufactured agricultural products, housing rents, and non-alcoholic beverages.[11]

Figure 2: Tax and VAT revenues in Benin



Note: Data from the Institut National de la Statistique et de l'Analyse Economique (INSAE) and the Direction Générale des Impôts et des Domaines (DGID).
The black dashed and full lines represent respectively the total tax revenues and VAT revenues to GDP ratio's, to be read off from the right vertical axis. The bars represent the VAT revenues to total tax revenues ratio (on the left vertical axis).

Like in other WAEMU countries, also in Benin VAT exemptions cause a gap between potential (the standard VAT rate times final consumption) and actual tax revenues, the so-called C-efficiency (Houssa et al., 2017,

[10] From 2016 to 2019 it evolved as follows: 12.5%, 13.2%, 14.0%, and 14.5%, respectively. Data stem from the Direction Générale de l'Economie (DGE), but GDP data were re-scaled such that there was no rebasing. *Rebasing* refers to the practice of the statistical authorities of many African countries, to revise retrospectively historic GDP figures in an attempt to include more items from mainly informal sectors, and coming this way closer to the standards of OECD countries.
[11] In Section C.1 of Appendix C we provide a complete list of goods and services that are exempted in Benin in 2015.

Banque Mondiale, 2018). Banque Mondiale (2018) argues that the erosion of VAT performance from 2014 onward in Benin results, among other things, from the increase in the number of exempted goods. Nevertheless, these exemptions serve at first glance social objectives. But actually, exempt items are consumed by both rich and poor households. Little quantitative analysis of the actual welfare implications of the exemption policy is available.

In 2017, the government adopted a Strategic Orientation Plan for Tax Administration[12] intended to modernise the tax administration and improve the mobilisation of internal resources. The most important reform in the field of VAT collection is the introduction of the standardised invoice since 2021, making use of electronic invoicing machines. The reform is part of a broader government reform agenda to digitise access to public services. In practice, however, the government cannot tax goods purchased from the informal sector or those derived from own production.

3 An optimal indirect tax approach

This section sets out the model employed to analyse optimal indirect tax policies from a welfare theoretical point of view. We start from a classical many-person Ramsey model of optimal indirect taxation (Ramsey, 1927, Diamond, 1975). Section 3.1 introduces notation and the assumptions of the underlying market model. Section 3.2 discusses principles of optimal taxation following from the social welfare framework.

3.1 Notation and assumptions

A society is composed of H households, indexed by $h = 1, 2, \ldots, H$. A household h consists of n_h members. There are $N \equiv \sum_{h=1}^{H} n_h$ individuals in society. Individuals are indexed by $i = 1, \ldots, N$. The vector of quantities of commodities consumed by a household h is denoted by $\mathbf{x}_h$. There are G commodity groups, indexed by g. Each commodity group g consists of a variety which is available on the market, denoted by g, m, and a variety that is produced by the household, denoted by g, a. We will use s as an index that runs over a and m. The consumption vector of household h can be partitioned as follows: $\mathbf{x}_h \equiv (\mathbf{x}_{m,h}, \mathbf{x}_{a,h})$ with $\mathbf{x}_{m,h} = (x_{1,m,h}, x_{2,m,h}, \ldots, x_{g,m,h}, \ldots, x_{G,m,h})$, being the vector of goods and services bought on the market, and $\mathbf{x}_{a,h} \equiv (x_{1,a,h}, x_{2a,h}, \ldots, x_{g,a,h}, \ldots, x_{G,a,h})$ the vector of auto-consumption.

Producer prices are fixed and normalised to one. So, they are independent of taxes, and quantities $x_{g,s,h}$ are measured in monetary terms, at producer prices. The assumption of fixed producer prices can be rationalised by supposing all producers operate a constant returns to scale technology with only one non-produced production factor, labour time. Only commodities bought on the market can be taxed. The vector of *ad valorem* indirect tax rates is denoted by $\mathbf{t} = (t_1, t_2, \ldots, t_g, \ldots, t_G)$.[13] Given the producer price normalisation, consumer market prices, $\mathbf{q}_m :- (1 + \mathbf{t})$, equal $(1 + t_1, 1 + t_2, \ldots, 1 + t_g, \ldots, 1 + t_G)$.

[12] The POSAF (Plan d'Orientation Stratégique de l'Administration Fiscale) covered the period 2017-2021. In 2022 the second POSAF plan was launched for the 2022-2026 period.

[13] Indirect taxes are assumed to be linear: the tax bill is a proportion of the amount spent on a particular good. Nonlinear indirect taxes are not easily implementable, as the amount expended to different goods is not easily observed. Nonlinear indirect taxes would easily lead to evasion by splitting or joining purchases.

The auto–consumption counterpart is: $\mathbf{q}_a = (\underbrace{1, \ldots, 1}_{G \text{ times}})$. The overall consumer price vector is denoted by $\mathbf{q} \equiv (\mathbf{q}_m, \mathbf{q}_a)$. Finally, $\mathbf{q}_g$ collects the market and auto–consumption variety consumer price of a commodity g: $\mathbf{q}_g = (q_{g,m}, q_{g,a}) = (1 + t_g, 1)$.

Expenditure on a good g, m equals $(1 + t_g)\, x_{g,m,h} = q_{g,m} x_{g,m,h}$, while for auto–consumption expenditure is valued at producer price and thus coincides with quantity. In general, expenditures by household h on a good g, s $(s = m, a)$, denoted by $w_{g,s,h}$, thus equal $q_{g,s} x_{g,s,h}$. Total household expenditures equal $\mathbf{q}'\mathbf{x}_h = \mathbf{q}'_m \mathbf{x}_{m,h} + \mathbf{q}'_a \mathbf{x}_{a,h} = \mathbf{q}'_m \mathbf{x}_{m,h} + \sum_g x_{g,a,h}$, and the household's indirect tax bill equals $\sum_{g=1}^{G} t_g x_{g,m,h}$. Household h's total expenditure is denoted by y_h and is assumed to be fixed. It will also be called disposable income in the sequel. It includes the value of auto-consumed goods, as these goods stem from own production and thus can alternatively be used to generate revenue. Consequently, $y_h = \mathbf{q}'\mathbf{x}_h$. The budget share spent on good g is $\alpha_{g,h} = \frac{(1+t_g) x_{g,m,h} + x_{g,a,h}}{y_h}$.

The assumption of fixed total expenditures can be motivated by the fact that we analyse indirect taxation keeping income taxes fixed.[14] Since we concentrate on the effects of indirect taxes, which distort relative prices of commodities, we want to be able to separate the individual welfare effects of redistribution of incomes, *e.g.* through direct taxes, from the redistributive impacts of commodity price changes. To do so, we assume preferences are homothetic. This assumption indeed results in a welfare measure which is equal to income divided by a price index, as we will see. Differences in consumption patterns across households are assumed to be accredited to differences in preferences (shape of indifference curves) instead of being the consequence of attaining different indifference curves from a common underlying indifference map, due to income differences.

To keep efficiency considerations simple, no cross price effects between any pair of goods g and g' are allowed for. This implies that expenditure shares of commodities, previously defined as $\alpha_{g,h}$, are assumed to be fixed, but they are allowed to be household specific. Within each commodity group g, the market and auto-consumption variety are assumed to be imperfectly substitutable. We impose this substitution elasticity between market and auto-consumption varieties to be common for all goods and households, and it is denoted by σ. Households may, however, exhibit a relatively more intense preference for the market or auto-consumption variety of a commodity g. This brings us to a nested preference structure where the upper layer captures the allocation of the global budget across commodity groups g. It is assumed to be of the Cobb-Douglas (CD) type, with household specific share parameters $\alpha_{g,h}$. Within each commodity group g, a Constant Elasticity of Substitution (CES) aggregator captures the household specific preference intensity over the market and auto-consumption variety of that good. As such, preferences can be represented by the

[14] Even then, of course, labour supply, and, therefore, income and total expenditures need not be independent of the indirect tax structure. The key assumption to separate the labour supply decision from the allocation of total expenditures on goods, is weak separability of preferences between leisure and commodities. In a landmark paper on optimal taxation, Atkinson and Stiglitz (1976) showed, however, that under this assumption, indirect taxation is redundant if you have optimal direct taxes. Their findings entailed a whole literature investigating which modifications of the Atkinson-Stiglitz model would break down this result. Heterogeneity of preferences and non-taxability of some goods turn out to be two of such elements. Therefore, the assumption of weak separability of preferences between leisure and commodities, which is key to isolate the implication of those two factors for the optimal indirect tax structure, does not make indirect taxation redundant in our model.

following utility function[15]:

$$u_h^{\text{CCD}}(\mathbf{x}) = \prod_g \left(\sum_s \delta_{g,s,h}^{1-\rho} x_{g,s}^{\rho} \right)^{\frac{\alpha_{g,h}}{\rho}}, \tag{1}$$

where the $\alpha_{g,h}$'s are the Cobb–Douglas share parameters, and equal household h's expenditure shares of the commodities g; the $\delta_{g,s,h}$'s are household and commodity specific distribution parameters indicating the relative intensity of preference for the s variety of good g. They are normalised such that $\sum_s \delta_{g,s,h} = 1$. The ρ-parameter equals $\frac{\sigma-1}{\sigma}$, with $\sigma \in [0, \infty)$ and $\rho < 1$.

The resulting Marshallian demand functions equal:

$$d_{g,s,h}^{\text{CCD}}(\mathbf{q}_g; y) = \frac{\alpha_{g,h}\delta_{g,s,h} y}{\phi_{g,h}(\mathbf{q}_g)^{1-\sigma} q_{g,s}^{\sigma}}, \tag{2}$$

where $\phi_{g,h}(\mathbf{q}_g) = \left(\sum_s \delta_{g,s,h} q_{g,s}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$, is a CES price index.

The indirect utility function associated with the utility function (1) is equal to:

$$v_h^{\text{CCD}}(\mathbf{q}, y) \quad := \quad u_h^{\text{CCD}}\left(d_{g,s,h}^{\text{CCD}}(\mathbf{q}_g; y); s = a, m; g = 1, \ldots, G\right) = y \prod_g \left(\frac{\alpha_{g,h}}{\phi_{g,h}(\mathbf{q}_g)}\right)^{\alpha_{g,h}}. \tag{3}$$

3.2 Welfare and optimal taxes

We start by defining the metric we use to measure individual welfare. Then we discuss the social welfare function and optimal tax rules. We next give a detailed decomposition analysis of the social welfare weights embodied in the social welfare function. We then derive a set of jointly sufficient conditions under which uniform taxes are optimal. We finally characterise the principles of optimal tax rate differentiation when the conditions for uniform taxes are not met.

