Title: Redistribution, Demand and Sustainable Production

Authors: Sonja Dobkowitz

Date: August 2021

RTG 2281 – Discussion Papers

No. 2021-14

Abstract

How does consumers' willingness to pay for sustainable goods, i.e., social respon-sibility, shape the optimal environmental policy in an unequal economy? Rising levels of social responsibility suggest a demand-driven transition to sustainable production. However, income inequality and basic consumption needs pose an obstacle. Therefore, the marginal propen-sity to consume unsustainable goods is income dependent so that lump-sum transfers alter the economic structure: a redistribution channel of environmental policy arises. To answer the research question, I solve a model of structural transformation from a Ramsey planner's perspective for exogenously varied levels of social responsibility. The paper finds a shift in the optimal policy from environmental taxation towards redistribution through labour taxation as social responsibility rises. The demand-driven reduction in the externality makes less gov-ernment intervention for environmental reasons needed, and lower efficiency costs leave more room for redistribution. In addition, the optimal policy relies on the redistribution channel of environmental policy. For the highest level of social responsibility considered, redistribution reduces the externality by 44%, while the environmental tax only accounts for a reduction of 10% relative to the laissez-faire allocation. The shift to redistribution is caused by inequality becoming too severe. As social responsibility rises, households want to consume a more expen-sive bundle so that the wedge between the actual and the composite-consumption maximising budget share increases: a recomposition effect rises the benefits of redistribution. Then, re-distribution attains a better balance between equity and the environmental good. However, efficiency costs are too high to fully exploit the redistribution channel of environmental policy and to offset the rise in inequality. Instead, there exists a level of social responsibility after which a further increase causes a rise of both inequality and the social costs of the externality under the optimal policy.

Funded by Deutsche Forschungsgemeinschaft German Research Foundation

Redistribution, Demand and Sustainable Production

Sonja Dobkowitz
Bonn Graduate School of Economics

First version: February 28, 2021
This version: August 17, 2021

Abstract How does consumers' willingness to pay for sustainable goods, i.e., social responsibility, shape the optimal environmental policy in an unequal economy? Rising levels of social responsibility suggest a demand-driven transition to sustainable production. However, income inequality and basic consumption needs pose an obstacle. Therefore, the marginal propensity to consume unsustainable goods is income dependent so that lump-sum transfers alter the economic structure: a *redistribution channel of environmental policy* arises. To answer the research question, I solve a model of structural transformation from a Ramsey planner's perspective for exogenously varied levels of social responsibility. The paper finds a shift in the optimal policy from environmental taxation towards redistribution through labour taxation as social responsibility rises. The demand-driven reduction in the externality makes less government intervention for environmental reasons needed, and lower efficiency costs leave more room for redistribution. In addition, the optimal policy relies on the redistribution channel of environmental policy. For the highest level of social responsibility considered, redistribution reduces the externality by 44%, while the environmental tax only accounts for a reduction of 10% relative to the laissez-faire allocation. The shift to redistribution is caused by inequality becoming too severe. As social responsibility rises, households want to consume a more expensive bundle so that the wedge between the actual and the composite-consumption maximising budget share increases: a *recomposition effect* rises the benefits of redistribution. Then, redistribution attains a better balance between equity and the environmental good. However, efficiency costs are too high to fully exploit the redistribution channel of environmental policy and to offset the rise in inequality. Instead, there exists a level of social responsibility after which a further increase causes a rise of both inequality and the social costs of the externality under the optimal policy.

1 Introduction

Climate change is one, if not the main, risk threatening humanity today. Macroeconomic research has focused on the supply side to study policies targeted at a transition to sustainable production. However, more and more consumers are concerned about the climate externality of their consumption bundle, and the percentage willing to pay a premium for sustainable products is rising.[1] On the other hand, income inequality renders sustainable goods unaffordable to some households posing an obstacle to a demand-driven transition. Therefore, this paper focuses on demand as a determinant of the degree of sustainable production in an unequal economy.

To highlight the role of demand, the paper develops a model of structural transformation with a sustainable and unsustainable production sector. Two aspects are essential for the composition of aggregate demand: *basic needs* and *social responsibility*. Social responsibility shapes the utility a household derives from consumption of the sustainable over the unsustainable good. A socially responsible household derives utility from the avoidance of negative externalities in the production process. Such behaviour can be rationalised, for instance, by intrinsic ethical motives or social norms.[2]

As social responsibility rises, aggregate production shifts towards the sustainable alternative to meet the rise in demand. However, a condition to satisfy basic needs drives a wedge between social responsibility and actual consumption. Basic needs denote the objective consumption bundle that is required to live a humane life. One can think of the bundle as containing expenses to cover physical needs and expenditures required to participate in society such as transportation. I assume that the satisfaction of basic needs has priority above consumption according to social responsibility: only if basic needs are sufficiently satisfied, demand fully reflects consumers' underlying social responsibility. If income is too low, in contrast, the consumption bundle tilts towards the cheaper alternative.

The paper studies optimal policies in a productive economy which would be capable to meet every households' basic needs[3] with sustainable goods. However, income inequality prevents sustainable coverage in the competitive economy.[4] The model differentiates two household groups: rich and poor, where the latter are not able to finance basic needs with the sustainable good in the baseline calibration.

[1] The Nielsen Company (2015) finds that in 2015 66% of households were willing to pay a premium for sustainable brands, compared to 50% in 2013 in a sample of 60 countries.

[2] Bénabou and Tirole (2010) provide motives for the existence of socially responsible behaviour.

[3] Here, the term *basic needs* refers to the specific bundle on which calculations are based in the paper. The bundle is defined by the *Institute for Women's Policy Research*. Section 2 and appendix section A.2 provide information on how the bundle is defined.

[4] The sustainable good is, for now, assumed to be more expensive.

Basic needs render the marginal propensity to consume unsustainable goods (MPCU) income dependent. Depending on the degree of social responsibility and the relative price, the unsustainable good is inferior at certain income levels.[5] This setup makes it interesting to zoom in on the role of distortionary labour taxation and redistribution as an environmental policy which has largely been overlooked thus far in the macro literature.

In general, distortionary taxation achieves a reduction in the externality by bluntly reducing aggregate production. In addition, redistribution becomes a more subtle environmental policy through income-dependent MPCUs. A *redistribution channel of environmental policy* arises: lump-sum redistributing one unit of income from a rich to a basic-needs constrained household alters the share of unsustainable production.

In the literature, environmental taxes levied either on the polluting sector or as value-added taxes directly on consumers are the prominent climate-change policies discussed. The analysis of the role of redistribution is, therefore, placed in a setting with environmental taxes. Then, both tax instruments compete in their effectiveness to lower the externality and to mitigate inequality[6] due to their efficiency costs.

The degree of social responsibility alters both the effect of taxes, on the one hand,[7] and the laissez-faire degree of inequality and the environmental externality, on the other hand.[8] Indeed, expecting the degree of social responsibility to rise further,[9] it is time to ask: what is the optimal policy? Even if the government has an environmental tax at hand, is redistribution employed as environmental policy?

The main experiment consists in exogenously changing the degree of social responsibility shared by households. For each level of social responsibility, a Utilitarian Ramsey planner maximises social welfare using a distortionary labour tax and a corrective environmental tax.

Results The first main finding is that, as social responsibility rises, the optimal policy mix shifts towards redistribution. As demand already directs a substantial share of production to the sustainable sector, there is less need for government intervention to target the externality; lower efficiency costs leave more room for redistribution. Additionally, redistribution becomes an important channel to lower the externality. It accounts for a reduction of the

[5] This is the case even under the assumption of a homogeneous distribution of social responsibility.

[6] Environmental taxes have distributional effects in the setting with basic needs since budget shares are heterogeneous. Furthermore, price changes alter the discrepancy between actual consumption and the share rationalised by social responsibility thereby affecting inequality.

[7] Redistribution, for instance, becomes more effective in lowering the externality when social responsibility is high.

[8] In the laissez-faire allocation, a demand-driven reduction in unsustainable production lowers the environmental externality; on the other hand, does it increase inequality since the consumption ratio of the poor is tilted further apart from the composite-consumption maximising ratio.

[9] This is thinkable as repercussions of climate change become more severe and concerns increase.

externality by up to 44% due to the unsustainable good being inferior to poor households. The environmental tax, in contrast, becomes relatively unimportant: lowering the externality by only 10%.

All in all, when social responsibility is high, the optimal labour tax rate is even above the optimal level in a model without externality where equity is the only motive for government intervention. I show that this gap is explained mainly by the government optimally relying on the labour tax as an environmental policy and not intensified equity concerns through environmental taxation. This finding is in sharp contrast to Bovenberg and De Mooij (1994). They argue that environmental-tax revenues are optimally used to lower the distortionary labour tax when the government has to generate funds. The reason being that recycling environmental revenues as transfers intensifies the efficiency costs of labour taxation through the income channel of the wage rate. This result of the paper, however, is in line with the paper by Jacobs and van der Ploeg (2019), who show that redistribution is used as an environmental policy instrument when labour taxation affects the consumption of the polluting good and the environmental tax does not fully internalise the social costs of the externality.

Although the redistribution channel of environmental policy adds to the benefits of labour taxation due to environmental gains, equity concerns explain the reliance on redistribution as an environmental policy instrument. As social responsibility rises, inequality becomes more severe since households desire a more expensive bundle. Therefore, more redistribution is needed to allow the poor to consume closer to the desired bundle. To stop inequality from rising, the planner forfeits a further reduction in the externality and the social costs of the externality increase.

Eventually, efficiency costs prevent sufficiently high levels of redistribution to fully exploit the redistribution channel of environmental policy. There exists a level of social responsibility after which a further rise implies an increase in both the social costs of the externality and inequality under the optimal policy.

Literature The paper is one of the first to relate social responsibility and inequality in a macroeconomic framework. Social responsibility has been studied in the behavioural economics literature. Bénabou and Tirole (2010) discuss the phenomenon and rationalise its existence, for example, by a (perceived) lack of government action. Bartling et al. (2015) provide experimental evidence that social responsibility shapes market interactions. The recent work by Aghion et al. (2021) is one rare example of the integration of social responsibility in a general equilibrium model. The authors study its interactions with competition, while the present paper keeps the supply side simple but introduces inequality and basic needs.

The paper is broadly related to the literature on optimal climate change policy. This strand of literature generally focuses on a representative household and environmental taxation (compare Acemoglu et al., 2016; Golosov et al., 2014).

More specifically, the paper connects to the discussion of optimal environmental policy in a distortionary fiscal setting. Barrage (2020) quantifies how the requirement to generate government funds drives a wedge between the social costs of carbon, i.e., the Pigouvian rate, and the optimal environmental tax in an integrated assessment model with carbon cycle.[10] As already alluded to, Bovenberg and De Mooij (1994) discuss the advantage of recycling environmental-tax revenues to lower distortionary labour taxes instead of increasing transfers. Jacobs and van der Ploeg (2019) add inequality and non-linear Engel curves to the setting in Bovenberg and De Mooij (1994). This latter feature makes redistribution affect the demand of the polluting good. While the paper by Jacobs and van der Ploeg (2019) nests the present model as a special case, the present one studies the effect of distinct intensities of the non-linearity due to varying degrees of social responsibility.

Finally, in the sense that demand initiates the transition to sustainability, the project adds to the literature on structural transformation (for an overview, see Herrendorf et al., 2014). Introducing a penalty term to capture the importance of basic needs when income is low allows for inequality and redistribution to matter for the economic structure. That is not the case under the frequently used Stone-Geary preferences because marginal propensities to consume either good are independent of income. In this regard, the model relates to the work by Matsuyama (2002) and Foellmi and Zweimüller (2008) who both employ hierarchical consumption preferences. Yet, in contrast, the present paper's model does not assume a fixed hierarchy of goods a priori. This seems to be a better fit for the distinction of goods along the dimension of sustainability.

Outline The remainder of the paper is structured as follows. Section 2 provides an empirical motivation for the model and exercise. A description of the model follows in section 3 and of the calibration in section 4. Section 5 shows Engel curves to highlight the impact of social responsibility on inequality and the externality. In section 6, results are presented and discussed. Sensitivity checks follow in section 7. Section 8 concludes.

[10] This mechanism had already gained some attention in the public finance literature (for instance Bovenberg and Goulder, 1996; Bovenberg and De Mooij, 1994): the optimal tax falls short to fully account for the social cost of carbon as the government internalises how the environmental tax reduces the ability to generate funds.

2 Empirical motivation

2.1 Social responsibility

The present paper's focus lies on the role of social responsibility: households' willingness to pay a premium for the avoidance of negative environmental externalities. Examples of such sustainable choices are the purchase of organic vegetables instead of conventional ones to avoid the usage of fertilisers or the consumption of energy from sustainable sources instead of carbon-high alternatives.

Social responsibility can be motivated by image concerns, perceived governmental inaction, social pressure, or ideals and personal norms, to only name a few (for a discussion from an economic perspective compare Bénabou and Tirole, 2010; Joshi and Rahman, 2015, provide an overview of psychological aspects).[11]

Rising concerns about climate change are named as one reason why social responsibility has increased recently. Indeed, attitudes towards climate change have been changing during the last decade. Data of the *Climate Change in the American Mind* project (Yale Program on Climate Change Communication (YPCCC) and George Mason University Center for Climate Change Communication (Mason 4C), 2020), a representative survey for the US population, demonstrates this: the percentage of US Americans being worried has risen steadily since 2010 from roughly below 50% in 2010 to close to 70% in 2019.[12] In line with this observation, the willingness to pay for sustainable products has been rising, too. In a sample of 60 countries, The Nielsen Company (2015) finds that in 2015 66% of households were willing to pay a premium for sustainable brands, compared to 50% in 2013.

However, the willingness to pay only reflects an intention and not actual behaviour. Indeed, the market share of sustainable consumer packaged goods in the US only rose from 14.3% in 2013 to 16.6% in 2018 (Kronthal-Sacco et al., 2020). These numbers seem to fall short of the relatively high willingness to pay and positive environmental attitudes. The gap between attitudes and intentions, on the one hand, and actual consumer behaviour, on the other hand, can be explained, for example, by the availability and convenience of sustainable goods, economic education, or habits.[13] The present paper focuses on price premia and

[11] In most of the literature on sustainability consulted, the term *sustainability* refers not only to environmental externalities but also to social and economically ones such as the treatment of livestock and the payment of fair wages. However, as found by a study conducted in 2019 by The Conference Board (2020), the main aspect of sustainability motivating global and North American households to pay a premium is the environmental externality which is the focus of this paper.

[12] For the respective graph the reader is referred to figure 11 in appendix section A.1.

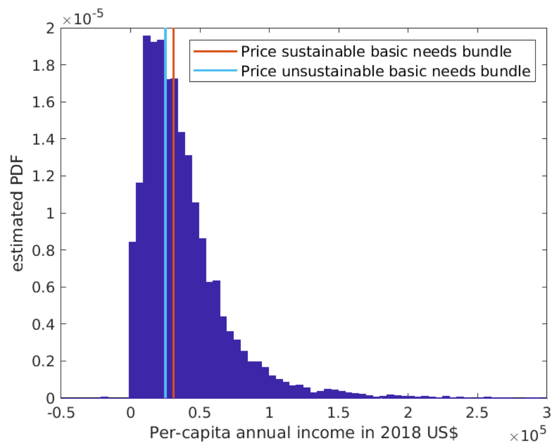
[13] For a recent qualitative study on the attitudes-intention-behaviour gap for the US see ElHaffar et al. (2020). Joshi and Rahman (2015) and Vermeir and Verbeke (2006) provide an overview of relevant literature.

income as reasons why actual behaviour falls short of attitudes.[14]

2.2 Income and basic needs

Imagine the rise in attitudes and social responsibility continues:[15] what is the effect on optimal policy in the light of income inequality and price premia? This central question of the paper gains in relevance when households are indeed too poor to consume sustainable goods. That is, they cannot ensure the satisfaction of their basic needs with sustainable goods. Figure 1 highlights the question's relevance by comparing a histogramme of per-capita disposable income in 2018 to the estimated costs to cover basic needs[16] with sustainable goods or unsustainable goods alone, depicted by the orange and the light blue line, respectively.

Figure 1: Distribution of per-capita disposable income in 2018



The plot is based on annual income data from the Panel Survey of Income Dynamics (PSID), and disposable income is derived using TAXSIM estimates of family income. As an objective measure of basic needs I refer to the consumption bundle calculated by the *Institute for Women's Policy Research* (IWPR).[17] For a single-adult household annual expenses to cover basic needs amount to US$ 25,128 in unsustainable and to US$ 30,752 in

[14] Price premia were found to be the main reason impedeng the purchase of environmentally friendly products for 41% of respondents in North America (The Conference Board, 2020).

[15] This can plausibly be the case as climate change and weather catastrophies continue threatening humans around the globe and in the US in particular. Other reasons are policies which target ethic consumption decisions such as product labeling.

[16] Objective basic needs are perceived as a minimum consumption level of which it is reasonable to argue that its sufficient satisfaction has priority above consuming according to environmental attitudes. In contrast, subjective basic needs which result from observed consumption, could well be altered when a household becomes more socially responsible. The research question, therefore, more precisely boils down to: what is the effect of a change in social responsibility if households reduce their consumption to a minimum.

[17] A variety of basic needs measures by different organisations for areas in the US exist. Gordon M. Fisher (2012) gives an overview of distinct measures for the US since 2006. The one provided by the IWPR has been choosen as it provides a nation-wide measure and necessary expenses by consumption category are presented.

sustainable quality. Sections A.2 and A.3 provide more information on data manipulations and definitions.

In 2018, 44.96% of US households did not have the financial means to purchase basic needs in a sustainable quality alone. They are to the left of the orange line in figure 1. I define these households as *basic needs-constrained* or *poor* since their financial means do not accommodate the satisfaction of basic needs to any arbitrary level of social responsibility. On average, rich households can afford 2.1 basic-needs bundles in sustainable quality and 2.5 of the unsustainable one. In contrast, low-income households can only afford to cover 56% of their basic needs if they only bought sustainable goods and 69% with unsustainable goods.

Accepting that basic needs take priority to consumption according over climate-change attitudes, these numbers imply that a high share of households cannot adjust their demand according to their attitudes towards climate change. Even if social responsibility is low and households only want to consume a small budget share of the sustainable good, inequality in the US prevents corresponding consumption. A fraction of 36% was financially incapable of covering basic needs with the unsustainable good alone, to the left of the light-blue line in the figure. Hence, observed income inequality reduces the effectiveness of consumers' social responsibility to induce a demand-driven transition towards sustainable production. Whether social responsibility is effective to reduce the externality under the optimal policy will be studied in course of this paper.

3 Model

3.1 Model and competitive equilibrium definition

Households The economy is populated by a unit mass of households. A share λ is rich and characterised by a high effective labour productivity z_h. The share of low-income households, $(1-\lambda)$, is less productive with $z_l < z_h$. Otherwise, households are the same in all remaining aspects.

A generic household chooses labour supply, unsustainable, and sustainable consumption

Other budgets refer to finer defined geographic areas to account for differences in minimum living costs across the US, a dimension this paper abstracts from.

to maximise lifetime utility according to:

$$\max_{\{c_s\}_{t=0}^{\infty},\{c_{nt}\}_{t=0}^{\infty},\{l_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(c_t, l_t; H_{nt}) \tag{1}$$

s.t.

$$p_{st}c_{st} + c_{nt} \leq w_t(1-\tau_{lt})zl_t + T_t \qquad \forall t \geq 0, \tag{2}$$

$$l_t \leq L \qquad \forall t \geq 0, \tag{3}$$

$$c_t = \begin{cases} \left(\omega^{\frac{1}{\sigma}} c_{st}^{\frac{\sigma-1}{\sigma}} + (1-\omega)^{\frac{1}{\sigma}} c_{nt}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} & \text{if } \sigma \neq 1, \\ c_{st}^{\omega} c_{nt}^{1-\omega} & \text{if } \sigma = 1. \end{cases} \tag{4}$$

Each period, the household receives income from lump-sum tranfers T and effective labour wzl, of which a fraction τ_l has to be paid as taxes. The choice of a linear labour tax is not innocent as a fully non-linear labour tax allows to correct for distributional effects of the environmental tax. I follow Jacobs and van der Ploeg (2019) who argue that a linear labour tax serves as a benchmark for the piece-wise linear tax schemes observed in reality which are not able to fully compensate for distributional effects of the environmental tax. The real wage, w, and the sustainable good's price, p_s, are denoted in units of the unsustainable good, c_n, which serves as numeraire. Total economic time endowment is denoted by L.

The household problem reduces to a static one as the model abstracts from capital, saving technologies and carbon cycles. Therefore, in what follows, time indices are dropped for simplicity.

Social responsibility The consumption goods, c_s and c_n, provide the same utility in terms of quantities consumed but differ with respect to the externalities occuring in the production process. The weight on sustainable consumption, ω, in the constant elasticity of substitution aggregator, equation 4, determines the willingness to pay for sustainable goods. As this parameter rises, households are willing to give up more units of the unsustainable good for an additional unit of the sustainable one. Therefore, ω is referred to as social responsibility. Goods are aggregated as imperfect substitutes in the composite consumption good emphasising their different ability to satisfy social responsibility concerns.

The period utility function is given by

$$U(c, l; H_n) = u(c, l) - penalty(\widehat{c}; \bar{c}) + g(H_n). \tag{5}$$

The felicity function u is strictly increasing and strictly concave in composite consumption,

c, and leisure, $L - l$.

The penalty term, $penalty(\widehat{c}_t; \bar{c})$, drives a wedge between social responsibility and actual consumption. The wedge depends on the gap between the sum of goods consumed and basic needs. Individual consumption goods enter as perfect substitutes: $\widehat{c} = c_n + c_s$. This assumption captures that goods are equal with the consumption service they provide to cover basic needs. It holds that: $penalty(\widehat{c}) \geq 0 \ \forall \widehat{c}$. The function is strictly decreasing in $\widehat{c}$ and approaches zero as $\widehat{c} \to \infty$. The period utility function is calibrated such that the penalty term reduces utility quickly when quantities consumed fall below basic needs, $\bar{c}$. This urges affected households to lay more emphasis on maximising the sum consumed instead of consuming in line with their taste for social responsibility. Throughout the paper this model is referred to as *baseline* model and a model without penalty term as *standard* model.

To gain some intuition on how the penalty term affects household decisions, eqautions 6 and 7 show optimality conditions for unsustainable consumption and labour, respectively. Assuming that $u(c,l) = log(c) - \chi \frac{l^{1+\frac{1}{\theta}}}{1+\frac{1}{\theta}}$ and replacing the first order condition for sustainable consumption, optimality conditions read:

$$c_n^{\frac{1}{\sigma}} = p_s \left(\frac{1-\omega}{\omega} \right)^{\frac{1}{\sigma}} c_s^{\frac{1}{\sigma}} - (p_s - 1) \frac{\partial penalty(\widehat{c}; \bar{c})}{\partial c_n} \frac{c^{\frac{\sigma-1}{\sigma}} c_n^{\frac{1}{\sigma}} c_s^{\frac{1}{\sigma}}}{\omega^{\frac{1}{\sigma}}} \tag{6}$$

$$\chi l^{\frac{1}{\theta}} = w(1-\tau_l) z \underbrace{\left(c^{\frac{1-\sigma}{\sigma}} (1-\omega)^{\frac{1}{\sigma}} c_n^{\frac{-1}{\sigma}} - \frac{\partial penalty(\widehat{c}; \bar{c})}{\partial c_n} \right)}_{=\mu}, \tag{7}$$

where the letter μ indicates the shadow value of income. Absent the penalty term, equation 6 coincides with the result in the standard model and unsustainable consumption is a constant fraction of income. Note that $\frac{\partial penalty(\widehat{c}; \bar{c})}{\partial c_n}$ is negative which implies that, whenever the sustainable good is more expensive, that is $p_s > 1$, unsustainable consumption is higher than in the standard model.

Although sustainability might be valuable to these poor households, their unsustainable demand remains high. As income rises, the penalty term vanishes and households start to recompose their budget to eventually consume at the *desired* ratio, i.e., the ratio which is in line with social responsibility as it maximises the composite consumption good given prices. From this income level onward, a marginal increase in income does not cause a reallocation of consumption shares and demand coincides with the one in the standard model. When the unsustainable good is more expensive, unsustainable consumption is below its standard counterpart.

Social responsibility diminishes the importance of the penalty term on unsustainable demand.[18] As the more expensive good provides more and more consumption utility through the felicity function, the household accepts a rise in the penalty term to consume closer to the desired consumption ratio. It follows that the unsustainable good becomes inferior at lower income levels already (if $p_s > 1$).

Basic needs impact the labour supply decision through the shadow value of income, equation 7. When basic needs are not sufficiently satisfied and the penalty term is distinct from zero, labour supply is higher than in the standard model since additional income is more valuable to the household.

These preferences capture two mechanisms through which income and environmental foodprint are related: first, poor households consume more unsustainable goods due to a lack of income. Second, rich households' consumption has a negative effect on the environment through high levels of composite consumption.

Externality Households suffer from the size of the unsustainable sector which they take as given, represented by the strictly decreasing, convex function $g(H_n)$. To motivate this specification, think of households understanding the connection between unsustainable production and the environmental externality. The size of the unsustainable sector, captured by its labour input, H_n, is associated with a higher risk of climate catastrophies which lowers utility. The household may suffer from the potential to be hit directly by disastrous events. Moreover, the disutility can be motivated by the household feeling empathetic with people around the globe or future generations whose risk to experience the consequences of climate change rise trough the size of unsustainable output.

The modelling choice assumes that households act responsibly motivated, for example, by the desire not to contribute to a worsening of climate conditions, ethical or social norms. Responsible behaviour is irrespective of whether they perceive their action to have an impact on the environmental externality. [19]

[18] Note that $\frac{c^{\frac{\sigma-1}{\sigma}} c_n^{\frac{1}{\sigma}} c_s^{\frac{1}{\sigma}}}{w_s^{\frac{1}{\sigma}}} = c_s c_n \left(c_n^{\frac{1-\sigma}{\sigma}} + \left(\frac{1-w_s}{w_s}\right)^{\frac{1}{\sigma}} c_s^{\frac{1-\sigma}{\sigma}} \right)$.

[19] An alternative modelling approach would be to have households internalise a fraction of the externality. A rise in social responsibility would then be designed as a rise in the share internalised. Both approaches capture distinct motives for sustainable consumption. The one studied here also incorporates phenomena such as social pressure, warm glow, the perception to act morally right and to contribute. The alternative model, in contrast, only captures perceived effectiveness to have an impact through consumption. Furthermore, the alternative approach leaves the efficiency level of the externality unchanged, whereas the baseline model does not: the utility derived from either good changes with social responsibility. As a result, when household derive less utility of the polluting good, a social planner would implement a lower level of unsustainable output. This aspect is aimed to be captured in the model.

Production Individual consumption goods are produced by a sustainable and an unsustainable sectors according to the following production function

$$Y_j = A_j H_j, \text{ for } j \in \{s, n\}. \tag{8}$$

While the sustainable sector does not cause negative externalities, the unsustainable one does. Profits of the sustainable and the unsustainable sector are given by

$$\pi_s = p_s Y_s - wH_s \tag{9}$$

$$\pi_n = p_n Y_n - w(1 + \tau_n) H_n. \tag{10}$$

The government levies ad-valorem excise taxes on unsustainable labour, τ_n. This choice is similar to Golosov et al. (2014) and Barrage (2020) who both consider excise taxes levied on energy producers. The present model abstracts from an energy sector implicitly assuming that the unsustainable sector produces in a dirty fashion. Accepting further that the use of dirty energy is positively associated with labour input, environmental taxes are levied on labour input of the unsustainable good to generate additional costs similar to a model with energy sector.[20]

Government The government maximise a Utilitarian social welfare function by the use of the environmental tax and the distortionary labour tax. It redistributes revenues to households as lump-sum transfers and runs a balanced budget:

$$T = \tau_l wH + \tau_n wH_n, \tag{11}$$

where $H = \lambda z_h l_r + (1 - \lambda) z_l l_p$. The Ramsey planner internalises the optimal behaviour of households and firms given taxes and transfers when maximising the social welfare function.

[20] Some algebra reveals that the ad-valorem excise tax is equivalent to an ad-valorem sales tax levied on unsustainable output. The unsustainable firm's problem under a sales tax becomes: $(1 - \widehat{\tau_n})Y_n - wH_n$ and equilibrium prices become $\widehat{w} = A_n(1-\widehat{\tau_n})$ and $\widehat{p_s} = \frac{A_n}{A_s}(1-\widehat{\tau_n})$. Since the environmental tax in both versions only affects prices directly, it follows that the equilibrium allocation is the same if $\tau_n = \frac{1}{1-\widehat{\tau_n}} - 1$. Results for a model with a corrective tax on unsustainable consumption are qualitatively and quantitatively similar to the ones from the baseline model. While a consumption tax leaves prices constant, the labour market distortion results from complementability of unsustainable consumption and leisure (compare Jacobs and van der Ploeg, 2019).