Individual welfare

Following the renewed justification of money metric utilities (Fleurbaey, 2011, Fleurbaey and Blanchet, 2013), we use a member of this class of utility functions to measure individual welfare. A Money Metric Utility (MMU) is the amount of money a household would need when confronted with a set of reference prices, $\mathbf{q}_{\text{ref}}$, in order to be able to guarantee its members the same welfare as under the actual or counterfactual price regime $\mathbf{q}$ and given the actual or counterfactual income y. In Appendix B.1 we derive that the MMU-class corresponding to the CES-CD preferences defined in Equation (1) equals:

$$MMU_h^{\text{CCD}}(\mathbf{q}, y; \mathbf{q}_{\text{ref}}) \equiv c_h^{\text{CCD}}(\mathbf{q}_{\text{ref}}; v_h^{\text{CCD}}(\mathbf{q}, y)) = y \prod_g \left(\frac{\phi_g(\mathbf{q}_{\text{ref},g})}{\phi_g(\mathbf{q}_g)}\right)^{\alpha_g}. \tag{4}$$

Up to now we were somewhat loose about the distinction between households and their members. At the theoretical level, preferences and welfare are individual characteristics. However, in practice we only observe

[15] The nested CES specification of preferences was first introduced by Keller (1976). In our case, the upper nest is of the CD-type.

consumption at the household level. We follow the by now classical approach in welfare analysis to bridge this gap between households and individual household members by assuming that all household members have identical preferences and obtain the same welfare level, but that there are some economies of scale within the household to produce welfare for its members. The estimation of the extent of such economies of scale is the subject of the construction of an equivalence scale, which is a function that produces the amount θ_h by which household income y has to be divided such that a single with income y/θ_h can obtain the same welfare as the household members. This equivalence scale depends on the number of household members and, possibly, other characteristics, such as age, of the household members.[16] Consequently, an individual welfare measure for an individual i in household h, denoted by i_h, can be obtained by:

$$m_{i_h}^{\text{CCD}}\left(\mathbf{q}, y; \mathbf{q}_{\text{ref}}\right) = \frac{MMU_h^{\text{CCD}}\left(\mathbf{q}, y; \mathbf{q}_{\text{ref}}\right)}{\theta_h} = \frac{y}{\theta_h}\frac{\Phi_h\left(\mathbf{q}_{\text{ref}}\right)}{\Phi_h\left(\mathbf{q}\right)}, \tag{5}$$

with $\Phi_h\left(\mathbf{q}\right) = \prod_g \left(\phi_{g,h}\left(\mathbf{q}_g\right)\right)^{\alpha_{g,h}}$, a CES-CD price index. Notice that $m_{i_h}^{\text{CCD}}\left(\mathbf{q}, y; \mathbf{q}_{\text{ref}}\right)$ is identical for all household members i_h, so that we will also write $m_h^{\text{CCD}}\left(\mathbf{q}, y; \mathbf{q}_{\text{ref}}\right)$ to denote the same function.

Equation (5) is the amount of money an individual i_h would need to buy the required consumption goods at reference prices $\mathbf{q}_{\text{ref}}$, in order to be equally well-off as (s)he is in the actual situation within the household h to which (s)he belongs. As such, it is a utility measure, that is, a numerical representation of preferences. One can interpret this measure also as real equivalised disposable income, because it is equivalised disposable income divided by a price index. This is a common feature of the class of homothetic preferences. It allows to distinguish neatly the individual welfare effects of redistributing incomes, *e.g.* through direct tax reforms, from the effects of commodity price changes, the latter running exclusively through the price index.[17]

Equation (5) shows that household disposable income affects individual welfare positively in a linear way. This is due to homotheticity of preferences and the choice of a welfare measure expressed in monetary units. The equivalence scale affects individual welfare negatively. Finally, welfare is decreasing in the prices. The price index is household specific, as it depends on the preference parameters $\alpha_{g,h}$ and $\delta_{g,s,h}$. A combination of a tax lift on one good with a decrease on another –keeping government revenues constant– may be detrimental to someone relatively more intensely preferring the good on which the tax has been raised, but the opposite might hold for someone more intensely preferring the good on which the tax has been decreased. Intensity of preferences in this model depends on the relative value of $\alpha_{g,h}$ versus $\alpha_{g',h}$'s and of $\delta_{g,s,h}$ versus $\delta_{g',s',h}$.

[16] We do not integrate here the recent trend to model within household inequalities by means of a collective bargaining model (see part I of Browning et al., 2014 for a review of that literature and Chiappori, 2016 for the implications with respect to the notion and use of equivalence scales). Bargain and Donni (2014) provide an optimal indirect tax exercise within a collective household framework.

[17] It is important to stress that the choice of reference prices in this measure does affect the ranking of individuals in terms of welfare. It does not affect, however, intra-personal comparisons. Certain interpersonal comparisons are also independent of the choice of reference prices. For example, suppose i_h is better off or equally well-off as $j_{h'}$ in situation A, $j_{h'}$ is not better off in situation B than in situation A, and i_h is at least as well-off in B than in A. In that case, the welfare difference between i_h and $j_{h'}$ is at least as large in B as in A, irrespective of the choice of reference prices. Moreover, this difference has become larger if at least one of the intra-personal comparisons between A and B in the premises, is strict. In order to neutralise somewhat the influence of reference prices, we will uniquely consider the case where all reference prices are equal to one (denoted by $\mathbf{q}_{\text{ref}} \equiv \mathbf{1}$). In this way $\Phi_h\left(\mathbf{q}_{\text{ref}}\right) = 1$ for all households, and no particular preference ordering is (dis)advantaged by the choice of the reference prices.

Social welfare and optimal taxes

Optimal indirect taxes maximise social welfare subject to a government budget fixed to $\bar{R}$. We use the Atkinson-Kolm-Sen social welfare function (see e.g. Adler, 2019):

$$SWF = \sum_h n_h \frac{\left(m_h^{\text{CCD}}\left(\mathbf{q}, y_h; \mathbf{1}\right)\right)^{1-e}}{1-e}, \tag{6}$$

with $e \geq 0$. The parameter e is known as inequality aversion parameter. When $e = 0$, we obtain the utilitarian case, that is a simple sum of individual utilities.[18] When $e \to \infty$, we obtain either the Rawlsian maximin case or its lexicographic extension (see Hammond, 1975).

Notice that social welfare is a function of the indirect tax rates and the distribution of total expenditures (or incomes), $\mathbf{y} \coloneqq (y_1, y_2, \ldots, y_h, \ldots, y_H)$. We will make this explicit by writing:

$$W\left(\mathbf{t}; \mathbf{y}\right) = \sum_h n_h \frac{\left(m_h^{\text{CCD}}\left(\left(1+\mathbf{t}, \mathbf{q}_a\right), y_h; \mathbf{1}\right)\right)^{1-e}}{1-e} = \sum_h \frac{n_h}{1-e} \left(\frac{y_h}{\theta_h \cdot \Phi_h\left(1+\mathbf{t}, \mathbf{q}_a\right)}\right)^{1-e}. \tag{7}$$

The government budget equation is equal to:

$$R\left(\mathbf{t}; \mathbf{y}\right) = \sum_g t_g \sum_h d_{g,m,h}^{\text{CCD}}\left(\left(1+t_g, 1\right); y_h\right) = \sum_g t_g \sum_h \frac{\alpha_{g,h} \delta_{g,m,h} y_h}{\phi_{g,h}\left(\left(1+t_g, 1\right)\right)^{1-\sigma} \left(1+t_g\right)^{\sigma}}, \tag{8}$$

where it is taken into account that only market varieties can be taxed.

Optimal indirect taxes are then the solution to the following problem:

$$\max_{\mathbf{t}} \; W\left(\mathbf{t}; \mathbf{y}\right) \qquad \text{s.t.} \quad R\left(\mathbf{t}; \mathbf{y}\right) \geq \bar{R}. \tag{max}$$

The (necessary) first order conditions of maximisation problem (max) are:

$$\lambda = -\frac{\partial W / \partial t_g}{\partial R / \partial t_g}, \text{ for all } g, \tag{9}$$

with λ being the Lagrange multiplier associated with the government budget restriction (A.10). In order to interpret the first order conditions of this maximisation problem, we introduce the concept of the marginal social welfare cost of raising an additional CFA franc by increasing the tax on commodity g, m. Following Ahmad and Stern (1984) this cost can be shown to be equal to:

$$MC_{g,m}\left(\mathbf{t}; \mathbf{y}\right) = -\frac{\partial W / \partial t_g}{\partial R / \partial t_g} = \frac{\sum_h \beta_h\left(\mathbf{t}\right) d_{g,m,h}^{\text{CCD}}\left(\left(1+t_g, 1\right), y_h\right)}{\sum_h \left(d_{g,m,h}^{\text{CCD}}\left(\left(1+t_g, 1\right), y_h\right) + t_g \left(\partial d_{g,m,h}^{\text{CCD}}\left(\left(1+t_g, 1\right), y_h\right) / \partial q_{g,m}\right)\right)}. \tag{10}$$

The numerator of this equation is the effect on social welfare of a marginal increase of the tax on commodity g, m. It is a weighted sum of individual consumption of commodity g, m. The weights $\beta_h\left(\mathbf{t}\right)$ are known as marginal social welfare weights. We will discuss these weights more in detail in the next para-

[18] When $e = 1$, $SWF = \sum_h n_h \ln\left(m_h^{\text{CCD}}\left(\mathbf{q}, y_h; \mathbf{1}\right)\right)$.

graph. The denominator of Equation (10) contains the effect on government revenues of such a marginal change in t_g. This denominator is lower, the higher own prices elasticities of demand are in absolute value. Indeed, the more an increase of the VAT tariff on a particular good reduces the demand for that good, the less revenues will increase, and thus the higher the social welfare cost will be.[19] A change in the tax rate t_g by $(\partial R/\partial t_g)^{-1}$, increases the government budget with one CFA franc. Consequently, the marginal social welfare cost $MC_{g,m}(\mathbf{t};\mathbf{y})$ is the effect on social welfare of raising an additional CFA franc through an increase of t_g.

If the marginal social welfare costs of two goods are unequal, social welfare can be increased as follows. Decreasing the tax rate of the good g, m with higher $MC_{g,m}(\mathbf{t};\mathbf{y})$ by $(\partial R/\partial t_g)^{-1}$, and simultaneously increasing the tax rate on commodity g', m by $(\partial R/\partial t_{g'})^{-1}$, leaves government revenues unchanged by construction. But the social welfare loss of increasing the tax rate $t_{g'}$, equalling $MC_{g',m}(\mathbf{t};\mathbf{y})$, is less than the gain from decreasing the rate t_g, with the initially higher social welfare cost $MC_{g,m}(\mathbf{t};\mathbf{y})$. It follows that in an optimum, tax rates, $\mathbf{t}^*$, should be such that the marginal social welfare costs of all taxable goods are equal:

$$\lambda = MC_{g,m}(\mathbf{t}^*;\mathbf{y}), \quad \text{for all } g. \tag{11}$$

Social welfare weights

Using Roy's identity, it can be derived from Equation (7) that:

$$-\frac{\partial W}{\partial t_g} = \sum_h n_h \left(m_h^{\text{CCD}}\left(\left((1+\mathbf{t}),\mathbf{q}_a\right), y_h; \mathbf{1}\right)\right)^{-e} \frac{\partial m_h^{\text{CCD}}}{\partial y_h} d_{g,m,h}^{\text{CCD}}\left((1+t_g,1), y_h\right). \tag{12}$$

Comparing Equation (12) with the numerator of Equation (10), one can see that the marginal social welfare weights are equal to:

$$\beta_h(\mathbf{t}) \quad = \quad \frac{\partial W}{\partial y_h} \quad = \quad \underbrace{\left(\frac{y_h/\theta_h}{\Phi_h\left(\left((1+\mathbf{t}),\mathbf{q}_a\right)\right)}\right)^{-e}}_{A} \underbrace{\frac{1}{\Phi_h\left(\left((1+\mathbf{t}),\mathbf{q}_a\right)\right)}}_{B} \underbrace{\frac{n_h}{\theta_h}}_{C}. \tag{13}$$

In line with Ray (1999), and contrary to many exercises of this type (as *e.g* in Saez and Stantcheva, 2016, and Bachas et al., 2023), we will fully take into account that these marginal social welfare weights are not only a function of income y_h, but depend also on the tax rates. Their values are therefore endogenous in the optimisation problem (max). These marginal social welfare weights contain three components. The first component (A) embodies the *equity* concerns built into the shape of the social welfare function and indicates the additional social welfare following a marginal increase in the individual welfare of a representative individual of household h. It depends on the degree of inequality aversion e. When $e > 0$ more weight is given to households whose members have a low level of individual welfare. In the utilitarian case ($e = 0$)

[19] There are no cross price effects between market goods in the Marshallian demands of our individual behavioural model. If there were, gross substitutes of the considered commodity g, increase the denominator and thus reduce the marginal social welfare cost. The reverse holds for gross complements.

this component vanishes: raising the welfare of any individual with one unit raises social welfare with one unit irrespective whether this individual has a high or low initial welfare level.

One cannot, however, transfer *welfare* from one individual to another. Only (monetary) resources can be redistributed. Parts B and C capture the *efficiency* with which a household h can transform an additional amount of money into individual welfare for its members. This depends on the tastes of the household members, captured by component B, and the degree to which the additional resources can simultaneously increase the individual welfare of several household members (component C). Component B will lower the welfare weight of households who's members more intensely prefer relatively more expensive goods.[20] Component C refers to the degree to which a household can serve a welfare improvement for relatively more individual members, with the same additional amount of money. We interpret the term n_h/θ_h as a measure of relative advantage from economies of scale within the household.

The price index $\Phi(\mathbf{q})$ and the equivalence scale θ_h occur in both, the equity component (A) and the efficiency components (B and C) of the marginal social weights. Their impact has, however, an opposite sign in these components: a higher price index or equivalence scale increases the social weight through its equity component (as it reduces the welfare measure and people with lower welfare get higher weight in the welfare function) while it decreases the weights through the efficiency components (as a higher price index or equivalence scale decreases the effect on welfare of an additional CFA). The (positive) equity effect dominates the (negative) efficiency effect if $e > 1$.[21]

When is a uniform rate optimal?

In our model, uniform optimal taxation of all goods (including auto-consumption varieties) amounts to a lump sum tax as total expenditure (disposable income) is exogenously given.[22] We start by investigating under which cases a uniform tax rate on all goods will be optimal (that is maximising social welfare). The rule that the marginal social welfare costs should be equal for all goods in an optimum (Equation 11) remains valid when all goods can be taxed, and irrespective of the individual welfare measure that is used, as long as it is a representation of preferences. We therefore rewrite the marginal social welfare cost formula (10) slightly for the more general case where also auto-consumption can be taxed[23]:

$$MC_{g,s}(\mathbf{t}) = \frac{\sum_h \beta_h(\mathbf{t})\, s_{g,s,h}(\mathbf{q};\mathbf{y})}{1+\sum_{j,r} t^*_{j,r} \sum_h \epsilon^h_{jr,gs}(\mathbf{q}, y_h)\, \frac{b_{j,r,h}(\mathbf{q};y_h)}{\sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})}}, \tag{14}$$

with $s_{g,s,h}(\mathbf{q};\mathbf{y})$ household h's consumption share of commodity g,s in the total consumption of that commodity, $s_{g,s,h}(\mathbf{q};\mathbf{y}) := d_{g,s,h}(\mathbf{q};y_h) / \sum_{h'} d_{g,s,h'}(\mathbf{q};y_{h'})$; $\epsilon^h_{jr,gs}(\mathbf{q};y_h)$ is the cross price elasticity of demand for commodity j,r with respect to the price of commodity g,s; $b_{g,s,h}(\mathbf{q};y_h)$ is the expenditure of household h on commodity g,s, that is $b_{g,s,h}(\mathbf{q};y_h) := (1+t_{g,s})\, d_{g,s,h}(\mathbf{q};y_h)$; and $t^*_{j,r} = t_{j,r}/(1+t_{j,r})$ is the tax rate

[20] Again, mind that the degree to which a good is relatively more expensive than another, depends on the tax rate in our model, and is therefore endogenous.

[21] For the equivalence scales, this ambivalence was already highlighted by Decoster (1988), Glewwe (1991), and Ebert (1997).

[22] In a model with a direct tax component and no other income than labour income, *uniform* indirect taxation is tantamount to saying that indirect taxation is redundant, as uniform indirect taxes are equivalent with a proportional tax on labour income.

[23] By a slight abuse of notation the argument of $MC_{g,s}$ is now a vector of length $G \times 2$ in stead of G.

expressed as a percentage of the consumer price.[24]

We now investigate under which conditions a uniform rate causes these marginal social welfare costs to be equal for all goods (market varieties and auto-consumption). We distinguish between two cases. First, preferences are homothetic and identical across all individuals. Second, the marginal social welfare weights $\beta_h(\mathbf{t})$ are identical for all households. Under homothetic and identical preferences, it can be shown that $s_{g,s,h}(\mathbf{q};\mathbf{y}) = y_h / \sum_{h'} y_{h'}$, and therefore independent of the specific good g, s. So the numerator of the marginal social welfare cost formula (14) is independent of the specific commodity g, s, irrespective of the value of the tax vector $\mathbf{t}$. Under a uniform rate t on all goods (including auto-consumption), the denominator is also good independent and can be shown to be equal to $(1+t)^{-1}$.[25] As a result, the marginal social welfare cost (14) reduces to:

$$MC_{g,s}((t,\ldots,t)) = (1+t)\sum_h \beta_h(t,\ldots,t)\frac{y_h}{\sum_{h'} y_{h'}}, \tag{15}$$

which is independent of the good g, s. Therefore, a uniform rate is optimal under homothetic and identical preferences. It is important to stress that this result holds for any degree of inequality aversion, and irrespective of differences in efficiency of the households to convert income into welfare (reflected in the B and C parts of the marginal social welfare weights, defined in Equation 13).

Turn now to the second case. When the β_h's are equal for all households (say β), the numerator of the marginal welfare costs Equation (14) reduces to $\beta(\mathbf{t})$, which is commodity independent. As in the previous case, the denominator under a uniform rate on all goods equals $(1+t)^{-1}$. So, when marginal social welfare weights are equal across households the marginal social welfare costs under uniform taxation are equal to:

$$MC_{g,s}(\mathbf{t};\mathbf{y}) = (1+t)\,\beta(t,\ldots,t), \tag{16}$$

and so they are equal across goods and thus uniform taxation is optimal (see also Stern, 1987, p.85).

Under what conditions are the marginal social welfare weights equal for all households? From equation (13) one can see that we could get rid of the equity component (part A) by putting inequality aversion e equal to zero. But this is not enough. Indeed, the B- and C-components remain household specific even when $e = 0$. Assume therefore in addition that all households exhibit the same degree of economies of scale. This is, for example, the case when the household equivalence scale θ_h equals the household size n_h. Then we are left with the B-component. When all goods can be taxed, and there is a uniform tax rate t, the term $\Phi_h(\mathbf{q})$ is, however, equal to $1+t$ for all households. But the B-component is income independent only because of the assumption of homothetic preferences.[26] We can conclude that the marginal social welfare weights are household independent and therefore uniform taxation is optimal, even in the presence of preference heterogeneity, when the following set of (sufficient) conditions are jointly satisfied:

- absence of any inequality aversion ($e = 0$);

[24] Notice that $s_{g,s,h}(\mathbf{q};\mathbf{y}) = b_{g,s,h}(\mathbf{q};y_h) / \sum_{h'} b_{g,s,h'}(\mathbf{q};y_{h'})$.
[25] Details of the derivation can be found in Appendix B.3.
[26] Generically, this term equals $(\partial c_h(\mathbf{q}_{ref}; v_h(\mathbf{q},y_h))/\partial U)\cdot(\partial v_h(\mathbf{q},y_h)/\partial y)$, and it may well depend on household income y_h.

– all goods (including auto-consumption varieties) can be taxed and preferences are homothetic;

– absence of economies of scale ($n_h = \theta_h$).

Differentiated optimal tax structures

We begin by examining the implications of relaxing the assumption that all goods can be taxed, while maintaining the assumption of identical and homothetic preferences. In Appendix B.4 we derive the following optimal tax rule for that case:

$$\frac{t_g}{1+t_g} = \frac{\gamma}{\epsilon^{\text{CCD}}_{gm,gm}\left(t_g\right)}, \tag{17}$$

where $\epsilon^{\text{CCD}}_{gm,gm}\left(t_g\right)$ is the own price elasticity of the market variety of commodity g and γ is a scalar. Equation (17) is the inverse elasticity rule: optimal taxes are inversely proportional to (own) price elasticities.[27]

When preferences are heterogeneous, the corresponding equation, derived in appendix B.4, is:

$$\frac{t_g}{1+t_g} = \frac{1}{\sum_h \epsilon^{\text{CCD},h}_{gm,gm}\left(t_g\right) s^{\text{CCD}}_{g,m,h}\left(\mathbf{q};\mathbf{y}\right)} \frac{\sum_h \beta_h\left(\mathbf{t}\right) s^{\text{CCD}}_{g,m,h}\left(\mathbf{q};\mathbf{y}\right) - \lambda}{\lambda}, \tag{18}$$

where $s^{\text{CCD}}_{g,m,h}\left(\mathbf{q};\mathbf{y}\right) = \frac{d^{\text{CCD}}_{g,m,h}(\mathbf{q};y_h)}{\sum_{h'} d^{\text{CCD}}_{g,m,h'}(\mathbf{q};y_{h'})}$, that is household h's consumption share of commodity g, s in the total consumption of that commodity according to the CES-CD demand functions.

The first factor on the RHS of this equation is reminiscent of the inverse elasticity rule. In the second factor the numerator of the marginal social welfare cost (Equation 10) reappears. Consequently, the A, B, and C-components of the welfare weights discussed earlier play each their role. As far as the B-component is concerned, recall that it is the inverse of a household specific consumption price index. This index is lower for households more intensely preferring the cheaper, that is the non-taxed variety of each commodity. Marginal social welfare weights are therefore higher for households predominantly liking the (nontaxable) auto-consumption varieties of goods (B-component). Bachas et al. (2023) argue that especially poorer households spend larger part of their budget on nontaxable goods. In our empirical analysis we find that for some commodities the richer households spend larger part of their budget on the auto-consumed variety than the poorer. In the absence of inequality aversion, government's optimal policy might then turn out to be advantageous for the richer households. When the government would become more inequality averse (that is, the A-component comes into play), the distributive motive and the efficiency parts of the welfare weights partially conflict with each other. The C-component (household economies of scale) plays a similar role as the B-component: goods particularly liked by households exhibiting larger economies of scale should be taxed lower. In the application below in Section 5.1 we isolate quantitatively the impact of each of these factors on the optimal tax rates and structure.

[27] We stress, however, that the elasticities generally depend on the tax rates and are therefore endogenous variables.

4 Data, model calibration, and baseline policy

4.1 Data

We use the Benin Enquête Modulaire Intégrée sur les Conditions de Vie des Ménages (EMICoV) of 2015, collected by INSAE. It is based on a representative sample covering households from the 77 administrative communes in Benin, including both rural and urban areas. The sample consists of 21409 households. It includes information on a wide range of household characteristics and on expenditures on goods and services. After cleaning the data we end up with a sample of 19920 households.[28]

Expenditure data are collected partly on a recall basis (with variable term, depending on the commodity). These data were recorded at the lowest level of aggregation according to the COICOP classification.[29] We only take into account expenditure on non-durable goods and services.[30] At the most detailed level of aggregation, 854 non-durable goods and services were distinguished. For each record of expenditures, it is indicated in the data whether this commodity was bought on the market, obtained from productive activities within the household, received as a gift, or acquired with the purpose to make a gift to others. It is this information which served to distinguish between market varieties (bought for own consumption or with the purpose of making a gift) and auto-consumption varieties (stemming from own produce or received as a gift) of a given good.[31] So, we have in principle for each of the 854 commodities a market variety and an auto-consumption variety (see Section 3.1 for the distinction between market and auto-consumption varieties in our theoretical model).

Using information from the fiscal laws, we coded for each of the 854 market varieties of the commodities whether they were liable to the 18% VAT rate in 2015. So the 854 commodities were subdivided into a class which is exempted, and a class which is taxed. Then, we aggregate goods within each of these two sets into broader categories. This was mainly done along the lines of the two-digit COICOP-classification (which distinguishes between 12 broad commodity groups). For example, *Transport* is such a broad commodity group. But within that broad category we distinguish goods that were liable to VAT in 2015 and those that were exempt. Some of these aggregates, however, contained only taxed commodities (for example *Clothing and footwear*), or only exempted ones (*Health*).