Market clearance To close the model, it is required that goods and labour markets clear in equilibrium:

$$\lambda c_{sr} + (1-\lambda)c_{sp} = Y_s \tag{12}$$

$$\lambda c_{nr} + (1-\lambda)c_{np} = Y_n \tag{13}$$

$$\lambda z_h l_r + (1-\lambda)z_l l_p = H_s + H_n. \tag{14}$$

Competitive equilibrium A competitive equilibrium is defined as an allocation $\{c_{nr}, c_{np}, c_{sr}, c_{sp}, l_r, l_p, H_s, H_n\}$, a set of prices $\{p_s, w\}$ and a tax system $\{\tau_n, \tau_l, T\}$ such that
(i) households maximise their lifetime utility, equation 1, subject to their budget and time constraint in each period, equations 2 and 3,
(ii) in each period sustainable and unsustainable firms maximise profits, equations 10 and 9,
(iii) the government maximises the social welfare subject to a balanced budget, equation 11, and
(iv) markets for the consumption goods, equations 13 and 12, and labour, 14, clear.

Appendix C collects all equations characterising a competitive equilibrium.

Ramsey problem The Ramsey planner's problem is defined by use of a primal approach which goes back to Lucas and Stokey (1983). In this approach, the optimal allocation is found by maximising the social welfare function, subject to the behaviour of firms and households and feasibility, and replacing pices and policy instruments by optimality conditions which hold in a competitive equilibrium. The planner chooses an allocation; prices, taxes and transfers are then backed out to implement the optimal allocation. Section D in the appendix lays out the Ramsey problem. The proofs to show (1) that the resulting optimal allocation can be implemented as a competitive equilibrium and (2) that a competitive equilibrium satisfies the constraints on the Ramsey planner's problem follow Barrage (2020).

4 Calibration

To calibrate the model, the following functional forms are assumed

$$
\begin{aligned}
u(c,l) &= \log(c) - \chi \frac{l^{1+\frac{1}{\theta}}}{1+\frac{1}{\theta}} \\
penalty(\widehat{c};\bar{c}) &= \frac{1}{\phi}\exp(-\phi(c_n + c_s - \bar{c})) \\
g(H_n) &= -\psi H_n^{\eta}.
\end{aligned}
$$

The model depends on five sets of parameters. Those that govern consumption prefernces, $\phi, \bar{c}, \sigma, \omega$, labour supply L, χ, θ, inequality, z_h, z_l, λ, production, A_n, A_s, and the externality η, ψ. In its initial steady state, the model is calibrated to the US economy in 2018. Table 2 in appendix B, provides an overview of all parameters, their target and the calibrated value.

The parameters governing inequality and basic needs, $\bar{c}$, are calibrated by comparing micro data on disposable household income from the PSID using tax estimates from TAXSIM to expenses required to satisfy basic needs defined by the IWPR as discussed in appendix A.2, A.3, and section 2. A share of $\lambda = 0.55$ of US households is found to be able to fully cover basic needs with sustainable goods and is therefore considered *rich*. Output and income measures are expressd in terms of the basic needs bundle which is normalised to $\bar{c} = 1$. The unsustainable good is the numeraire. Thus, unsustainable output of $Y_n = 1$ is, for instance, equivalent to one annual basic needs bundle of unsustainable goods and one unit of output in the sustainable sector $Y_s = 1$ equals one annual basic needs bundles of the sustainable good.

Effective labour productivity of the poor, z_l, is chosen to match average income of the poor in 2018 in terms of unsustainable basic needs: 0.69. To ensure consistency with total per-capita output in $US, total income of the rich is the difference between GDP and total income of the poor. As a result, average household income of a rich household in the model overestimates income in the data. This approach is nevertheless followed since this project's focus rests on the financial capacity of low income households. Aggregate output is equally important as it determines the economies ability to satisfy basic needs. This approach results in $z_l = 0.02$, $z_h = 2.5$ and $A_n = 8.44$.

The parameter which governs the importance of basic needs, ϕ, is set to 15. This value allows to solve the model for relatively low income levels while, at the same time, ensuring a decent importance of the penalty term when income is low. Given this value of ϕ, one can calculate the price elasticity of substitution of households which are unconstrained by basic needs, σ, from micro data. It is calculated to equal 1.73 based on the study by Chen et al.

(2018) for organic and conventional milk[21], are matched. The calibrated value is reasonable in that σ determines the elasticity of substitution between the unsustainable and the sustainable good in the composite consumption function which captures how the way a good is produced matters for utility. Hence, as regards their production process goods are no close substitutes but have contrary characteristics. This renders high values of σ implausible. The goods are no complements either as it would be counterintuitive if utility from sustainable consumption can only be derived if there is unsustainable consumption, too.

The parameter determining social responsibility in the baseline calibration, ω, is chosen to make model equations consistent with the market share of sustainable goods in 2018, which is taken from Kronthal-Sacco et al. (2020), and given calibrated productivity of rich and poor households. This approach leads to a value of $\omega = 0.24$. Therefore, on average, households derive a higher utility from unsustainable consumption. This seems questionable since the unsustainable good is inferior as regards concerns about climate change. How can it be preferred by consumers? The reason is that the model only explicitly accounts for income and price differentials to explain the attitudes-behaviour gap discussed in section 2. Therefore, ω captures not only attitudes but also factors other than income and prices which decouple attitudes from actual consumption behaviour. For example, the utility derived from unsustainable consumption can be higher as these goods are easier available or are in line with habits.

Total time endowment is calibrated to match 14.5 hours per day (following Jones et al., 1993) and normalised to 1. The Frisch elasticity, θ, is set to 0.75 as suggested by Chetty et al. (2011) who search to reconcile micro and macro estimates. The disutility of labour, χ, ensures that total labour supply matches the average hours worked in 2018 in the US normalised by total hours provided by the OECD which is 0.34. The resulting value is $\chi = 43.06$.

The relative price observed for the food bundle in 2018, $p_s = 1.56$, is used to inform the production gap between the sustainable and unsustainable sector. It follows that the unsustainable sector produces 56% more output per unit of labour input and $A_s = 5.4$. This price difference is used instead of the one resulting from the relative price of the sustainable versus unsustainable needs bundle since the expenditure categories in the basic needs bundle are rather broad and do not allow to decide more granularly whether a sustainable counterpart exists. This most likely reduces the relative price of the sustainable bundle which is found to equal 1.22. This approach is subject to caveats. For instance, it only relies on price differentials in selected food markets, market imperfections such as monopolistic powers, and price stickiness are abstracted from. However, the production gap is a crucial parameter in the model. Section 7, therefore, discusses results for a lower productivity gap.

[21] Section B.1 expounds the derivation of the price elasticity of substitution.

Calibration of the parameters, χ, A_n, A_s, z_h, z_l, is done jointly by ensuring that the model rationalises observed labour supply, output, prices and household income in the base year.

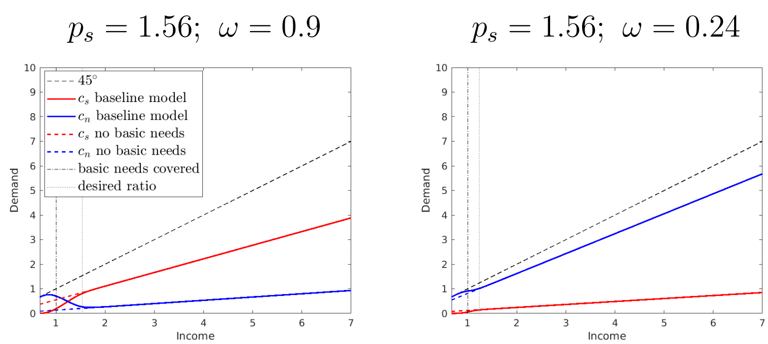
The labour tax rate is set to the value reported in Barrage (2020) for the US, $\tau_l = 0.24$. The tax on unsustainable labour input is set to $\tau_n = 0$.

Externality parameters are chosen to make a rich household willing to give up 2% of its annual unsustainable consumption for a 1% reduction in unsustainable labour input in 2018. It is also ensured that the function is convex.

5 Social responsibility and redistribution

To better understand the effects of social responsibility on optimal redistributive policy, this section discusses Engel curves. Not only does social responsibility alter the effectiveness of redistribution as an environmental policy measure, but also does it change the severity of income inequality[22].

Figure 2: Engel curves



Labour taxation as environmental policy In the standard model, distortionary labour taxation is used as an environmental policy by bluntly slowing down aggregate production and thus the externality: the *efficiency channel of environmental policy.* The externality reduction follows a decrease in labour supply. In the baseline model, there is a second mechanism that adds to the effectiveness of labour taxation: the *redistribution channel of environmental policy.* Figure 2 motivates this mechanism.

Each plot in figure 2 depicts demand as a function of income for two different values of social responsibility, a low one, $\omega = 0.24$ on the left, the calibrated value in 2018, and a high one, $\omega = 0.9$, on the right. The sustainable price is fixed at $p_s = 1.56$, corresponding to an environmental tax equal to zero in the baseline calibration. The equivalent plots for

[22] By *severity* in relation to income inequality I refer to how income translates to inequality in composite consumption and, hence, utility.

a scenario with a sustainable price below unity are presented in section E in the appendix. Demand for the unsustainable good is plotted in blue and for the sustainable one in red. The solid graphs refer to the baseline model with basic needs. The dashed ones refer to the equivalent variable in the standard model.

Consider, first, the left-hand plot in figure 2 with $\omega = 0.9$ and a rich and a poor household with an income level of 2 and 1,[23] respectively. In the baseline model, transferring a marginal unit of income lump-sum from the rich to the poor results in a reduction of unsustainable and an increase in sustainable demand on aggregate. The rich household reduces both sustainable and unsustainable consumption to keep the ratio constant at the desired ratio. The poor household, in contrast, who is rich enough to cover basic needs with the cheaper alternative is now able to recompose the consumption bundle towards the more preferred sustainable good: the household reduces unsustainable consumption and raises sustainable consumption by more than $\frac{1}{p_s}$. The unsustainable good is inferior to the poor household.

On the other hand, considering an initial income of the poor household sufficiently below unity, lump-sum redistribution has the contrary effect. In this scenario, the poor household is financially unable to satisfy its basic needs with the cheaper good. An additional unit of income is then mainly spent on the unsustainable, cheaper good. On aggregate, unsustainable production rises. Income of poor households is, therefore, especially important for the size of transfers required to make redistribution negatively affect the externality.

Focusing on the right-hand plot, which depicts Engel curves with $\omega = 0.24$ reveals, first, that unsustainable demand for all household types is at least as high as in the high-responsibility world. Furthermore, the effectiveness of redistribution as an environmental policy instrument strongly depends on households' taste for sustainability. Lump-sum transferring one unit of income to the poor leads to a negligibly low reduction of unsustainable consumption. The reallocation of consumption bundles is muted as the consumed ratio of goods at an income level below unity is closer to the desired allocation. Moreover, the unsustainable good becomes inferior only after a higher income level than in the high-responsibility world. Redistribution is more effective when social responsibility is high so that the poor are more eager to recompose their consumption shares.

Social responsibility and inequality While social responsibility reduces the externality, its effect on equity is detrimental. To see this, note that the recomposition of the consumption bundle is extended up to a higher income level when social responsibility is high. Thus, a higher income is needed for poor households to align demand with their concerns about climate change. Note further that the utility rise resulting from one more unit of income to a

[23] These levels of income buy 2 and 1 units of the basic needs bundle in unsustainable quality, respectively.

household that does not consume the desired ratio is higher than the utility increase resulting from one more unit of income to a household that already consumes the desired ratio. This *recomposition effect* makes more redistribution optimal as social responsibility rises.[24]

All in all, the effect of a rise in social responsibility on the externality and inequality is ambiguous. On the one hand, the induced shift in demand makes less government intervention for environmental concerns needed leaving more room for redistribution. On the other hand, social responsibility has adverse effects: as inequality becomes more severe, the government might accept higher externality levels for the sake of efficiency costs.

6 Results

This section is structured as follows: the optimal policy and allocation as a function of social responsibility are shown and the latter are discussed in section 6.1. Section 6.2 quantifies the effect of the redistribution channel of environmental policy and shows that the government deliberately uses labour taxation as an environmental policy instrument. Finally, section 6.3 discusses the results: What makes the optimal policy optimal?

6.1 Optimal Policy and Allocation

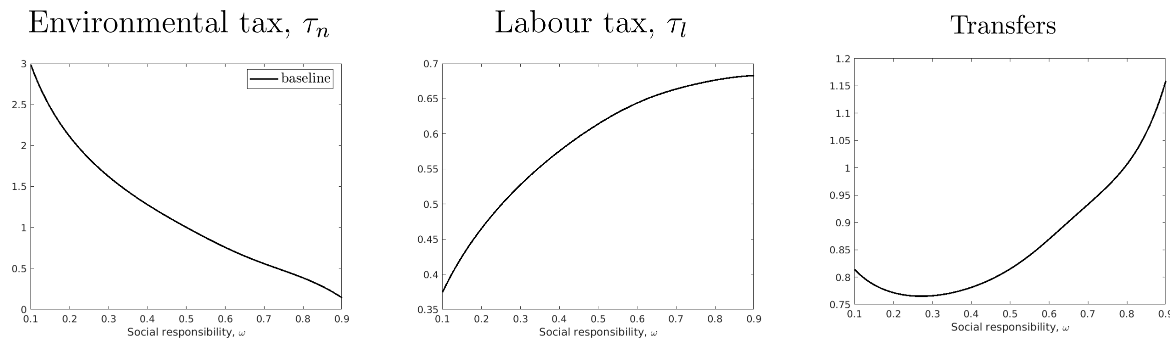
We are now equipped to run the main experiment: exogenously changing the degree of social responsibility shared by households. What is the optimal policy as households become more willing to pay for the avoidance of the externality?

6.1.1 Optimal policy

Figure 3 shows how optimal taxes and transfers vary with social responsibility. It stands out that the optimal policy mix shifts towards redistribution as social responsibility rises. This is the first main result. When social responsibility is relatively low as in the baseline calibration with $\omega = 0.24$, a high environmental tax of $\tau_n = 1.87$ characterises the optimal policy: that is, unsustainable producers' tax burden amounts to1.87 times their production costs. The optimal labour tax for the baseline calibration is $\tau_l = 0.49$; the government charges roughly half of a household's labour income. Transfers equal 77% of the basic needs bundle in unsustainable goods.