Furthermore, for food commodities we constructed a non-conventional categorisation. On the basis of inspection of the pattern through the welfare distribution of budget shares and shares in total consumption of particular goods, we made a subdivision between ‘poor’ and ‘rich’ foods. The budget shares of the former ones are largely displaying a decreasing course through the welfare distribution, while that of the latter tend to increase with welfare. In this way, we want to exploit patterns of correlation between welfare levels

[28] For some households we lack data on expenditures or household characteristics.

[29] COICOP (Classification of Individual Consumption according to Purpose) is an international standard for classifying consumption goods, maintained under the authority of the United Nations Statistics Division (UN, 2018).

[30] Durable goods expenditures are too irregular to be captured accurately given the recall period of the survey and such goods yield services over a longer period than the one year period that forms the scope of our analysis.

[31] Bachas et al. (2023) use for Benin the same survey as we do. They make the split between informal and formal consumption on the basis of the type of store in which the good was bought, assuming that in small shops and on local markets, no VAT is charged. We do not dispose of this information on the location of purchase.

and preferences (as far as they are reflected in budget shares), since such patterns are important for the redistributive potential of indirect taxation in the face of preference heterogeneity (see Section 3.2).

Given that for the purpose of model calibration (see Section 4.2) we can only group together commodities that face the same tax rate in the baseline policy of 2015, we thus arrive at four categories of food commodities labelled as follows: 'Food rich taxed', 'Food rich exempt', 'Food poor taxed', and 'Food poor exempt.' The 'rich' and 'poor' in these labels refer to the fact that the budget shares of the former tend to increase through the welfare distribution, and those of the latter tend to decrease. This is shown in the middle part of Table 1.[32]

Table 1: Budget shares by goods category and by decile (%)

	Deciles				
Decile	**1**	**2**	**5**	**9**	**10**
All Market	73.4	75.5	83.9	86.8	91.3
All Auto	26.6	24.5	16.1	13.2	8.7
			Market		
Food rich taxed	3.6	4.0	5.8	8.1	10.3
Food rich exempt	9.4	10.6	16.3	18.0	18.8
Food poor taxed	8.8	6.8	5.5	4.2	3.3
Food poor exempt	10.8	12.6	11.6	8.0	7.7
			Auto		
Food rich taxed	0.9	0.7	0.7	1.1	0.7
Food rich exempt	3.1	3.6	3.8	4.3	2.7
Food poor taxed	0.3	0.4	0.4	0.1	0.1
Food poor exempt	12.9	12.5	5.3	3.1	1.6

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). Average shares 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).

We finally arrive at 23 market commodity aggregates.[33] For 21 of these, an auto-consumption variety exists. The following categories are solely bought on the market: 'Education exempt' and 'Other services exempt.' The 'Food rich' category includes meat, fish, milk, cheese, eggs, etc., while 'Food poor' includes bread, cereals, oil, vegetables, sugar, etc. Full detail on the composition of all commodity categories can be found in Appendix C.1.

The top panel of Table 1 shows that there is a welfare gradient in the budget shares of auto- *versus* market varieties. A full picture for all welfare deciles is given in Tables C.2 and C.3 of Appendix C.2. This aggregate correlation between welfare and the share of goods bought on the market is a key observation in the analysis of Bachas et al. (2023). In the present paper, we provide more detail on this observation. Remark for example the welfare gradient is not so obvious for the auto-consumed 'Food rich' categories (bottom panel

[32] A full picture for all welfare deciles is given in Table C.2 of Appendix C.2.

[33] We conjecture that at this level of aggregation, the fact that we did not cover excises, which are levied on a limited number of specific commodities within the categories of transport, non-alcoholic and alcoholic beverages, and other products with very small budget shares, will not seriously affect our results.

of Table 1 and corresponding information for all deciles in C.3 of Appendix C.2).

4.2 Model calibration and baseline policy

Preference parameters were calibrated from the data as follows. First, the $\alpha_{g,h}$ were equated to the sum of observed expenditure on the market and auto-consumption varieties of a good divided by total expenditures. Calibration of the $\delta_{g,m,h}$ is dependent on an assumption about the degree of substitutability between market and auto-consumption varieties of the same good (σ). We assume $\sigma = 0.5$ for all goods and households.[34] Given a value for σ, $\delta_{g,m,h}$ can be read off from the data as follows: $\delta_{g,m,h} = \left(1 + \frac{w_{g,a,h}}{w_{g,m,h}} \left(\frac{q_{g,m}}{q_{g,a}}\right)^{1-\sigma}\right)^{-1}$, where $w_{g,s,h}$ are observed expenditures by household h on commodity g, s, $s = m, a$, $q_{g,a} = 1$ and $q_{g,m} = 1+t_g$, with $t_g = 0.18$ if the good is taxed, and $t_g = 0$ if it is exempted.[35] We use the demographic information from the survey to calculate household size and OECD equivalence scales.[36]

Optimal taxes are calculated for different degrees of inequality aversion: $e = 0$, 0.25, 0.5, 0.75, 1.25, 1.5, and 2.[37] We compare the optimal tax simulations with a baseline policy that collects the same amount of revenues, but safeguards the existing tax structure with one standard rate and a fixed list of VAT exempted commodities. In this way our tax policy comparisons maintain the assumption of government budget neutrality and can be interpreted as assessments of the welfare implications of different indirect tax policies that all achieve the same government budget objective. In our main analyses, we study the case where the government budget is fixed to reach the WAEMU-UN objective of 20% of GDP. This amounts to VAT revenues from the household sector to attain 237.7 billion CFA or 4.8% of GDP, and can be obtained by a standard rate of 25.56% (see Section 2). This is our baseline policy. In Appendix E.3 we provide a robustness analysis by fixing the government budget to the current value of 14.5% of GDP.

Our individual demand model (see Section 3.1) implies that budget shares of some goods will (slightly) differ depending on tax rates. To illustrate this, Tables C.4 and C.5 of Appendix C report the estimated budget shares of different commodities for the case with the standard tariff increased to 25.56% (corresponding to reaching the WAEMU-UN objective) and can be compared with those in Tables C.2 and C.3, that apply the situation as observed in the data (standard rate 18%, and the same list of exempted goods). Budget shares on varieties that belong to the exempted categories are not changing. The differences across deciles for those goods are solely due to the fact that the deciles are differently composed in both cases. The budget shares of the market variety of the taxed good categories increase in the government budget, while those of the corresponding auto-consumption varieties decrease. The reverse holds for quantities consumed (decreases for the market variety of taxed commodities, and increases for the corresponding auto-consumption varieties).

[34] We did a robustness check for $\sigma = 1.5$, but results were qualitatively comparable with the ones reported in the paper.

[35] When imposing identical preferences below, we calibrate the parameters α_g and $\delta_{g,m}$ using aggregate market expenditures in stead of the household expenditures.

[36] The latter are constructed as follows. The reference person in the household counts for one adult equivalent individual; each additional person in the household aged 14 or more, counts for one half adult equivalent; and any additional other person aged less than 14, counts for 0.3 adult equivalent persons. The equivalence scale is the number of adult equivalents in the household.

[37] According to Stern (1977) an inequality aversion $e = 2$ already comes close to the maximin case.

5 Empirical results

We start with the structure of optimal indirect tax rates (Section 5.1). Sections 5.2 and 5.3 consider the welfare effects of a switch from the baseline policy to optimal taxes. In Section 5.4 we present additional results and extensions.

5.1 Optimal tax structure

In the present section we study quantitatively how each of the factors causing deviations from uniform tax rates, contribute to the optimal tax rate differentiation. Tables 2 and 3 report optimal tax rates when all goods can be taxed and the case when only market goods can be taxed (auto-consumption cannot be taxed), respectively.[38] Comparing each column of Table 2 with the corresponding column of Table 3 isolates the effect of the presence of commodities cannot be taxed (auto-consumption). Furthermore, each of the two tables separately introduces gradually the three factors causing deviation from uniform taxation: i) preference heterogeneity (versus identical preferences in the first column of each table); ii) inequality aversion (increased from $e = 0$ to $e = 2$ in columns 2–7, and columns 8–13, respectively); and iii) household economies of scale (comparing each of column 2, 3, . . . with the corresponding columns 8, 9, . . . in each table separately). We first discuss deviations from the uniform rule due to preference heterogeneity and household economies of scale. Next, we add the impact of the presence of nontaxable goods (auto-consumption). Finally, we compare the the optimal tax structure under different degrees of inequality aversion with the current two-part tariff policy.

Deviations from the uniform tax rule when *all* goods can be taxed

When preferences are identical and homothetic, and all goods can be taxed (Column 1 of Table 2), we find a uniform rate of 11.7%, consistent with our theoretical results (Section 3.2). When there is no inequality aversion and there are no differences in household economies of scale, preference heterogeneity does not cause deviations from the uniform tax rule.[39] Therefore, Column (2) of Table 2 also generates the optimal rate of 11.7%.[40] So, when all goods can be taxed and there are no differences in household economies of scale, preference heterogeneity will only cause deviation from the uniform rule in the presence of inequality aversion ($e > 0$). In this case preference heterogeneity will mainly play a redistributive role. Commodities more intensely preferred by richer individuals are taxed more heavily when inequality aversion increases, and *vice versa* for goods more intensely preferred by the poorer individuals.

[38] Not only the level of the rates are important to interpret the results, but also which commodities bear a relatively higher or lower tax. Therefore, we also report for each of the columns in Tables 2 and 3 the ranks of the optimal tax rates in Tables D.1 and D.2 of Appendix D.1.

[39] This only holds when preferences are homothetic. Otherwise differences in the efficiency to generate welfare depend on the household income and the marginal social welfare weights may become household specific.

[40] When a uniform rate on all goods (including auto-consumption) is optimal, the level of the tax rate is actually independent of preferences or elasticities.

Table 2: Optimal tax rates when *all* goods can be taxed

Preferences	Identical	Heterogeneous											
	Uniform rule	No household economies of scale: $\theta_h = n_h$						Household economies of scale: θ_h =OECD-scale					
		Inequality aversion						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)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Other services e	11.7	11.7	6.7	6.5	10.9	17.3	53.3	3.5	2.8	4.5	12.6	20.6	60.0
Other services t	11.7	11.7	-11.1	-18.3	-26.5	-27.4	-18.7	5.4	-13.1	-19.1	-25.9	-26.4	-16.6
Food poor t	11.7	11.7	-0.7	-5.6	-16.2	-23.7	-44.4	8.5	-1.5	-5.9	-16.0	-23.3	-43.1
Recreation, culture e	11.7	11.7	14.2	16.6	25.4	33.7	72.6	9.6	13.3	16.1	25.9	34.7	75.6
Recreation, culture t	11.7	11.7	10.9	9.6	6.9	7.0	18.7	10.3	10.0	9.1	7.4	7.9	20.6
Education e	11.7	11.7	22.4	25.2	24.1	20.7	15.1	11.1	21.9	24.9	24.4	21.0	15.4
Food poor e	11.7	11.7	5.6	3.1	-0.9	-2.6	-8.1	11.6	5.8	3.3	-1.1	-3.0	-8.8
Furnishings & equipm. t	11.7	11.7	8.3	6.7	5.6	7.4	24.5	11.9	8.3	6.7	5.6	7.4	24.3
Transport t	11.7	11.7	17.8	20.0	23.2	24.9	35.2	12.0	17.4	19.7	23.6	25.8	36.5
Health e	11.7	11.7	9.0	7.5	3.0	-2.4	-32.7	12.6	9.2	7.6	3.0	-2.4	-32.5
Alcoh. bev. & tob. e	11.7	11.7	1.6	-3.3	-12.1	-15.2	-13.4	12.9	1.3	-3.5	-11.8	-14.6	-11.9
Clothing t	11.7	11.7	14.3	13.8	11.2	9.9	12.8	13.0	14.4	13.8	11.2	10.1	12.4
Food rich e	11.7	11.7	19.5	23.7	33.3	39.7	56.9	13.1	20.4	24.1	32.8	38.7	55.1
Others non serv. t	11.7	11.7	13.3	13.2	10.9	8.2	0.5	13.5	13.9	13.4	10.7	7.8	-0.8
Housing utilities e	11.7	11.7	15.3	16.5	19.7	22.7	37.8	14.1	16.0	16.8	19.5	22.3	36.4
Food rich t	11.7	11.7	28.9	36.6	49.3	53.1	53.1	14.4	30.1	37.2	48.8	52.2	50.9
Housing utilities t	11.7	11.7	9.9	9.8	12.0	15.4	35.2	14.4	11.4	10.6	11.3	14.0	32.4
Alcoh. bev. & tob. t	11.7	11.7	10.3	7.3	0.2	-2.4	1.0	14.7	11.0	7.5	0.1	-2.6	0.1
Communication t	11.7	11.7	22.8	27.8	34.4	34.1	25.3	14.9	24.1	28.3	34.0	33.5	24.4
Catering and accomm. t	11.7	11.7	22.1	27.0	37.0	42.6	58.7	15.4	23.8	27.9	36.2	41.1	56.4
Transport e	11.7	11.7	22.7	26.5	27.9	22.9	3.1	19.6	26.0	28.0	26.8	20.9	0.0
Non alcoh. bev. t	11.7	11.7	31.3	36.6	41.1	42.6	52.7	19.9	33.9	37.6	40.7	42.2	53.1
Housing rent e	11.7	11.7	35.9	47.9	72.2	86.0	129.3	25.2	42.9	51.4	68.8	79.2	115.0

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.

For example, the tax rate of the food poor commodity groups is decreasing with inequality aversion, from 11.7% to -44.4% for 'food poor t', and to -8.1% for the corresponding exempted category, while those of the food rich categories increases from 11.7% to 53.7% and 56.9% for the currently taxed and exempted varieties, respectively (see the relevant rows in Columns (2) to (7) of Table 2).[41] The efficiency role of household economies of scale can be seen by comparing optimal rates in Column (8) of Table 2 with column (2): deviations from the uniform rule are now only due to differences in household economies of scale. Commodities consumed more intensely by households with a lower degree of economies of scale, typically smaller households, will tend to be taxed relatively high. For example, we obtain a high tax rate of 15.4% for catering and accommodation, which might reveal that especially individuals living in smaller households tend to go out eating.

Deviations from the uniform tax rule in the presence of auto-consumption

The effect of the presence of nontaxable goods is obtained by comparing the uniform tax rule (Column (1) in Table 2) with the results obtained from applying the inverse elasticity rule (Column (1) in Table 3). We find that starting from the uniform rate of 11.7%, the introduction of auto-consumption causes a tax differentiation ranging from 12.8 to 20% under identical preferences. Now, introducing preference heterogeneity plays also an efficiency role, causing deviations from the inverse elasticity rule even in the absence of inequality aversion (compare column (2) with column (1) in Table 3): goods more intensely preferred by individuals living in households that are more efficient in producing welfare should be taxed lower. This explains the deviations from the inverse elasticity rule when moving from column (1) to column (2) in Table 3. Tax rates stay generally close to those obtained by the inverse elasticity rule, but the tax structure is affected considerably. For instance, education which was taxed at the lowest rate under identical preferences (12.8%) is taxed at the tenth highest rate under preferences heterogeneity (13.6%). Table B.1 in Appendix B.4 presents these deviations more in detail.

Accounting in addition for the households economies of scale affects the tax structure. When there is no inequality aversion, the economies of scale are producing much larger deviations from the inverse elasticity rule than only preference heterogeneity (compare the difference in tax rates between columns (8) and (1) of Table 3 with those between columns (2) and (1) of that same table). However, when inequality aversion increases, the redistributive role of preference heterogeneity tends to predominate on the efficiency role of household economies of scale. Indeed, tax rates in columns (3) to (7) are becoming closer to the corresponding rates in columns (9) to (13) as inequality aversion increases.

Actual policy and optimal tax structure

We now compare the optimal optimal tax structure with the current policy of two rates. More specifically, we evaluate whether the commodities that are exempted under the current policy, in order to reach social objectives are in line with goods that should be taxed relatively less, or even subsidised in the optimum, when inequality aversion increases. We focus on both the change in tax rates and the the relative ranking in terms of tax rates of the commodities as inequality aversion increases.

[41] As shown in Equation (A.22) of Appendix B.3, the denominator of the marginal social welfare costs, which reflects the impact on the government budget of an increase in a specific tax rate, becomes generally commodity specific when deviating from uniform taxation. So, while it is true that from Columns (2) to (7) of Table 2, we only increase the inequality aversion, and keep anything else constant, the optimal rates are also affected by efficiency considerations. The same remark holds true for the B-component of the social welfare weights (see Equation 13). The quantitative impact of these efficiency considerations on the optimal tax rates and structure might differ for different degrees of inequality aversion.

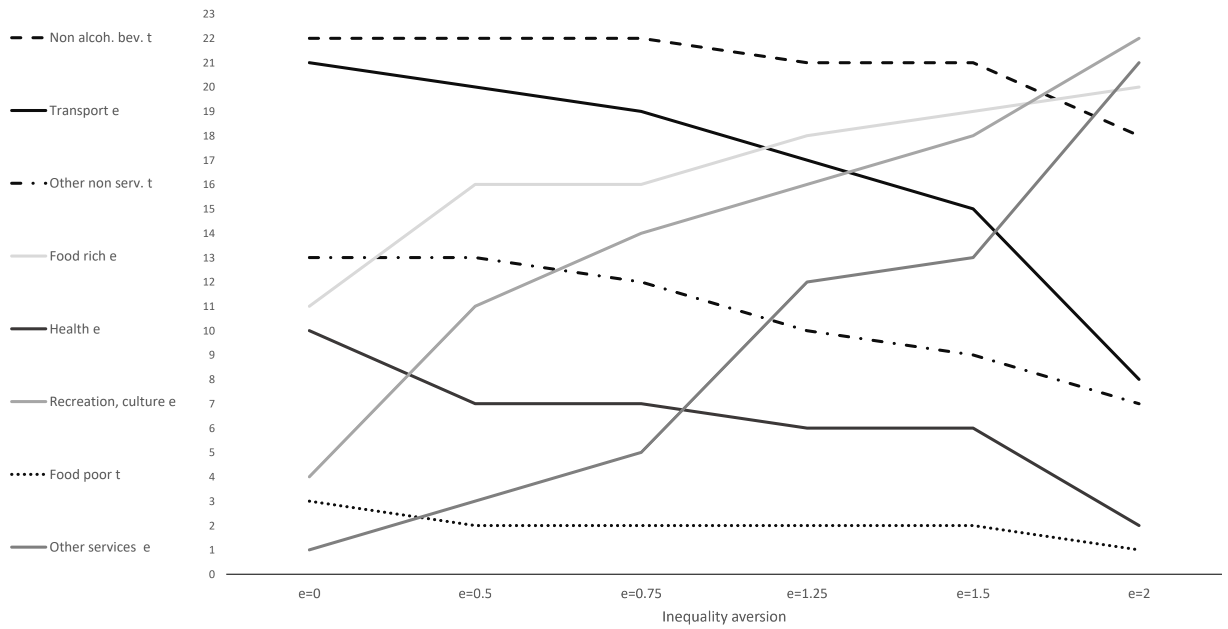
Table 3: Optimal tax rates when *only market* goods can be taxed

Preferences	Identical	Heterogeneous											
	Inverse elasticity	No household economies of scale: $\theta_h = n_h$						Household economies of scale: θ_h =OECD-scale					
		Inequality aversion						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	12.78	13.6	20.1	21.6	19.1	15.6	11.3	11.5	19.1	21.1	19.4	16.1	11.9
Other services e	12.78	14.2	4.6	3.2	6.5	12.6	48.6	4.2	0.2	1.1	8.3	16.1	55.3
Health e	12.81	13.1	7.4	4.7	-1.5	-7.0	-34.7	13.1	7.2	4.5	-1.4	-6.7	-34.4
Communication t	12.82	13.5	20.6	24.1	28.9	28.6	21.7	15.4	21.3	24.4	28.7	28.3	21.0
Transport t	12.83	13.3	16.1	16.9	17.8	19.0	29.6	12.5	15.2	16.4	18.5	20.2	31.4
Others non serv. t	12.83	13.2	11.7	10.2	5.9	2.8	-3.7	13.9	11.7	10.2	5.9	2.7	-4.7
Transport e	12.84	13.7	20.5	23.0	23.2	18.4	0.9	20.1	23.2	24.2	22.2	16.7	-1.9
Furnishings & equipm. t	12.88	12.8	7.1	4.2	0.5	1.1	16.7	12.5	6.7	4.0	0.7	1.5	17.2
Housing utilities t	12.94	13.5	7.9	6.6	7.3	10.2	30.0	14.8	8.8	7.1	6.7	9.1	27.7
Other services t	12.95	12.1	-11.5	-19.9	-30.6	-32.7	-25.7	6.0	-13.7	-20.8	-29.9	-31.4	-23.1
Recreation, culture e	12.97	13.3	12.7	14.0	21.1	28.8	67.7	10.0	11.4	13.4	21.7	30.1	71.2
Recreation, culture t	13.08	13.4	9.3	6.9	2.7	2.3	14.2	10.6	7.9	6.2	3.3	3.5	16.4
Food poor t	13.08	12.9	-2.1	-8.2	-20.3	-27.7	-46.5	9.0	-3.3	-8.6	-20.0	-27.1	-45.0
Non alcoh. bev. t	13.28	13.8	29.0	32.8	35.4	36.4	46.8	20.6	31.0	33.5	35.3	36.5	47.9
Catering and accomm. t	13.33	13.7	19.7	23.1	30.8	35.7	52.0	16.0	20.8	23.6	30.3	34.7	50.3
Food rich t	13.49	14.0	26.5	32.5	43.2	46.8	48.7	14.9	26.9	32.8	43.0	46.3	46.9
Alcoh. bev. & tob. t	13.52	13.3	9.6	5.3	-4.5	-8.0	-4.7	15.9	10.0	5.4	-4.3	-7.7	-4.7
Alcoh. bev. & tob. e	13.62	12.8	1.2	-5.1	-16.2	-19.8	-17.2	14.0	0.6	-5.5	-15.7	-18.9	-15.4
Clothing t	13.63	13.8	12.0	9.8	4.2	1.7	3.3	13.8	11.6	9.5	4.5	2.3	3.5
Housing utilities e	13.92	13.3	13.2	13.1	14.1	16.2	30.8	14.4	13.5	13.2	14.1	16.1	30.0
Food rich e	14.06	14.2	17.1	19.7	27.6	33.7	52.5	13.6	17.2	19.8	27.4	33.2	51.2
Food poor e	15.23	14.2	1.8	-2.7	-9.0	-11.0	-14.6	11.8	1.2	-2.9	-8.9	-11.0	-14.8
Housing rent e	20.06	14.6	32.9	43.1	66.0	80.1	125.3	26.2	38.9	46.1	62.9	73.8	111.4

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 only market 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.

To this end, we use the most complete version of our model, that is the case with heterogeneous preferences taking into account household economies of scale and the fact that not all goods can be taxed. The optimal rates for different degrees of inequality aversion are reported in columns (8) to (13) of Table 3. To facilitate the reading, we reproduce the tax rates for these cases in Table D.3 of Appendix D.1, but now ranked from high to low taxes in the case of absence of inequality aversion ($e = 0$). The information on ranks of the tax rates and how they change with inequality aversion is for a number of goods reproduced graphically in Figure 3.