[24] In contrast to the standard model, where income inequality and consumption inequality, measured by the Gini coefficient, coincide, the same distribution of income translates to a higher inequality of consumption in the baseline model. The discrepancy between income and consumption inequality increases with social responsibility when the sustainable good is more expensive.

Figure 3: Optimal policy



As social responsibility rises to the highest value of $\omega = 0.9$ considered, the environmental tax steadily reduces to 14%, and the labour tax increases to 68%. Transfers reach their peak with 1.16 units of the unsustainable needs bundle.

6.1.2 Optimal allocation

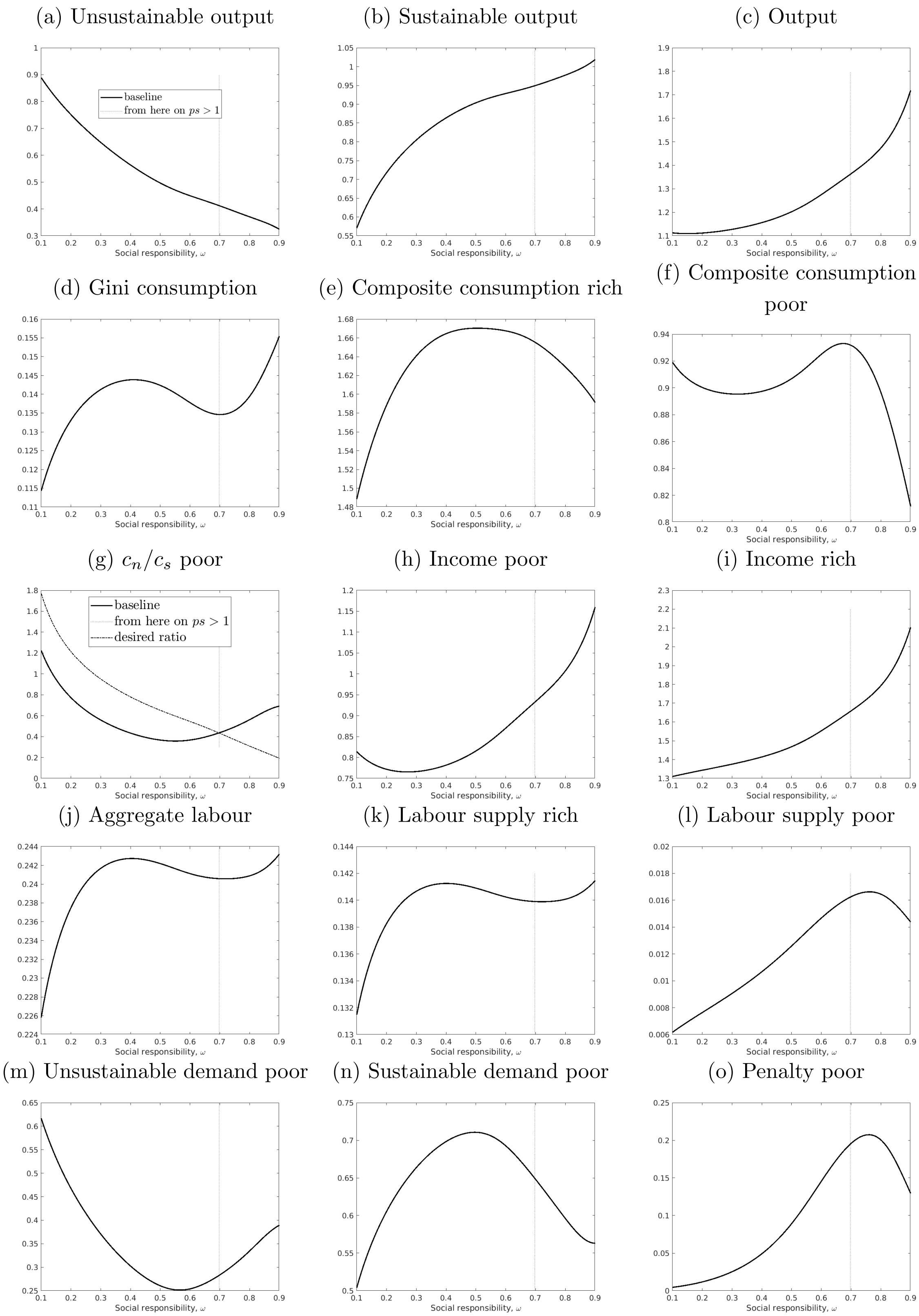
Figure 4 depicts some key variables under the optimal policy as a function of social responsibility. The solid line reflects the variable; the dotted vertical line indicates when the sustainable good becomes more expensive than the unsustainable one.

Output First, unsustainable output, that is the externality, falls by more than 50% from 0.69 when $\omega = 0.24$ to 0.32 at $\omega = 0.9$. Sustainable output rises with social responsibility from 0.74 to 1 basic need bundles, compare panels (a) and (b), respectively. This is driven not only by the shift in demand towards sustainable goods but also by policy interventions.[25] The output of both sectors displays retardation in the rise/drop as social responsibility increases (roughly at $\omega = 0.55$). As the environmental tax reduces, the price premium for sustainable goods rises, compare panel (c) in figure 14 in appendix F, which slows down the demand-driven rise in sustainable output and the drop in unsustainable output through consumption by the rich. Unsustainable demand by the poor, panel (m) in figure 4, even resurges once the sustainable good becomes too expensive and the poor revert to unsustainable consumption to cover basic needs despite a stronger taste for sustainability. Sustainable demand by the poor, plot (n), mirrors this pattern.

The rise in aggregate output from 1.09 units of the unsustainable bundle to 1.68 is explained by two forces: first, a rise in labour supply as the wage rate rises, panel (j), increases output. Second, a reduction in the environmental tax implies a reduction in distortions of

[25] Figure 13 compares allocations in the laissez-faire economy to the one under optimal policy to differentiate the effect of the change in preferences from policy interventions.

Figure 4: Optimal allocation



labour allocations.[26]

Inequality The Gini coefficient of consumption, plot (d), also rises with social responsibility but not monotonically: there is a downward sloping part starting from a value of social responsibility of approximately $\omega = 0.4$ to slightly below $\omega = 0.7$. To better understand how the Gini moves with social responsibility, panels (e) and (f) show composite consumption by household type. Composite consumption is affected by three factors. First, the change in social responsibility mechanically alters composite consumption as the weight on individual consumption goods changes and households react to this change in preferences. Absent any policy intervention, this implies that the desired bundle becomes more expensive with social responsibility and, at a constant level of income, composite consumption reduces; compare the laissez-faire allocation in figure 13. Second, taking into account optimal policy, both income and the sustainable good's price become an increasing function of social responsibility; compare panel (h) and panel (c) in figure 14 which shows additional variables. This explains the inverted U-shaped behaviour of composite consumption of the rich: at the upward sloping part, income is low and the price of the more preferred good is high. As income rises and the unsustainable good becomes less expensive, the composite consumption of the rich increases. The rise in composite consumption stops once the continuing rise in income is not enough to make up for the desired bundle becoming more expensive again.

Composite consumption of the poor is affected by a third factor: basic needs. Not only is their composite consumption lower than that of rich households due to a lower quantity of the composite bundle consumed, but also because they do not allocate their income to maximise composite consumption for the given price, the desired ratio. Panel (g) shows how the actual consumption ratio of the poor deviates from the desired one, the dashed-dotted graph.[27] When the unsustainable good is more expensive, to the left of the vertical indicator, the poor consume a higher share of the sustainable good; this pattern reverses once the unsustainable good becomes the cheaper alternative.

Why the movements in the actual-desired consumption gap? When the unsustainable

[26] With a non-zero environmental tax, labour is not allocated to maximise the composite consumption good given productivities but distorted by the environmental policy. This effect is present also in a representative agent model absent basic needs. Market clearance, utility-, and profit maximisation imply

$$\frac{h_s}{h_n} = (1 + \tau_n)\frac{\omega}{1 - \omega}.$$

The environmental tax renders the sustainable sector relatively more productive in the eyes of the agents. But it is not and aggregate output reduces.

[27] The equivalent graph for the rich is shown in panel (a) figure 14. The rich are always capable to consume the desired ratio. Panel (b) of the same figure shows the actual-desired consumption gap of the poor measured as Euclidean norm.

good is more expensive, a rise in the sustainable price implies convergence of both good's prices which allows poor households to consume closer to the desired ratio. Once the sustainable good is more expensive, a further rise widens the price differential and the poor consume further away from the desired ratio. In addition, when the sustainable good is cheaper, a rise in social responsibility reduces the gap since the desired bundle becomes cheaper. In contrast, as the sustainable good is more expensive the rise in social responsibility intensifies the gap. The rise in income of the poor adds to closing the gap between actual and desired consumption. A reduction of the gap implies a rise in composite consumption.

Since there is a reduction of the gap until the sustainable price exceeds unity, the initial small reduction of composite consumption by the poor is driven by a reduction in income; compare panel (h). Roughly, as income starts to rise, the composite consumption of the poor reaches a trough. The fall in the actual-desired consumption gap adds to the rise in composite consumption until the sustainable good becomes more expensive than the unsustainable one. From here on, the widening of the gap amplifies the reduction in composite consumption of the poor relative to the reduction in composite consumption by the rich.

The initial rise of the Gini of consumption is, thus, explained by a reduction of income of the poor while consumption of the rich rises. It reduces once composite consumption of the poor increases faster than that of the rich as they can close the actual-desired consumption gap. As the unsustainable good eventually becomes cheaper, and the gap widens again, consumption of the poor reduces faster and the Gini of consumption increases.

Labour supply Aggregate labour supply is shown in panel (j) followed by household-specific supplies in panels (k) and (l). The aggregate level mainly reflects labour supply of the rich as they are characterised by a very high effective labour productivity. Absent policy intervention, labour supply is constant except for a rise in labour supply by the poor; compare figure 13 in appendix F.[28] The movements in labour supply are, therefore, the effect of taxes and transfers.

The initial rise in labour supply is driven by the strong reduction in the environmental tax. The higher wage rate makes the rich want to work more. The slow down in the reduction of the environmental tax and the rise in labour taxes diminishes the rise of after-tax wages; compare panel (e) in figure 14. This adds to the subsequent reduction in labour supply. The rise in transfers additionally mitigates work efforts by the rich. As the rise in the after-tax wage accelerates again, labour supply by the rich rises.

Labour supply of the poor tells a different story. For this household group the penalty

[28] The rise in labour supply by the poor in the laissez-faire economy is driven by an increase in the penalty term. As social responsibility rises, the poor eventually accept a lower sum consumed at the expense of a higher penalty. This makes them willing to work more.

term determines the pattern of labour supply; compare panels (l) and (o). The high penalty term increases the shadow value of income so that the household is willing to work more. Despite the rise in transfers and income, this household type experiences a reduction in the sum consumed as social responsibility rises. When the sustainable good is cheaper, the shift in social responsibility towards the sustainable good should imply at most no reduction in the quantity consumed. However, the parallel increase in the sustainable price outweighs this effect. So that the sum consumed falls. After the sustainable good becomes more expensive than the unsustainable good, the penalty term reduces again, although tastes become more expensive. This reduction is, therefore, explained by the accelerated rise in income through transfers.

6.2 The redistribution channel of environmental policy

6.2.1 Effectiveness of redistribution as environmental policy instrument

The shift towards more redistribution suggests that the optimal policy relies on redistribution through labour taxation as an environmental policy instrument. However, it is unclear how important the contribution of redistribution is for the reduction of the externality. This section aims to fill this gap. Given that the impact of taxes on allocations is interdependent, further assumptions are necessary to tell apart the effect of either tax. I make the following assumption: the government chooses the optimal tax system jointly but implements them sequentially. In step 1, the environmental tax is implemented; then, the optimal labour tax is enforced. The effect of the labour tax is split into redistribution keeping labour supply fixed, step 2, and the efficiency channel when labour supply is allowed to react, step 3.[29]

Figure 5 represents the results.[30] Panel (a) shows the contribution of each channel: the effect of the environmental tax, in red, the redistribution channel, in blue, and the efficiency channel, in green, as a percentage of the laissez-faire level. The black graph refers to the total policy impact.[31] To better understand the result, plots (b) and (c) represent levels of unsustainable output, unsustainable consumption of the poor and the rich, respectively. Here, the red graph shows the laissez-faire allocation, the blue one the allocation after the environmental tax has been implemented. The green graph shows the allocation after additionally redistributing and keeping labour supply fix, and the black graph refers to the full model allocation.

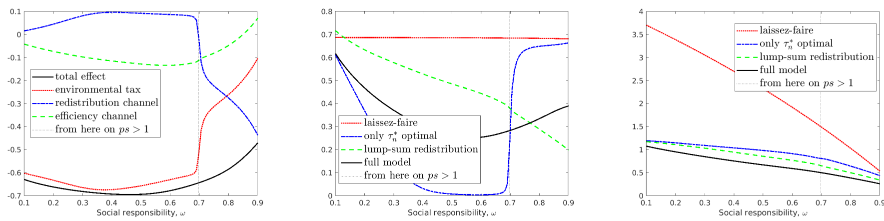
[29] Section F.1 explains the experiment in more detail.

[30] Figure 15 in appendix F.1 shows the results for the standard model without basic needs. Here, redistribution has no effect on the externality.

[31] Percentage changes are calculated as $\frac{X^2-X^1}{X^0} = \frac{X^2-X^0}{X^0} - \frac{X^1-X^0}{X^0} =$% *change through policy 2 in addition to effect of policy 1.* Where the superscript indicates the step in the experiment; X stands in for any model variable. Zero indicates the laissez-faire economy.

Figure 5: Decomposition policy effects

(a) Percentage change unsustainable output | (b) Unsustainable consumption poor | (c) Unsustainable consumption rich



To summarise the main finding of this exercise: redistribution positively affects the externality for lower levels of social responsibility below $\omega = 0.7$. For all levels of social responsibility above $\omega = 0.7$, redistribution adds to the reduction of the externality. Its importance increases with social responsibility eventually accounting for the main part of environmental policy implying a reduction of up to 44%. Simultaneously, the impact of the environmental tax reduces to -10%. At the highest level of social responsibility considered, the redistribution channel accounts for 93% of the total reduction in the externality. Environmental taxation, in contrast, only makes up for 22%.[32] The following paragraphs explain the mechanisms for each policy element.