Figure 3: Optimal tax structure for selected goods: the impact of inequality aversion



Note: Each point on a line denotes the rank of the optimal tax rate of a given commodity for a given value of inequality aversion. Only commodities for which the rank is uniformly decreasing or increasing in inequality aversion are selected. Selected commodities are ordered according to the rank of their tax optimal tax rate for inequality aversion $e = 0$. Grey lines refer to the commodities for which the rank of the corresponding tax rate is increasing in inequality aversion; black lines are decreasing. Full lines refer to commodities that are exempt under the baseline situation and broken lines to those that are taxed in the baseline.

Irrespective of the degree of inequality aversion, the current policy deviates from the optimal tax structure. Housing rent, for example, is currently exempted but should bear the highest tax rate in the optimum, irrespective of the degree of inequality aversion. This commodity refers to rents effectively paid for non owner-occupiers. About 11% of the population live in households that rent the house they live in.[42] These persons belong predominantly to the richest deciles according to the baseline situation; more than half belong to the top three deciles. This might explain why the tax rate is going up when inequality aversion increases.[43] Even for mild inequality aversion, some commodities should be subsidised in the optimum (*e.g.* 'food poor t' and 'other services t' in case $e = 0.5$). In case $e = 2$, the optimal tax rate of eight commodity categories is

[42] This and the following results on housing need to be treated with some care. The auto-consumption variety of housing is imputed rents for owner-occupiers. However, for 37% of the households in the sample, we have no information on the house they live in. We have no value for rent neither one for imputed rent, in the data. Probably these are households that live in the house of relatives. If that is the right hypothesis, ideally we would like to have imputed rents also for the houses these households live in. Unfortunately the data do not contain such information. Also, the assumption that owner-occupiers cannot be taxed on the value of their house might be questionable.

[43] Among renters, though, the household budget share of rents among the poorer is substantially higher though than among the richer ones. When all households are taken into account, the average budget share drops from 7.5% to 1.4%, and that share is almost monotonously increasing through the deciles. The budget shares per decile for the whole population are reported in Table C.4 of Appendix C. The conditional figures are not given in detail here but are available upon request.

negative.[44] The evolution of the tax rates is not necessarily monotone in the degree of inequality aversion. For example the optimal tax on 'communication t' is increasing in inequality aversion up to a value $e = 1.25$, while afterwards it starts to decrease. On the contrary, the optimal tax on 'furnishings & equipment t' first decreases from 12.5% when $e = 0$ to 0.7% for $e = 1.25$, and starts to increase again till 17.2% for $e = 2$.

Notice that a non-monotonous course of the optimal tax rate with inequality aversion does not imply that the change in ranking of the tax rates from low to high for each of the optimal tax rates is also non-monotonous. For example, the tax rate on 'transport e' is increasing in inequality aversion until $e = 0.75$, (from 20.1% to 24.2%), and then decreases again to become even negative for $e = 2$, but the rank of the tax rates decreases monotonously with the degree of inequality aversion for that commodity: it bears the third highest tax rate when $e = 0$, while its rate is the eighth lowest one for $e = 2$. Since ranks and levels of the tax rates give independent information on the optimal tax structure, we report these ranks in Table D.2 of Appendix D.1. Also the evolution of these ranks with respect to inequality aversion is not necessarily monotonous. In Figure 3 we report the commodities for which these ranks evolve monotonously with inequality aversion. The black lines gives the evolution of the rank of the tax rate for commodities for which it is uniformly decreasing. The grey lines are for goods which become relatively more heavily taxed when inequality aversion increases. The selected commodities are ordered according the rank of their tax rate when there is no inequality aversion ($e = 0$). For example 'recreation, culture e', which is a commodity category that is not taxed in the baseline, is also relatively lowly taxed in the optimum when $e = 0$, the optimal rate being 10% in that case, the fourth lowest tax rate. On the other hand, with an optimal tax of 71% this commodity bears the second highest tax rate when $e = 2$. Notice that the current policy for exempting these recreation and culture goods is at odds with what would be advocated from a social welfare point of view with high concern inequality aversion, which advocates relatively high taxation. This observation holds true for all the other goods for which the rank of the optimal tax is uniformly increasing in inequality aversion. This is not necessarily true for the case where the rank of the optimal tax rate is decreasing in inequality aversion (black lines). Indeed, some of these goods, such as 'transport e' or 'health' are exempt in the baseline simulation and their rank is decreasing in inequality aversion. However, notice again that ranks of the tax rate are not always giving similar information as the levels of the optimal tax rate. The optimal tax on 'non-alcoholic beverages t' is 20,6% when $e = 0$, and it uniformly increases to almost 48% when $e = 2$, while its rank decreases from 22 when $e = 0$ to 18 when $e = 2$.

5.2 Welfare gains and losses across the welfare distribution

We compare for each individual of our sample the welfare obtained under the baseline policy (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015), with the welfare level obtained when applying the optimal indirect taxes for different levels of inequality aversion. Individual welfare levels are calculated using the equivalised money metric utility defined in Equation (5). The difference will be expressed in levels (CFA) and relative to the baseline welfare (percentage). Table 4 shows the overall average gains from switching from the baseline towards an optimal tax structure, for different values of inequality aversion. The confidence intervals are obtained from applying a bootstrap with 500 replications (see Section B.5). The table illustrates the well-known equity-efficiency

[44] 'Alcoholic beverages & tobacco t' turn out to be subsidised when inequality version becomes high ($e \geq 1.25$). The reason is that our model does not take into account negative health effects of the consumption of such goods, when they are not internalised by the consumer. Besley (1988) provides a model that would capture such external effects, and Decoster and Schokkaert (1989) provide an *ad hoc* method to integrate them into marginal tax reform analysis.

trade-off. When inequality aversion is zero, government tries to maximise mean welfare, and the welfare gain in levels *vis-à-vis* the baseline is positive and maximal. Average welfare gain is decreasing when inequality aversion increases. The average gain is even negative when inequality aversion is higher or equal to 1.25. One wants to give up size of the pie in order to obtain a more equitable distribution. All differences are statistically significantly different from zero. The same conclusions holds for the relative welfare changes.

Table 4: Inequality aversion and average welfare gain

	Average change in welfare					
	Levels (CFA)			Percentage		
Inequality aversion	LB 95% CI	Mean	UB 95% CI	LB 95% CI	Mean	UB 95% CI
e=0.00	2015	**2160**	2256	0.49	**0.53**	0.55
e=0.50	1273	**1426**	1559	0.31	**0.35**	0.38
e=0.75	355	**590**	770	0.08	**0.14**	0.19
e=1.25	-2422	*-1859*	-1445	-0.59	*-0.45*	-0.35
e=1.50	-4850	*-3671*	-2864	-1.19	*-0.89*	-0.71
e=2.00	-20030	*-12008*	-5560	-4.49	*-2.93*	-1.36

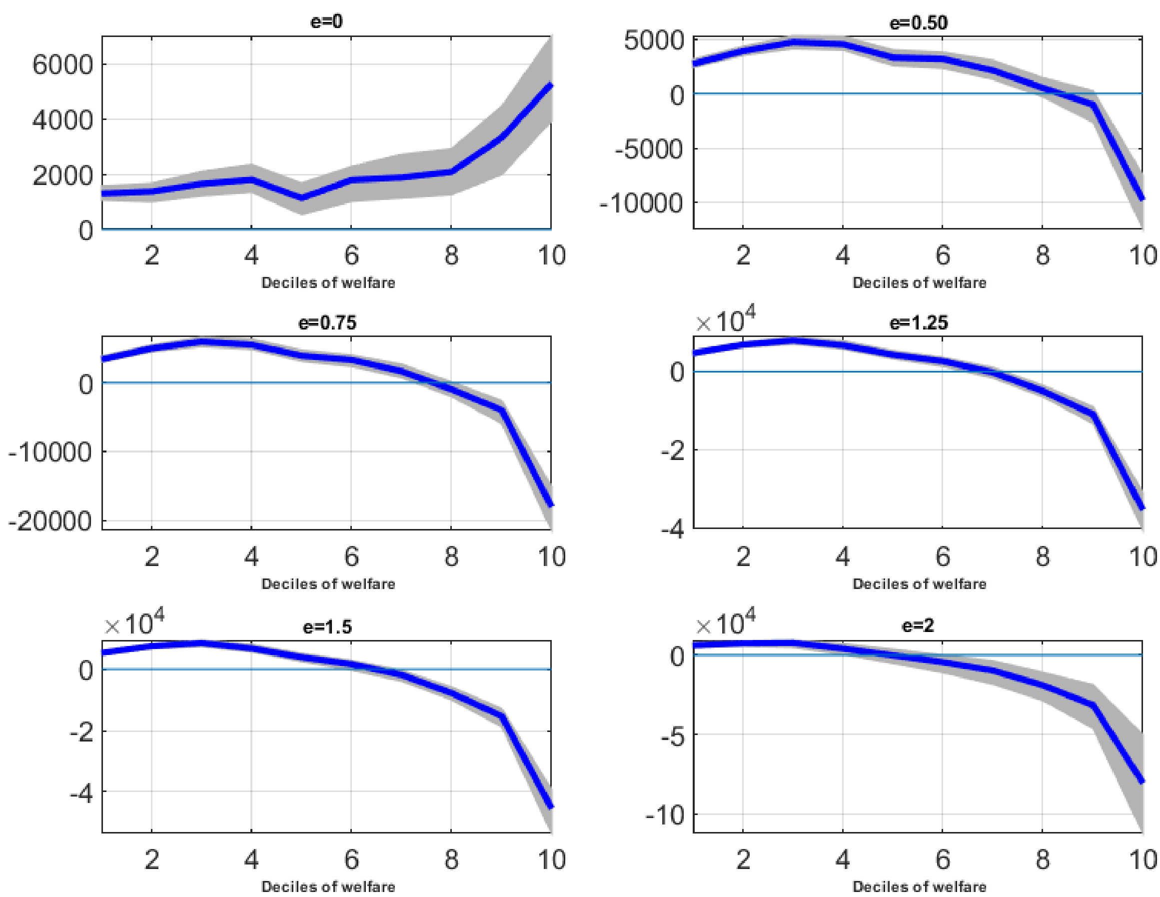
Note: Comparisons are with the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the baseline (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015). Welfare levels are calculated using the equivalised money metric utility defined in Equation (5). Averages are calculated at the individual level. Percentage gains are calculated as average gain over average baseline welfare (see Section B.5).
Confidence intervals are calculated by means of 500 bootstrap replications of the estimates (see Section B.5). Bold face figures indicate significantly positive values at the 5% level, and italic numbers significantly negative ones.

Figures 4 and 5 show how these average gains are distributed across the baseline welfare distribution. For each decile of the baseline welfare distribution the average gain is calculated. The blue lines connect those averages. Each panel is for a different value of inequality aversion. Figure 4 shows the welfare gains in levels, while Figure 5 applies to the relative differences.[45] In absence of any inequality aversion ($e = 0$), the average gain in levels per decile is always significantly positive and it almost uniformly increases with deciles (the only exception being the small dip for decile 5). When inequality aversion is positive ($e > 0$), the average welfare gain across deciles has roughly an inverted U-shape. The top average gain is always obtained in the third decile, but the decreasing part is much steeper as inequality aversion increases. The decile at which the average gain becomes negative is decreasing in inequality aversion. For example, when $e = 0.5$ there is an average loss only for deciles 9 and 10 (and it is only statistically significant for the tenth decile). When $e = 2$, there is on average a loss from the fifth decile onwards, and it is statistically significant from the seventh decile onwards. Moreover, the redistribution is increasingly shifted towards the first decile: this is the only decile for which the average gain is increasing uniformly with inequality aversion. For the second decile, for example, the average gain is slightly lower when $e = 2$ compared to the case of $e = 1.5$, and this is even more explicitly so for the third and fourth decile. This confirms the equity efficiency trade-off we referred to earlier. When inequality aversion increases, one primarily wants to increase the welfare of persons belonging to the bottom deciles of the welfare distribution, at cost of larger losses for persons belonging to middle and higher deciles. Still, even for high inequality aversion, efficiency concerns remain important, reflected by the fact the average gain of the second and third decile is higher than that of the bottom decile.[46]

The picture is somewhat different when one looks at relative gains across deciles (Figure 5 and Table D.5), though the main qualitative conclusions on the equity-efficiency trade-off remain to hold. The most salient

[45] Tables D.4 and D.5 contain the numerical values of the point estimates.
[46] This prevalence of efficiency over equity of traditional social welfare functions was already noticed and analysed by Shorrocks (1983) and Bosmans (2007).

Figure 4: Average welfare gain per decile from applying optimal taxes (levels, CFA)



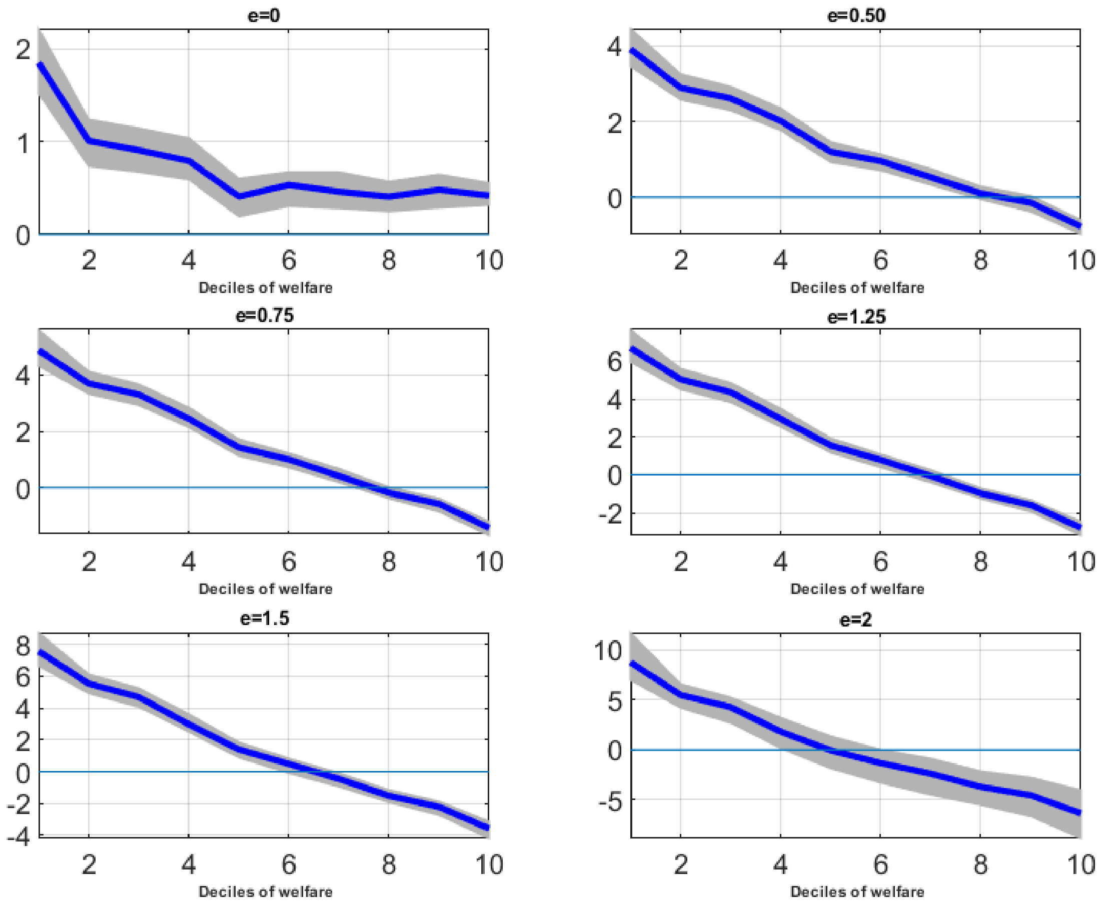
Note: The vertical axis reports average welfare differences in levels (CFA) between the application of the optimal tax and the baseline simulation (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015). Each panel is for a different value of inequality aversion. The blue lines represent weighted averages within each decile. The grey areas represent the 95% confidence interval constructed from 500 bootstrap replications (see Section B.5). Averages and deciles are calculated for the population of individuals.

difference with the picture for welfare gains in levels is that the relative average welfare gain is not anymore inverted U-shaped, but uniformly decreasing across deciles when inequality aversion is positive. The decline of the relative average gain across deciles becomes steeper when inequality aversion increases. In the absence of inequality aversion ($e = 0$), the negative slope only extends up to fifth decile after which the relative average gain remains more or less constant. It remains to hold that only for $e = 0$ the relative average gain is (significantly) positive through all deciles.

We conclude that there is scope for redistributive policies through indirect taxes by a careful diversification of tax rates. However, the effectiveness of such policies is very much dependent on the extent to which preference heterogeneity is correlated with welfare. For example, if a certain policy is hitting severely a person belonging to the top of the (initial) welfare distribution, and someone at the bottom has similar preferences, she will be hit too.[47] As a consequence of imperfect correlation between welfare level and

[47] This statement should be qualified when preference were non-homothetic, as it may then well be possible that indirect taxes have a different effect on welfare for two persons with the same preferences, but different (initial) welfare levels. Theoretically, it is the correlation with preferences and the welfare levels evaluated at the optimum that matter. As these welfare levels are partially dependent on the optimal taxes, the correlation between preferences and welfare partially depends on the optimal tax

Figure 5: Average welfare gain per decile from applying optimal taxes (% of baseline welfare)



Note: The vertical axis reports relative welfare differences (in % of baseline welfare) 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 panel is for a different value of inequality aversion. The blue lines represent weighted averages within each decile. The grey areas represent the 95% confidence interval constructed from 500 bootstrap replications (see Section B.5). Averages and deciles are calculated for the population of individuals. The averages 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).

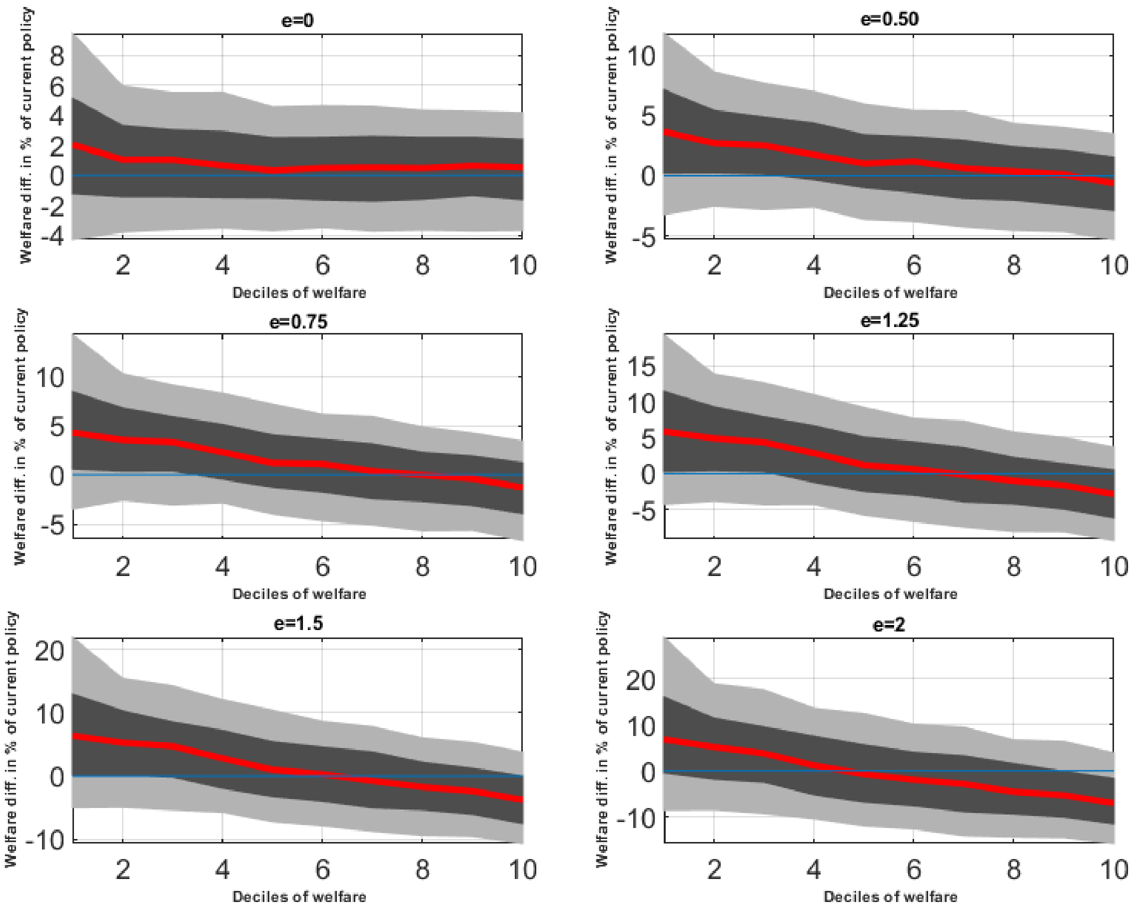
preferences, any optimal policy will cause winners and losers all over the welfare distribution. Figure 6 illustrates the extent to which this is the case in our simulations. It shows for each decile of baseline welfare the first and ninth decile value, the first and third quartile, and the median of the relative gain in welfare for a switch from the baseline simulation to an optimal policy for a given value of inequality aversion.[48] The red lines in the figure connect the median values for each decile. If this median value is below zero, it means that more than half of the persons belonging to this decile are loosing from a switch of the baseline policy to the optimum. The dark gray areas in the figure are bounded by the first and third quartile value of the corresponding decile. If the lower boundary of that area is larger than zero for a given decile, less than a quarter of the population of that decile loses by the switch. On the contrary, when the upper boundary is below zero, less than a quarter of that same population gains. The light grey areas are bounded by the first

structure and is therefore endogenous. The extent to which the welfare distribution is affected by the optimal policy is discussed more in detail in Section 5.3.

[48] The corresponding figure for levels of welfare gains, Figure D.1, is discussed in Appendix D.3.

and ninth decile value.

Figure 6: Heterogeneity of relative welfare gains within deciles



Note: The vertical axis reports the, within each baseline welfare decile, quantile values of relative welfare differences (in % of baseline welfare) 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 panel is for a different value of inequality aversion. The red lines connect the median value of the relative gain 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 relative difference within each baseline.

For the case of absence of inequality aversion, a majority of persons within each baseline welfare decile is gaining from a switch of the baseline to the optimal tax structure. At the same time, more than a quarter of the persons are losing from such a switch in all baseline deciles. When inequality aversion increases, the quantile values tend to have a decreasing and steeper course across deciles. In all cases with positive inequality aversion, a majority in the lower deciles is gaining by the switch, while a majority loses in the upper deciles. The switch from a majority of winners to a majority of losers occurs at lower deciles as inequality aversion increases. Surprisingly, for intermediate values of inequality aversion ($e = 0.5, 0.75$, or 1.25), less than a quarter among the population belonging to the lower deciles in the baseline, loses from the switch, while for a high value of inequality aversion more than a quarter loses in each decile, including the lowest decile. Moreover, the spread between the better off and worse off is increasing with inequality aversion. Nevertheless, the ninth to first decile ratio narrows down across deciles. This narrowing is limited to the first few deciles when there is no inequality aversion, and continues to hold throughout all deciles when inequality aversion is positive. For the higher values of inequality aversion ($e \geq 1.25$) the mean change is higher than the median for all baseline deciles, indicating that, within each decile, the distribution of welfare changes is skewed toward the upper half of the values. For lower values of inequality aversion the median is lower than the mean welfare for the lowest baseline deciles, while the reverse holds true for the highest baseline welfare deciles. Surprisingly, when there is no inequalty aversion the mean is lower than the median for both the lowest and highest baseline deciles. Only for the middle deciles the reverse holds true.