Environmental taxation accounts for a reduction in unsustainable output by between 60% and 70% when social responsibility is below $\omega = 0.7$, as shown by the red graphs in plot (a), thereby accounting for the bulk of the impact of environmental policy. The environmental tax affects unsustainable production through two mechanisms: (1) by changing the relative price and (2) by changing households' income. Rendering the sustainable good the cheaper alternative implies a strong reaction in demand by the poor who now rely on the sustainable good to cover their basic needs, compare the blue graph in panel (b) relative to the red one.

The additional reduction going from $\omega = 0.1$ to $\omega = 0.3$ is explained by the demand of poor households. A decrease in transfers, compare figure 16 in appendix F.1, which shows additional variables, makes the poor poorer such that they recompose their budget towards the cheaper, that is the sustainable good. Transfers reduce due to the demand-driven reduction in the tax base and the tax rate. Furthermore, the cross-price effect of the sustainable good's price on unsustainable demand by the poor is negative at the marginal environmental tax rate; compare figure 16. Being constrained by basic needs implies a small substitution effect in reaction to a marginal change in the relative price. Demand for the cheaper good remains strong so that the income effect of a price change exceeds the

[32] The reduction in labour supply due to labour taxation implies an increase in the externality at this levels of social responsibility by 7%.

substitution effect. In sum, demand for the unsustainable good falls as the sustainable good becomes more expensive. This mechanism adds to the importance of the environmental tax for low levels of social responsibility.

The total impact of the environmental tax on unsustainable output reduces as social responsibility rises above $\omega = 0.4$. Up to a value of social responsibility equal to $\omega = 0.7$. This is driven by the consumption behaviour of the rich; see panel (c) in figure 5. As the environmental tax reduces with social responsibility, the unsustainable good becomes cheaper and the rich recompose their consumption less intensely than in the laissez-faire economy towards sustainable demand; compare the slopes of the red and blue graphs. Furthermore, the rich become richer again as the pre-tax wage rate rises; this, as well, increases their demand for unsustainable produce.

Once the environmental tax is so low that the sustainable good becomes more expensive than the unsustainable one, the absolute impact of the environmental tax drops sharply from 60% to roughly above 40%. The main reason is that the price elasticity of demand by the poor is low. They only lower their unsustainable consumption by a small amount once it is the cheapest alternative; compare the red and the blue graph in panel (b).

The redistribution channel counteracts the effect of the environmental policy when the sustainable good is the cheaper alternative. Consider now the blue dashed-dotted graph in panel (a) and the green one in plots (b) and (c). When the unsustainable good is more expensive, until $\omega = 0.7$, redistribution implies a rise in the externality of up to 12% compared to the laissez-faire world in addition to the environmental tax. More income to the poor allows them to recompose their consumption away from the cheaper alternative towards the unsustainable good. In contrast, the rich reduce their unsustainable demand as their income falls. Since the sustainable good is less expensive than the unsustainable one, the poor have a higher MPCU than the rich. An additional unit of income to the poor implies a rise in unsustainable demand on aggregate. The poor increase their consumption of the unsustainable good more than the rich reduce theirs.

The picture changes once the environmental tax is set such that the unsustainable good becomes the cheaper one. Now, the MPCU of the poor is, aggregated over the amount redistributed, lower than that of the rich and redistribution causes a reduction in unsustainable demand on aggregate. The difference in MPCU across households increases with social responsibility and an increase in the sustainable price, so that redistribution becomes more and more important an environmental policy as households desire for the sustainable good rises. While redistribution accounts for a reduction in the externality rising gradually from 10% to 44% with social responsibility, the environmental tax loses in importance and its impact on the externality falls from approximately 40% to 10% in absolute terms.

Efficiency channel Finally, the effect of labour taxation on labour supply adds to the reduction in the externality when social responsibility is relatively low; focus on the green graph in panel (a) and the black one in the remaining panels. The labour supply of both household types reduces in reaction to labour taxation, the income of both types falls, causing a reduction in unsustainable demand. However, starting from a level of social responsibility slightly above $\omega = 0.8$ the efficiency channel has a positive additional effect on the externality. This again is driven by basic-needs constrained households. The reduction in their income leads to an increase in unsustainable demand. To cover basic needs, they revert to consume the less preferred but cheaper good.

6.2.2 Reliance on labour tax as environmental policy instrument

The previous two sections do not show that redistribution is deliberately used as environmental policy. The importance of redistribution to lower the externality could be a byproduct of equity provision.

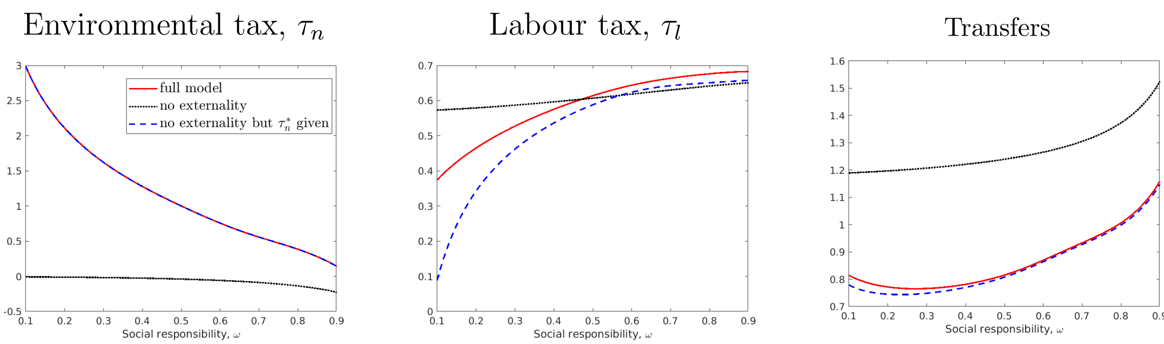
Figure 6 highlights that labour taxation is used as an environmental policy. In each panel, the black graph shows optimal policy when the externality is set to zero so that the government only cares about inequality. The red solid graph reflects the optimal policy in the baseline model. The blue-dashed graph depicts optimal labour taxes and transfers when the optimal environmental tax resulting in the full model is fed into the Ramsey model as a parameter but the externality is kept at zero. This experiment is informative on the optimal labour tax and transfers that result only from equity concerns (which might be altered through regressivity of the environmental tax) but at intensified efficiency costs through environmental taxation. The difference between the blue and the red graph is solely explained by environmental concerns.

At all levels of social responsibility, labour taxation is used as an environmental policy measure. When households do not care about how their consumption is produced, labour tax is almost 30 percentage points higher to reduce the externality. The effect at these levels of social responsibility runs through the efficiency channel. The reliance on labour taxation as environmental policy vanishes with social responsibility, but not completely; instead, it remains constant at around 0.25 percentage points.

The reliance on labour taxation as environmental policy pushes labour taxes above optimal tax levels absent externality (the black graph). This finding is in contrast to Bovenberg and De Mooij (1994) who argue that environmental tax revenues are optimally used to lower the distortionary labour tax. Here, instead, the labour tax is set even higher despite higher efficiency costs which points towards higher benefits of labour taxes when social responsibility is high. The finding is in line with the work by Jacobs and van der Ploeg (2019) who show that with non-linear Engel curves labour taxes may be higher in the light of an environmental externality when the optimal environmental tax is below the Pigouvian tax.[33]

Note, though, that it is not clear whether this finding is due to the redistribution channel of environmental policy. It could be that environmental taxes are chosen lower to avoid disadvantageous consequences for inequality; reverting to higher labour taxes, instead, achieves a better balance between equity and environmental policy.

Figure 6: Reliance on labour tax as environmental policy



6.3 Discussion

Having seen that redistribution is the main pillar of environmental policy when social responsibility is high, this section tries to answer the question of why the government finds this policy optimal. Notice that the reliance on redistribution is a choice. An environmental tax that is high enough to make the sustainable good the cheaper alternative when social responsibility is high would render redistribution run counter a reduction of the externality.

6.3.1 What drives the shift to redistribution?

Since both taxes imply a reduction in aggregate labour supply in this model,[34] the government trades off benefits and costs of individual taxes against each other. The question, therefore, becomes: Why is the competition between taxes decided in favour of labour taxation as social responsibility rises?

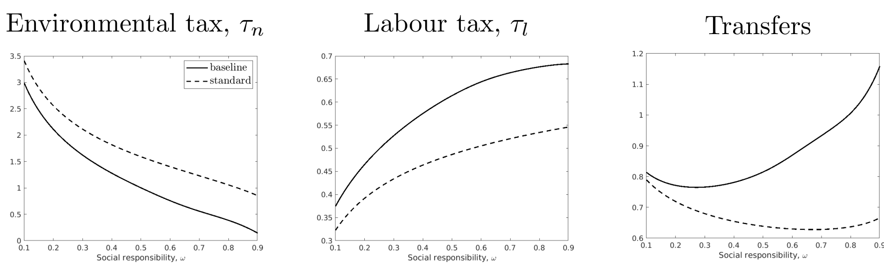
[33] In the standard model, the optimal labour tax in the specification with externality never exceeds the level in the world without externality. Figure 17 in the appendix compares labour taxes in the standard and the baseline model. Labour taxes are only relied on as an environmental policy measure when social responsibility is low.

[34] Compare panel (f) in figure 16.

Comparing the optimal policy resulting from the baseline model to the results in the standard model is informative on the effect of basic needs on the optimal policy mix. The mechanism, however, can be driven by inequality or environmental concerns as basic needs alter the impact of both taxes on both targets.[35] What remains the same is the effect of a rise in social responsibility on the efficiency level of the externality[36] As households prefer the polluting good less, the efficient level of the externality reduces with social responsibility. Absent a change in demand, this effect makes more government intervention optimal. On the other hand, there is a demand-driven reduction in the externality as households' demand reacts to the shift in preferences which again diminishes the need for intervention. This reaction is less intense in the baseline model since basic needs prevent a strong substitution by poor households.

Comparing the optimal policies in the standard to those in the baseline model, depicted by the dashed and solid graphs in figure 7, respectively, reveals that the shift to redistribution is also present in the standard model but more intense in the model with basic needs. The environmental tax is throughout lower, whereas the labour tax is always higher in the baseline model. Transfers in the baseline model are half a basic needs bundle bigger than in the standard model when social responsibility is the highest while the difference is less than 10% at the lowest level of social responsibility.

Figure 7: Optimal policy with and without basic needs



The shift in the standard model is explained by lower unsustainable demand and unsustainable sector size in the laissez-faire economy. The need for environmental measures reduces despite the lower efficiency level. As a result, freed-up resources can be used for redistribu-

[35] In the baseline model, the environmental tax has distributional consequences as households consume different budget shares; see appendix section F.2.2 for the definition of tax regressivity considered. It also varies how close basic-needs constrained households consume to the desired ratio by changing the price premium. On the other hand, the impact of the environmental tax on the externality changes with the introduction of basic needs as the elasticity of unsustainable demand with respect to relative prices for basic-needs constrained households changes. The optimal labour tax rate can be different since the same distribution of income implies a different level of inequality due to the poor not spending each unit of income as to maximise composite consumption. Finally, the redistribution channel of environmental policy alters the effect of redistribution through labour taxation on the externality.

[36] A social planner chooses the same level of the externality in both models.

tion. Since the demand-driven transition is less pronounced in the baseline model, it seems to suggest itself that more redistribution in the baseline model is chosen for environmental reasons.

However, the total impact of government intervention on the externality is smaller in the baseline model than in the standard model for high levels of social responsibility. This is shown by panel (a) in figure 8, which represents the total percentage change on unsustainable output and inequality in panels (a) and (b) relative to the laissez-faire economy. At a level of social responsibility of $\omega = 0.9$, the Ramsey planner reduces unsustainable production by more than 65% in the standard model but only by approximately 46% in the baseline model although unsustainable output in the laissez-faire economy is higher in the baseline model. Instead, basic needs make it optimal to lower inequality by close to 65% in the baseline model and by 47.5% in the standard model; compare panel (b). Hence, more resources are spent on inequality when social responsibility is high indicating that the intensified shift to redistribution is mainly driven by increased importance of inequality for government intervention as social responsibility rises.

The social costs of the externality (SCE), also known as the Pigouvian tax, shown in plot (c) supports this narrative. The Pigouvian rate is defined similarly to Barrage (2020) so that it only captures the costs of the externality on households absent its effect on tax bases.[37] In both models, the Pigouvian rate falls with social responsibility indicating that when social responsibility rises, the reduction in the social costs of the externality dominates the fall in the marginal utility of unsustainable consumption under the optimal policy. The Pigouvian rate is lower in the baseline model as the average household is willing to give up less unsustainable consumption under the optimal policy.

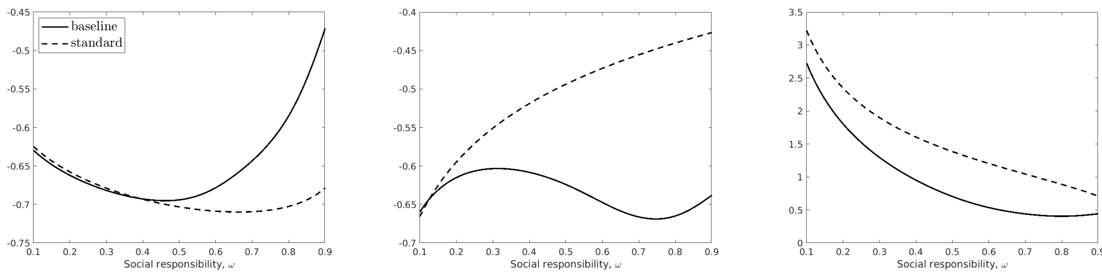
While the SCE are falling in social responsibility at all levels in the standard model, the SCE is slightly upward sloping after a value of $\omega = 0.8$ in the baseline model. This suggests that the shift to more redistribution in the baseline model does not sufficiently lower the externality. Instead, the optimal policy for these high levels of social responsibility target equity, and higher externality costs are accepted.[38]

[37] Section F.2.1 in the appendix derives the Pigouvian rate in this model with heterogenous households as the average household's willingness to pay for a marginal reduction in the externality.

[38] Another experiment, where the optimal policy from the standard model is implemented in the baseline model, shows that a higher environmental tax would imply lower externality levels. Hence, it can be ruled out that the environmental tax is not effective to lower the externality. Instead, efficiency costs which are mainly borne by the poor are too high. Results are not shown.

Figure 8: Effects policy intervention with and without basic needs

(a) Unsustainable output (b) Gini of consumption (c) Social cost of externality



6.3.2 Assessing the rise in social responsibility in an unequal society

Results suggest that efficiency costs prevent a full usage of the redistribution channel of environmental policy: as shown by plot (g) in figure 4, the poor do not consume the desired ratio of goods. Hence, an additional unit of redistribution would not only increase equity but also lower the externality through the redistribution channel of environmental policy. Due to efficiency costs, there exists a level of social responsibility after which both inequality (compare the Gini of consumption in panel (d) of figure 4) and the SCE rise with social responsibility under the optimal policy.

The picture is different in the standard model. In this case, social responsibility does not pose any cost as it leaves inequality unchanged and only implies a demand-driven reduction in the externality in the laissez-faire economy. This observation highlights the importance to consider basic needs and inequality in an analysis of social responsibility: a trade-off arises which is inherent in the level of social responsibility.[39]

7 Sensitivity

While social responsibility is changed exogenously, it is assumed that all other features of the economy remain unchanged. This seems questionable since variations in social responsibility most likely take time. Changes may run through adjustments in attitudes and norms. However, one might argue for an acceleration of changes in social responsibility given the prominence of climate change in politics and the media triggered, for instance, by the COVID-19 pandemic and extreme weather events. Then again, these events also alter inequality and the speed of technological innovations. Political momentum or the rise in sustainable demand could well foster sustainable innovation so that the price premium vanishes over time thereby

[39] While this project remains agnostic towards reasons for the change in social responsibility, it could also be a political choice variable that the government may target through measures such as economic education, transparent information on production processes, or product labelling.

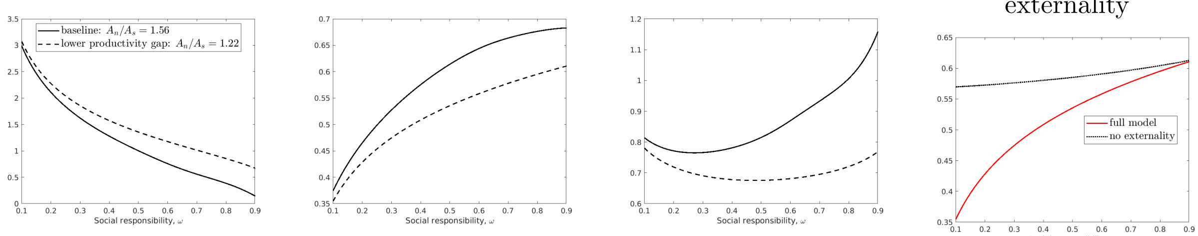
changing the effectiveness of social responsibility. This section, therefore, discusses results with (1) a lower productivity gap and (2) changes in the income distribution.

7.1 Lower productivity gap

Comparison of the optimal policy at a lower productivity gap of $A_n/A_s = 1.22$ to the baseline calibration[40] resembles the comparison to the standard model. As shown by figure 9, the shift to redistribution is less pronounced when productivity in the sustainable sector is higher. The environmental tax is so high so that the sustainable good is the cheaper alternative for all values of social responsibility. As a result, the redistribution channel of environmental policy increases the externality throughout. Furthermore, the optimal labour tax never exceeds the optimal tax absent an externality, compare panel (d), which is in line with the finding in Bovenberg and De Mooij (1994): the increased efficiency costs through environmental taxation reduce the optimal labour tax relative to the no-externality world.

Figure 9: Optimal policy with lower productivity gap

(a) Environmental tax, τ_n (b) Labour tax, τ_l (c) Transfers (d) τ_l with and without externality



7.2 Less inequality

Income of the poor plays a crucial role; as argued, the severity of inequality makes the shift to redistribution optimal when social responsibility is very high. A higher income of these households eventually results in the non-existence of basic-needs constrained households so that the optimal policy approaches the one in the standard model.

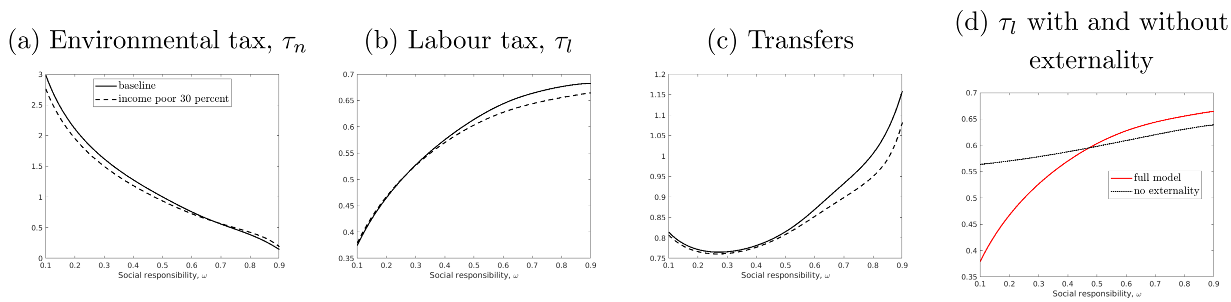
Increasing income of the poor by 30% so that they can consume 90% of an unsustainable basic needs bundle in the baseline calibration[41] results in a reduced shift to redistribution. The environmental tax is higher for high levels of social responsibility and the labour tax is also reduced. Nevertheless, redistribution remains a pillar of environmental policy under this

[40] This calibration results in $A_s = 6.9$ instead of $A_s = 5.4$ in the baseline calibration. All other parameters remain unchanged.

[41] In this counterfactual calibration $z_h = 2.7$ and $z_l = 0.17$ in contrast to $z_h = 2.8$ and $z_l = 0.03$ in the baseline calibration. All other parameters remain unchanged.

calibration.[42] As a result, the optimal labour tax is higher than in a non-externality world without basic needs; see panel (d).

Figure 10: Optimal policy with poor 30% richer



8 Conclusion

Social responsibility triggered, for example, by concerns about climate change is on the rise, and the market share of sustainable products increases. It seems that households can alter the economic structure according to their preferences for sustainability. However, income inequality in the US is high and sustainable products sell at a premium. The requirement to satisfy basic needs renders sustainable goods unaffordable for low-income households. In 2018, 45% of US households were unable to cover an objective basic needs bundle defined by the *Institute for Women's Policy Research* with sustainable goods alone. As a result, redistribution becomes an environmental policy instrument: allowing poor households to lower their unsustainable consumption reduces the externality. As social responsibility rises, the effect intensifies. Therefore, this paper asks: what is the optimal policy in a socially responsible yet unequal world?

To answer the question, a model of structural transformation with inequality, explicitly accounting for basic needs, is solved from a Ramsey planner's perspective for different levels of social responsibility. The planner uses a distortionary labour tax and an environmental tax levied on input costs of the unsustainable sector to maximise the Utilitarian social welfare function.

The paper finds that, as social responsibility rises, the optimal tax mix shifts to more redistribution. A demand-driven reduction in the externality before government action mainly explains the shift. As less intervention for an environmental motive is required, more resources can be spent to mitigate inequality. Furthermore, the optimal policy relies on the

[42] The ratio of unsustainable to sustainable consumption by the poor exceeds the desired consumption ratio when social responsibility is high similar to results under the baseline calibration. Graph is not shown.

redistribution channel of environmental policy when social responsibility is high. For all levels of social responsibility above $\omega = 0.7$, redistribution through labour taxation reduces the externality. The effect of this channel relative to the laissez-faire level gradually increases up to -44% at the highest level of social responsibility considered. The effectiveness of environmental taxation, in contrast, simultaneously decreases from around -60% to -10%.

Despite its importance as environmental policy, equity concerns explain the shift to redistribution. As tastes become more expensive with social responsibility, poverty is more costly: the poor suffer more from not consuming in line with their underlying level of social responsibility. More redistribution for equity reasons becomes optimal, and labour taxation attains a better balance between equity and the environmental motive of government intervention.

Additional redistribution at the optimum would achieve a lower externality and inequality of consumption. However, efficiency costs are too high, and there exists a level of social responsibility after which a further rise augments both the social costs of the externality and inequality under the optimal policy.

A Attitudes, Basic needs and inequality

A.1 Attitudes

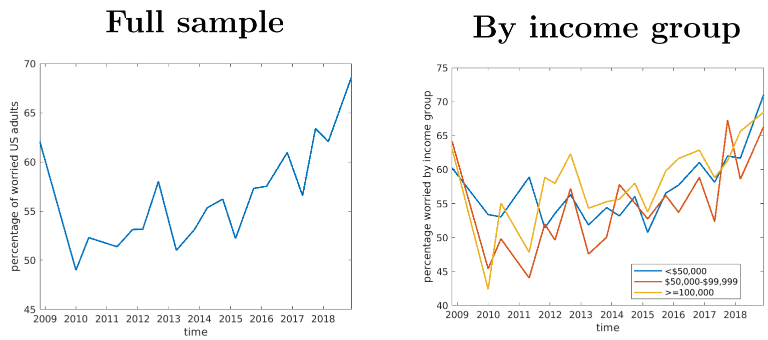
Panel (a) in figure 11 shows the percentage of US adults who are worried about climate change. Where a participant was counted as *worried* if he/she chose category 3 or 4 out of 4 categories in response to the question "*How worried are you about global warming?*". The highest category 4 was labeled *a great deal* and category 1 *not at all*. Participants who refused to answer at maximum made up 2.3% of the whole weighted sample population which was in 2010.

Panel (b) differentiates participants according to three broad income groups. The rise in concerns is homogeneous across income groups. It suggests that income does not induce heterogeneity into worriness. One might have expected that the high income group is more concerned with climate change, for example, due to education being positively correlated with income. However, the sharp increase from 2018 to 2019 was driven by the lowest income group of a yearly income below $50.000.

A.2 Basic needs

Basic needs for a single-adult working household are taken from the *Institute for Women's Policy Research's* (IWPR) *Basic Economic Security Tables* from Institute for Women's Policy

Figure 11: Concerns about climate change in the US.



Research (2018). The basic needs bundle is more objective in that it does not (solely)[43] rely on observed consumption and expenses which most likely do not reflect needs but are affected by financial constraints or habits. For example, rents and utilities are taken from the US Department of Housing and Urband Development Fair Market Rents which are rents at the 40th or 50th percentiles of US rents. Food is taken from the USDA Center for Nutrition Policy and Promotion's low-cost food plan. Which is the third lowest out of four consumption food plans. The USDA includes a bit more than a minimal standard of nutrition but does only allow for self-prepared food. For more information on the methodology see McMahon, Shawn and Horning, Jessica and Suh, Joo Yeoun (2018).

Table 1 shows for each consumption category expenses for an unsustainable, column (2), and sustainable, column (3), quality. Throughout the calculations, conservative choices are made so that the resulting expenses can be interpreted as a lower bound of basic needs. Therefore, basic needs for a single adult without child but with employer benefits are considered reducing expenses for childcare and health. Furthermore, savings for emergencies and retirement are also abstracted from.

It is assumed that the expenses provided by the IWPR are given in terms of unsustainable goods which make up the biggest market share and are generally cheaper, more in line with a basic needs bundle. To proxy expenses for sustainable counterparts, I use the relative price resulting from a food basket constructed by the EAT-Lancet Commission[44] and prices of the USDA for organic and conventional goods[45] The price for the organic bundle is 56% higher than its unsustainable counterpart in 2018.

This price difference is applied to those categories which plausibly have a sustainable

[43]The *Health care* and *Personal and Household items* are based on observed expenditures.

[44]The EAT-Lancet Commission constructed dietary plans which are on the one hand healthy but also respect the planetary boundaries. The advantage of this consumption basket is that contains detailed information on quantities and product types and therefore allows to calculate a sustainable price which is not the case for the more granular food category in the IWPR's basic needs bundle.

[45]Data retrieved from `https://marketnews.usda.gov/mnp/dataDownload`. The bundle consists of the items in the Lancet report for which sustainable and unsustainable prices are available.

counterpart, as indicated by column (3) in table 1. Again, since categories are fairly broad, I only apply the price difference to categories which broadly allow for a sustainable choice. For instance, since rents make up the biggest part of the *Housing & Utilities* category, I do not multiply this item despite energy expenses falling into this category, too. Summing over all consumption categories gives expenses for a sustainable and an unsustainable bundle.

Table 1: Monthly basic expenses for a US single working adult in $US

Category	(1) Unsustainable	(2) Sustainable	(3) Sustainable exists
Housing & Utilities	785	785	false
Food	267	417.23	true
Transportation	476	476	false
Personal & Household Items	389	607.88	true
Healthcare	177	276.59	true
Monthly Basic needs (sum)	2,094	2,562.70	
Annual Basic needs	25,128	30,752.38	

A.3 Income inequality

Expenses for the single-adult sustainable basic needs bundle are compared to households' per-capita disposable income to judge whether a household has too few resources to consume according to an arbitrary level of social responsibility.

Annual income data comes from the PSID and taxes are calculated using the NBER's TAXSIM tool[46]. The total family income measure encompasses pre-tax income from all sources including transfers and social security income. The old OECD equivalence scale[47] is applied to derive the respective per capita income a household has at its disposal. I then subtract taxes for a single-adult household provided by the IWPR basic needs dataset amounting to US$483 per month.

A.3.1 Comparison to the official US poverty threshold

The unsustainable basic needs expenses are almost twice as big as the official poverty threshold provided by the Bureau of Labour Statistics in 2018 which on average across the US amounts to US$12,784 for a single adult. The official poverty measure is an inflation-correct

[46]Provided here `https://users.nber.org/~taxsim/taxsim32/`.

[47] I use the "old" OECD equivalence scale which applies a higher weight on the second adult and children than the modified version. Under the modified version per-capita household income is then higher for families. The coice of the old equivalence scale is justified since the old equivalence scale which accounts more resources to additional household members is closer to more generous definitions of basic needs such as the one used here (Bradshaw et al.). The modified scale underestimates the needs for families.

measure of a poverty level defined in 1963. The measure is three times expenses for a minimum diet in 1963.[48] It, hence, does not account for changes in medical care or transportation costs. For more details on how the census bureau's poverty threshold is derived see `https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html`.

B Calibration

B.1 Price elasticity of substitution

The price elasticity of substiution between sustainable and unsustainable produce, defined as

$$PES = \frac{\frac{d\left(\frac{c_n}{c_s}\right)}{\frac{c_n}{c_s}}}{\frac{d\left(\frac{p_s}{p_n}\right)}{\frac{p_s}{p_n}}},$$

is matched with the price elasticity of substitution between organic and conventional milk purchases derived from estimates found by Chen et al. (2018). The study uses Nielsen scanner data for 2013 in the US with a final sample of 24,861 households who purchased milk regularly. The milk market seems to be a good proxy for the market for sustainability as no close substitutes are available.