5.3 Winners and losers

Figure 6 already allowed to derive that there are winners and losers within *all* deciles, irrespective of the degree of inequality aversion. In Table 5 we show the estimated proportion of winners of a switch from the baseline to the optimal policy for different values of inequality aversion, across the whole population. For all except the highest value of inequality aversion we considered ($e = 2$), a statistically significant majority of the population would gain. When inequality aversion is high ($e = 2$), a slight majority would lose, although the result is not statistically significant. One can give a political economy interpretation to these results. If the whole population could chose between the baseline policy to reach the UN objective to attain a total tax revenue of 20% of GDP, and an optimal policy, and people would vote only on the base of the effects of such policies on their welfare, a majority is expected to vote for the optimal policy, except when the latter is designed by a policy objective embodying a considerable amount of inequality aversion, in which case we cannot make statistically significant conclusions.

Table 5: Inequality aversion and percentage of winners

Inequality aversion	Percentage of winners		
	LB 95% CI	Mean	UB 95% CI
e=0.00	57.8	**58.9**	59.7
e=0.50	62.3	**63.1**	63.9
e=0.75	60.5	**61.4**	62.2
e=1.25	55.4	**56.5**	57.7
e=1.50	52.2	**54.0**	55.5
e=2.00	40.2	46.4	52.5

Note: Comparisons are with the individual welfare measure (equivalised money metric utility, Equation 5) evaluated in the baseline (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015). Cells show the percentage of winners when applying the optimal tax for a given value of inequality aversion (rows) compared to the baseline.
Confidence intervals are calculated by means of 500 bootstrap replications of the estimates. Bold face figures indicate significantly larger than 50% at the 5% significance level; italic numbers are significantly lower than 50%.

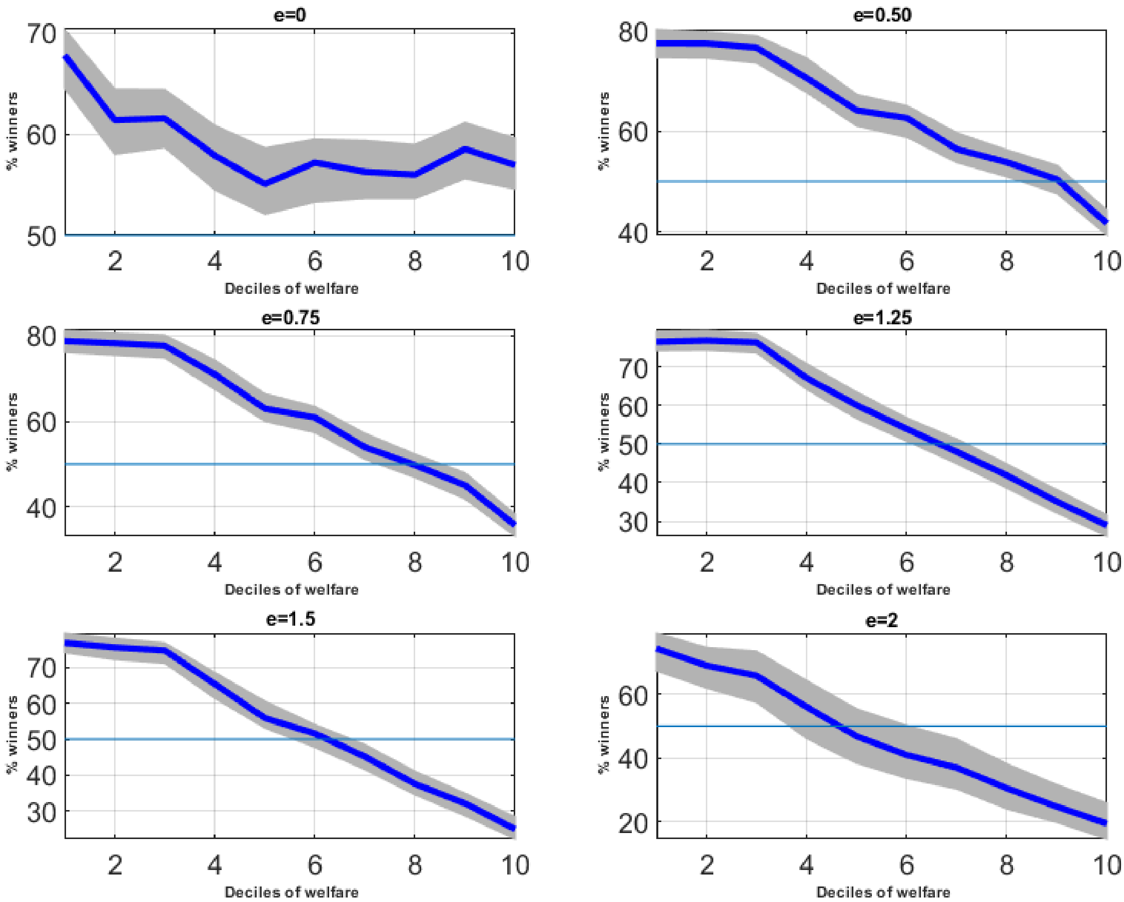
Figure 7 illustrates how the number of winners and losers are distributed across the deciles of baseline welfare.[49] Our first observation is that there a considerable number of losers across all deciles, irrespective of the degree of inequality aversion (at least one fifth of the persons within a decile lose). The patterns in Figure 7 closely resemble those of the average *relative* welfare gains across baseline deciles (Figure D.5). When there is no inequality aversion, the percentage of winners is decreasing almost uniformly until the middle, after which it wiggles around 55 to 57%. For each decile there is a statistically significant majority of winners. For intermediate values of inequality aversion, the number of winners is almost constant over

[49] The values of the percentage of losers per decile are represented in Table D.6 of Appendix D.4.

the first three deciles and then decreases. For higher deciles a significant majority even loses. Wen $e = 2$, the percentage of winners is decreasing uniformly, and a majority loses from decile 5 onward (though only statistically significant from decile 7 onward). The deciles at which a significant majority becomes losers for $e = 1.5, 1.25, 0.75$, and 0.5, are respectively 7, 8, 9, and 10.

Surprisingly, from inequality aversion $e = 1.25$ onward, the percentage of losers in each decile, including the lower ones, is increasing with inequality aversion. There are *e.g.* 26% losers in the lowest decile when $e = 2$, while the corresponding figure for $e = 0.5$ is 23%. Apparently, when inequality aversion increases, it might become optimal to design policies such that a larger gain is obtained for a smaller number of poor persons, rather than distribute gains evenly across the poor. This stands to reason, as an extra gain for the poorer is worth more than the same gain for a rich person.

Figure 7: Percentage of winners by decile



Note: The vertical axis denotes the percentage of winners when switching from the baseline policy (standard tariff of 25.56%, guaranteeing to reach the UN tax revenue objective of 20% of GDP, with goods exempted as in 2015) to optimal taxation for different values of inequality aversion. The blue lines connect the point estimates for each decile. The grey areas represent 95% confidence intervals estimated from 500 bootstrap replications (see Section B.5).

As there are winners and losers in all deciles, the welfare ranking of individuals in the baseline might change under the optimal policies. Table 6 represents, for different values of inequality aversion, the percentage of persons who move to a different welfare decile under the optimal policy than they belong to under the

Table 6: Changes in welfare ranking across simulations

Inequality aversion					
e=0	**e=0.5**	**e=0.75**	**e=1.25**	**e=1.5**	**e=2**
Percentage of movers from one decile to another					
10	12	13	18	20	27

Note: The figures in the table indicate the percentage of individuals that belong to a different welfare decile in the baseline as compared to the decile they belong to under implementation of optimal taxes for different values of inequality aversion.

baseline.[50] For example, one tenth of the population belongs to another welfare decile under the baseline simulation as compared to the decile they belong to under the optimal policy in absence of inequality aversion ($e = 0$). This percentage is gradually increasing with inequality aversion. When $e = 2$, almost three out of ten people move across deciles. These figures illustrate that the welfare distribution under optimal policy is endogenous. Therefore, statistics on the correlation between preferences and welfare for a given tax policy, can be misleading for drawing conclusions on the structure of optimal taxes in comparison with that policy.

5.4 Extensions and other results

In the present section, we discuss first results when we limit the number of optimal tax rates. Then we perform regional differences in the welfare effects of optimal taxes. Finally, we look at the impact of the level of the government budget. We only report some headlines. Details can found in Appendix E.

Restricted number of tax rates

We study whether restricting the number of tax rates to maximally four different rates, which is more feasible from a policy perspective, has much impact on the welfare effects we obtained so far. Our main observation is that restricting the number of tax rates to a manageable number of at most four rates, can approximate the full optimum quite well in terms of welfare. The most surprising result is perhaps that the number of winners under the restricted optimum is higher for the higher deciles than under the unrestricted optimum, even under high inequality aversion. We give more detailed comments on this observation in Appendix E.1.

Other results

Appendix E.2 inspects the regional impact of the optimal tax schemes. We compare the welfare across the 12 geographical Benin's departments. We find that average welfare gain tends to be higher for poorer departments when inequality aversion increases. Finally, the role of the level of the government budget is studied in Appendix E.3. Our results remain qualitatively unchanged when the government budget is set at the current level of 14.5% of GDP as compared to the 20% of GDP. The amount of winners and the average gain tend to increase slightly with the government budget. This means that when the government budget is raised, people tend to lose more under the existing policy of one standard rate and a fixed list of exempted goods, than under the application of optimal taxes.

[50] Tables D.7 and D.8 of Appendix D.5 give more detail on these figures. The main lesson is that there are more 'movers' in the middle of the distribution than at the extremes.

6 Conclusion

Current VAT policy in West Africa consists of imposing a single rate, but several commodities are exempted. With the exemption of certain commodities governments aim to reach the social objective of a more equitable distribution of the tax burden. There is little formal analysis about the extent to which such an objective can be reached with the current policy. The question of equitable tax reforms becomes even more important in the light of the ongoing debate on raising domestic revenue in Low Income Countries (LICs).

We use a many-person Ramsey type of optimal indirect taxation model to derive principles of alternative tax policies that might do better in terms of combining equity and efficiency objectives of taxation. The model incorporates the distinguishing feature of LICs that a considerable part of consumption goods stem from own produce. These auto-consumed goods cannot (easily) be taxed, but do contribute to individual welfare. We apply our framework to the case of Benin, using data from a budget survey of 19920 households.

We show that the presence of nontaxable goods (*e.g.* due to auto-consumption) leads to a differentiated optimal tax rate structure, even when preferences are identical and homothetic: goods exhibiting a relatively large own price elasticity (in absolute value) are taxed relatively low in the optimum. Quantitatively, auto-consumption causes a tax differentiation ranging from 12.8 to 20% as compared to a uniform rate of 11.7% when all good can be taxed. Preference heterogeneity and within household economies of scale lead to a further differentiation of the optimal tax rates in deviation of the inverse elasticity rule, even if there is no inequality aversion. Preferences heterogeneity plays a more dominant role as inequality aversion rises. These results illustrate the equity-efficiency trade-off. In the absence of inequality aversion, government sets indirect taxes so that total (or average) welfare is maximised. As inequality aversion rises, commodities more intensely preferred by individuals living in households with higher equivalised welfare, tend to be taxed higher. Moreover, we find that up to a substantial level of inequality aversion level, a statistically significant majority of the individuals in Benin would gain from switching to optimal taxes. On the contrary, optimal taxes for the highest level of inequality aversion we used, are rejected by a majority, though this result is not statistically significant at the 5% level. We find, however, winners and losers in all welfare deciles, due to preference heterogeneity within those deciles. Our results are qualitatively unchanged when we restrict the number of goods or fixing the government budget to different values. When the government budget is raised, people tend to lose more under the existing policy than under the application of optimal taxes.

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