In the model, the unsustainable price is held fix with the unsustainable good being the numeraire. This is not the case in the data and both conventional and organic prices vary. In order to reconcile this discrepancy, the following identity is used. It is further assumed that the unsustainable price is constant in the data, too. As a result, the 1 percentage change in the relative price is solely driven by a change in the sustainable price.

$$\frac{d\left(\frac{p_s}{p_n}\right)}{\frac{p_s}{p_n}} = \frac{dp_s}{p_s} - \frac{dp_n}{p_n} = \frac{dp_s}{p_s}. \tag{15}$$

[48]The factor of three equals the relation of food expenses to total after-tax moneay income of the average US family in 1955.

and the price elasticity of substitution becomes

$$PES = \frac{\frac{d\left(\frac{c_n}{c_s}\right)}{\frac{c_n}{c_s}}}{\frac{dp_s}{p_s}} = \frac{\frac{dc_n}{c_n}}{\frac{dp_s}{p_s}} - \frac{\frac{dc_s}{c_s}}{\frac{dp_s}{p_s}}. \tag{16}$$

In the data, cross and own price elasticities of three milk categories are documented: *organic, conventional brand* and *conventional private label*. The organic category is treated as the sustainable counterpart in the data. The conventional subcategories are added to match unsustainable consumption. Hence,

$$c_n = c_{cpl} + c_{cb},$$

where *cpl* and *cb* indicate *conventional private label* and *brand*, respectively. The elasticity of unsustainable consumption with respect to sustainable prices is then given by

$$\frac{\frac{dc_n}{c_n}}{\frac{dp_s}{p_s}} = \frac{\frac{dc_{cpl}}{c_{cpl}}}{\frac{dp_s}{p_s}} \frac{c_{cpl}}{c_n} + \frac{\frac{dc_{cb}}{c_{cb}}}{\frac{dp_s}{p_s}} \frac{c_{cb}}{c_n}.$$

All terms on the right-hand side are available from Chen et al. (2018) as is the own price elasticity of sustainable consumption. The resulting price elasticity is 2.5197. That is, a 1 percentage increase in the price of organic milk implies a 2.5% rise in the ratio of unsustainable to sustainable consumption.

The elasticities estimated in Chen et al. (2018) are measured at the average consumer in the sample; therefore, the model is calibrated to match the price elasticity of substitution at the observed average values of consumption and budget shares in the data.

Table 2: Calibration baseline model

Parameter	Target/Source	Calibration	Meaning
Utility			
ϕ	-	15	importance of basic needs
σ	PES found in Chen et al. (2018) at observed consumption levels	1.73	governs price elasticity of substitution (PES)
ω	sustainable market share Kronthal-Sacco et al. (2020) at observed income levels	0.24	social responsibility
$\bar{c}$	expenses for annual basic needs bundle from iwpr for single-adult household excluding taxes and savings in base year: 25,128$	1	basic needs, normalised
Labour supply			
L	time endowment per day: 14.5 Jones et al. (1993)	1	annual time endowment, normalised
χ	average hours worked: 0.34 (OECD)	43.06	disutility from labour
θ	Chetty et al. (2011)	0.75	Frisch elasticity
Externality			
η	percentag of composite consumption a rich household is willing to give up for a 1% reduction in H_n: 2%	1.30	curvature externality
ψ		9.43	importance externality
Inequality			
z_l	average disposable income poor in terms of basic needs in base year: 0.68	0.03	effective labour productivity poor
z_h	average disposable income rich in terms of basic needs in base year as difference between income poor and GDP: 4.00	2.85	effective labour productivity rich
λ	share able to purchase basic needs sustainably	0.55	share of rich households
Production			
A_n	GDP per capita in terms of $\bar{c}$ in base year: 2.5	8.44	TFP unsustainable sector
A_s	relative price of sustainable food bundle in base year: 1.56	5.4	TFP sustainable sector
Baseline policy			
τ_l	taken from Barrage (2020)	0.24	labour income tax
τ_n	carbon tax on national level in base year	0	environmental tax

C Model equations competitive equilibrium

$$
\begin{aligned}
\text{FOC consumption rich} \quad & U_{csr} = p_s \mu_r \\
& U_{cnr} = \mu_r \\
\text{FOC consumption poor} \quad & U_{csr} = p_s \mu_p \\
& U_{cnr} = \mu_p \\
\text{Labour supply} \quad & \chi l_r^{1/\theta} + \gamma_{lr} = \mu_r w(1-\tau_l) z_h \\
& \chi l_p^{1/\theta} + \gamma_{lp} = \mu_p w(1-\tau_l) z_l \\
\text{Household budgets} \quad & c_{sr} p_s + c_{nr} = l_r w(1-\tau_l) z_h + T \\
& c_{sp} p_s + c_{np} = l_p w(1-\tau_l) z_l + T \\
\text{Profit maximisation by firms} \quad & A_n = w(1+\tau_n) \\
& p_s A_s = w \\
\text{Production} \quad & Y_s = A_s H_s \\
& Y_n = A_n H_n \\
\text{Government budget} \quad & T = \tau_n w h_n + \tau_l w (H_n + H_s) \\
\text{Market clearance} \quad & H_s + H_n = \lambda z_h l_r + (1-\lambda) z_l l_p \\
& \lambda c_{sr} + (1-\lambda) c_{sp} = Y_s \\
\text{Complementary slackness conditions} \quad & \gamma_{lp}(L - l_p) = 0 \\
& \gamma_{lr}(L - l_r) = 0
\end{aligned}
$$

The market for the unsustainable good clears by Walras's law.

D Ramsey Problem Primal Approach

Throughout an interior solution is assumed. In a competitive equilibrium, the following holds:

$$\text{FOC consumption rich} \qquad p_s = \frac{U_{c_{sr}}}{U_{c_{nr}}} \tag{17}$$

$$\text{FOC labour rich} \qquad w(1-\tau_l) = \frac{-U_{l_r}}{z_h U_{c_{nr}}}, \tag{18}$$

$$\text{Profit max. sustainable sector} \qquad w = A_s p_s \tag{19}$$

$$\text{Profit max. unsustainable sector} \qquad \tau_n = \frac{A_n}{w} - 1 \tag{20}$$

$$\text{Government budget} \qquad T = \tau_l(H_s + H_n)w + \tau_n H_n w, \tag{21}$$

where $U_{lr} = -\chi l_r^{1/\theta}$.

Using the equations characterising a competitive equilibrium, see section C, the Ramsey problem can be written as

$$\begin{aligned}
\max_{c_{sr},\ c_{sp},\ c_{np},\ l_r\ l_p,\ H_s,\ H_n} \mathcal{L} =& \lambda U_r + (1-\lambda)U_p \\
& - \mu_{imr}\lambda \left[c_{sr}U_{c_{sr}} + (c_{nr} - T)U_{c_{nr}} + l_r U_{lr}\right] \\
& - \mu_{imp}(1-\lambda)\left[c_{sp}U_{c_{sp}} + (c_{np} - T)U_{c_{np}} + l_p U_{lp}\right] \\
& - \mu_{rc}\left[p_s\left(\lambda c_{sr} + (1-\lambda)c_{sp}\right) + \lambda c_{nr} + (1-\lambda)c_{np} - p_s A_s H_s - A_n H_n\right] \\
& - \mu_{lab}\left[H_n + H_s - (\lambda z_h l_r + (1-\lambda) z_l l_p)\right] \\
& - \mu_{FOCps}\left[ps - \frac{U_{c_{sp}}}{U_{c_{np}}}\right] \\
& - \mu_{FOCw}\left[w(1-\tau_l) - \frac{-U_{lp}}{z_l U_{c_{np}}}\right] \\
& - \mu_{sus.market}\left[\lambda c_{sr} + (1-\lambda)c_{sp} - A_s H_s\right],
\end{aligned}$$

where prices and policy instruments are substituted by equations 17 to 21. I further assume that the Ramsey planner's first-order conditions are also sufficient to maximise the objective function.

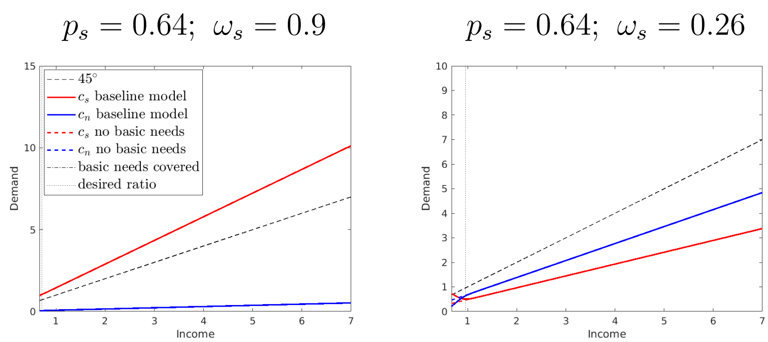
The first two constraints, following μ_{imp} and μ_{imr}, the *implementability constraints*, ensure that the households budget holds under the optimal allocation. Satisfaction of the resource constraint, following μ_{rc}, and labour market clearing, μ_{lab}, is also ensured. To account for inequality, the first order conditions of the poor household type which include prices are explicitly considered as constraints to the Ramsey problem, following the Lagrange multipliers

μ_{FOCps} and μ_{FOCw}, while the respective equations for the rich household type are used to replace prices and policy instruments. In contrast to Barrage (2020), where only one consumption good exists, the market clearing condition for the sustainable market needs to be explicitly considered as a constraint, too; the respective multiplier is $\mu_{sus.market}$.

By substituting the optimal allocation from the Ramsey problem into equations 17 to 21, prices and the optimal policy are determined.

E Redistribution as environmental policy instrument

Figure 12: Engel curves for $p_s < 1$



F Results

F.1 Policy decomposition

The experiment runs as follows: Starting from the laissez-faire economy, I feed in the optimal environmental tax letting everthing including transfers and labour supply adjust. I save the resulting variables, X^1. In a second step, I set labour taxes to the optimal level but keep labour supply fixed at values resulting under step 1. Comparing the resulting variable values, X^2, to X^1 quantifies the effect of the redistribution channel of environmental policy.[49] The difference of X^2 to the allocation in the full baseline model is then explained by changes in labour supply, i.e., the efficiency channel of environmental policy. Note that this approach treats changes in tax bases (a third mechanism through which labour taxes affect the externality) as part of either the redistribution or the efficiency channel.

[49] Redistribution has itself an effect on labour supply. In this experiment, it is treated as part of the efficiency channel of environmental policy.

Figure 13: Optimal and laissez-faire allocation

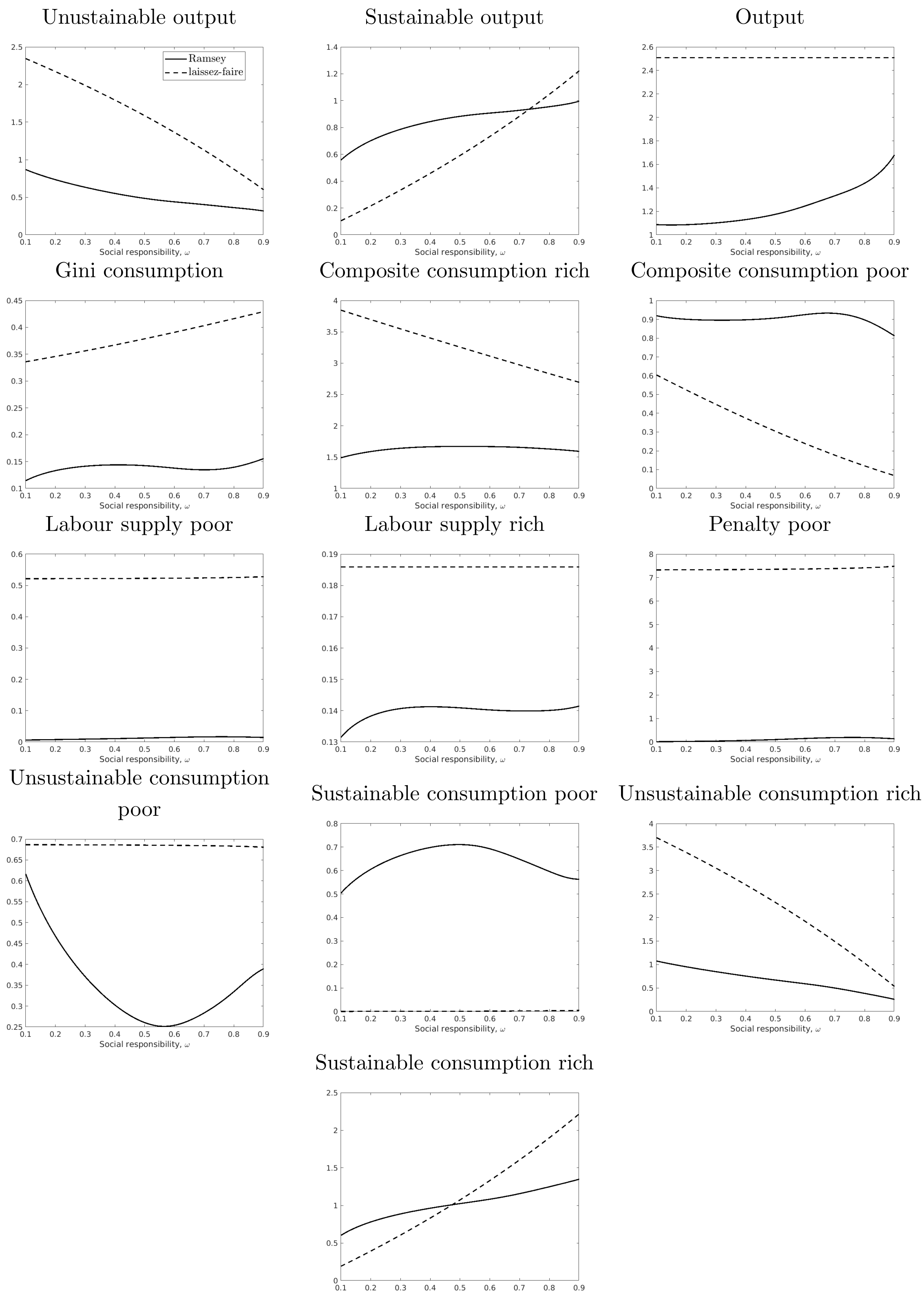
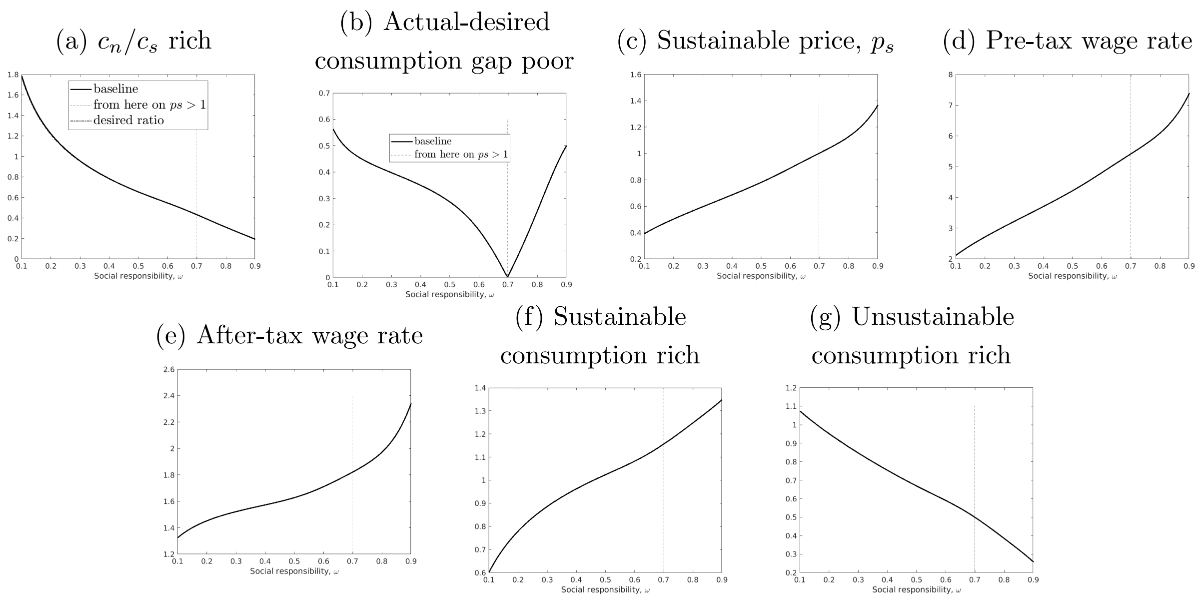
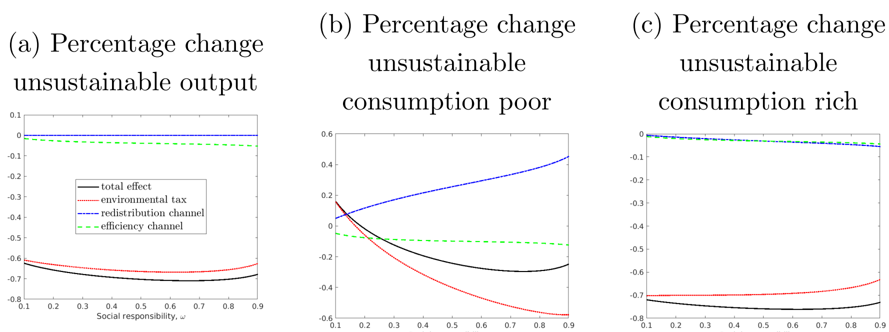


Figure 14: Additional graphs main experiment



(a) c_n/c_s rich (b) Actual-desired consumption gap poor (c) Sustainable price, p_s (d) Pre-tax wage rate (e) After-tax wage rate (f) Sustainable consumption rich (g) Unsustainable consumption rich

Figure 15: Decomposition standard model



(a) Percentage change unsustainable output (b) Percentage change unsustainable consumption poor (c) Percentage change unsustainable consumption rich

F.2 Definitions

F.2.1 Social costs of externality

The Pigouvian rate, i.e., the social costs of the externality (SCE), is given by the aggregate willingness to pay for a marginal reduction in the externality. In contrast to Jacobs and van der Ploeg (2019), I define the Pigouvian rate as only capturing the marginal social benefits of an externality reduction not accounting for effects on tax bases. The proposed definition here is closer to the notion of "social costs of the externality" and in line with Barrage (2020). The Pigouvian tax as defined here results from maximising the average household's problem assuming the existence of a market for the externality. The maximisation problem reads

$$\max \mathcal{L} = \lambda U_r + (1-\lambda)U_p + \lambda\mu_r(I_r - c_{nr} - p_s c_{sr} - p_E h_n) + (1-\lambda)\mu_p(I_p - c_{np} - p_s c_{sp} - p_E h_n).$$

Figure 16: Decomposition additional graphs baseline model

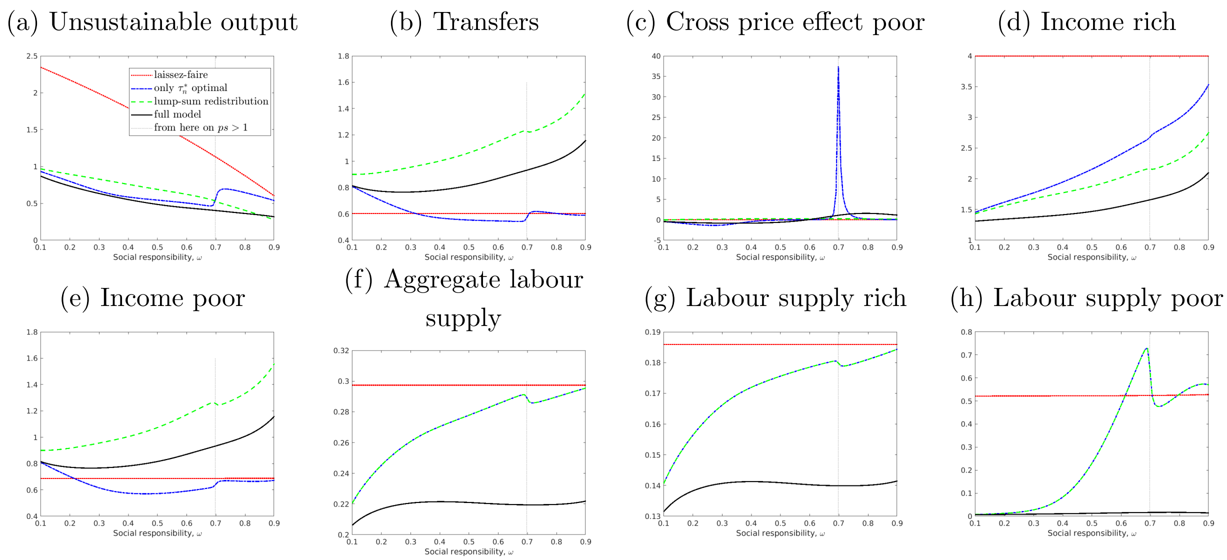
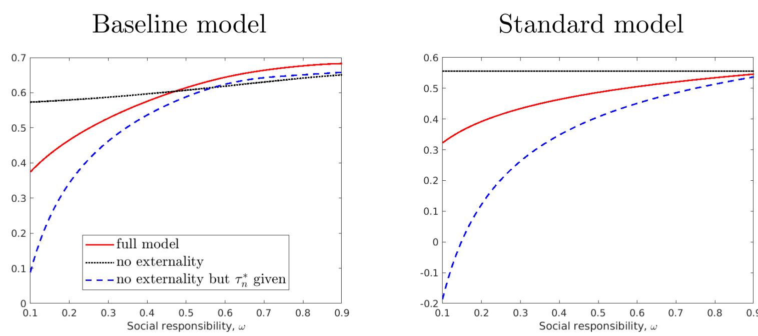


Figure 17: Labour tax with and without externality



Note that the total amount paid by unsustainable producers for causing the externality is given by $w\tau_n H_n$ so that

$$\tau^{Pigou} = \frac{-p_E}{w} = \frac{-\frac{\partial g}{\partial h_n}}{\lambda \mu_r + (1-\lambda)\mu_p}.$$

Defined in this manner, the Pigouvian rate can be interpreted as the aggregate willingness to pay by households for the avoidance of a marginal increase in the externality. As regards aggregation, the Pigouvian rate is similar to the one defined in Jacobs and van der Ploeg (2019) when the distortionary tax equals zero.

F.2.2 Environmental tax progressivity

I define a tax as regressive, if the average tax over total income is higher for the poor than for the rich at the resulting allocation. This implies for the environmental tax that it is regressive, whenever the unsustainable budget share of the poor is higher than that of the rich under the optimal policy. This follows from deriving an expression of the average tax rate by replacing firms profit-maximising conditions into total expenditures:

$$c_s \frac{w}{A_s} + c_n \frac{w}{A_n}(1+\tau_n). \tag{22}$$

The environmental tax incidence by household is, thus,

$$c_n \frac{w}{A_n} \tau_n, \tag{23}$$

and the average tax rate is given by

$$\frac{c_n}{I} \frac{w}{A_n} \tau_n. \tag{24}$$

Clearly, whenever the poor consume a higher share of unsustainable goods than the rich, this fraction is higher for the poor and the environmental tax is regressive.

References

Acemoglu, D., Akcigit, U., Hanley, D., and Kerr, W. (2016). Transition to Clean Technology. Journal of Political Economy.

Aghion, P., Bénabou, R., Martin, R., and Roulet, A. (2021). Environmental Preferences and Technological Choices: Is Market Competition Clean or Dirty?

Barrage, L. (2020). Optimal Dynamic Carbon Taxes in a Climate-Economy Model with Distortionary Fiscal Policy. Review of Economic Studies, 124(2):1–39.

Bartling, B., Weber, R. A., and Yao, L. (2015). Do markets erode social responsibility? Quarterly Journal of Economics, 130(1):219–266.

Bovenberg, A. L. and De Mooij, R. A. (1994). Environmental Levies and Distortionary Taxation. American Economic Review, 84(4):1085–1089.

Bovenberg, A. L. and Goulder, L. H. (1996). Optimal Environmental Taxation in the Presence of Other Taxes: General-Equilibrium Analyses. American Economic Review.

Bradshaw, J., Middleton, S., Davis, A., Oldfi, N., Smith, N., Cusworth, L., and Williams, J. A minimum income standard for Britain What people think. Retrieved from `https://www.jrf.org.uk/report/minimum-income-standard-britain-what-people-think`, May 2020.

Bénabou, R. and Tirole, J. (2010). Individual and corporate social responsibility. Economica, 77(305):1–19.

Chen, B., Saghaian, S., and Zheng, Y. (2018). Organic labelling, private label, and U.S. household demand for fluid milk. Applied Economics, 50(28):3039–3050.

Chetty, R., Guren, A., Manoli, D., and Weber, A. (2011). Are micro and macro labor supply elasticities consistent? A review of evidence on the intensive and extensive margins. American Economic Review, 101(3):471–475.

EAT-Lancet Commission. Healthy Diets From Sustainable Food Systems Summary Report of the EAT-Lancet Commission. Retrieved from `https://eatforum.org/eat-lancet-commission/eat-lancet-commission-summary-report/`, May 2020.

ElHaffar, G., Durif, F., and Dubé, L. (2020). Towards closing the attitude-intention-behavior gap in green consumption: A narrative review of the literature and an overview of future research directions. Journal of Cleaner Production, 275.

Foellmi, R. and Zweimüller, J. (2008). Structural change, Engel's consumption cycles and Kaldor's facts of economic growth. Journal of Monetary Economics, 55(7):1317–1328.

Golosov, M., Hassler, J., Krusell, P., and Tsyvinski, A. (2014). Optimal Taxes on Fossil Fuel in General Equilibrium. Econometrica, 82(1):41–88.

Gordon M. Fisher (2012). Standard Budgets (Basic Needs Budgets) in the United States Since 2006. Retrieved from https://www.census.gov/content/dam/Census/library/working-papers/2012/demo/udusbd3.pdf, 29/07/2021.

Herrendorf, B., Rogerson, R., and Valentinyi, A. (2014). Growth and Structural Transformation. In Handbook of Economic Growth, volume 2, pages 855–941.

Institute for Women's Policy Research (2018). Basic Economic Security in the United States: How Much Income Do Working Adults Need in Each State? Retrieved from https://iwpr.org/wp-content/uploads/2020/08/R590_National_finalx.pdf, 29/07/2021.

Jacobs, B. and van der Ploeg, F. (2019). Redistribution and pollution taxes with non-linear Engel curves. Journal of Environmental Economics and Management, 95:198–226.

Jones, L. E., Manuelli, R. E., and Rossi, P. E. (1993). Optimal Taxation in Models of Endogenous Growth. Journal of Political Economy, 101(3):485–517.

Joshi, Y. and Rahman, Z. (2015). Factors affecting green purchase behaviour and future research directions. International Strategic Management Review, 3:128–143.

Kronthal-Sacco, R., Van Holt, T., Atz, U., and Whelan, T. (2020). Sustainable Purchasing Patterns and Consumer Responsiveness to Sustainability Marketing Messages. Journal of Sustainability Research, 2(2).

Lucas, R. E. and Stokey, N. L. (1983). Optimal Fiscal and Monetary Policy in an Economy without capital. Journal of Monetary Economics, 12:55–93.

Matsuyama, K. (2002). The Rise of Mass Consumption Societies. Journal of Political Economy, 110(5):1035–1070.

McMahon, Shawn and Horning, Jessica and Suh, Joo Yeoun (2018). The basic economic security tables. Methodology and Supplemental Data. Retrieved from https://iwpr.org/wp-content/uploads/2020/08/US-BEST-Draft-Methodology-Report_Suh1-CH_JC.pdf, 29/07/2021, Institute for Women's Policy Research.

The Conference Board (2020). Consumers' Attitudes about Sustainability. Retrieved from https://conference-board.org/pdfdownload.cfm?masterProductID=20499, 11/01/2021.

The Nielsen Company (2015). The Sustainability Imperative. Retrieved from https://www.nielsen.com/wp-content/uploads/sites/3/2019/04/Global20Sustainability20Report_October202015.pdf, 11/01/2021.

Vermeir, I. and Verbeke, W. (2006). Sustainable food consumption: Exploring the consumer "attitude - Behavioral intention" gap. Journal of Agricultural and Environmental Ethics, 19(2):169–194.

Yale Program on Climate Change Communication (YPCCC) and George Mason University Center for Climate Change Communication (Mason 4C) (2020). Climate Change in the American Mind: National survey data on public opinion (2008-2018). doi: 10.17605/OSF.IO/JW79P.