Towards Optimal Taxation: Designing Tax Systems and Navigating Fiscal Challenges

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Preface

Tax systems are critical in enabling governments to achieve various economic, social, and fiscal objectives. Taxation not only provides the necessary revenue for funding public goods and services but also influences economic behavior, resource allocation, and overall social welfare. A well-designed tax system can promote economic growth, mitigate inequality, foster social cohesion, and ensure the efficient allocation of resources within an economy. By carefully crafting tax systems, policymakers can strike a balance between equity and efficiency, two opposing objectives of tax design.

Equity entails ensuring that the tax burden is distributed fairly across individuals and households, with those who can afford to contribute more shouldering a greater proportion of the burden. Efficiency dictates that taxes should not unduly distort economic behavior or impede productive activities, allowing resources to be allocated in a manner that maximizes overall welfare.

Utilizing different forms of taxation is essential for achieving these objectives. For instance, by incorporating wealth taxation alongside capital income taxation, policymakers can establish a more efficient and equitable tax system, aiming to reduce inequality and generate revenue from those with significant assets. This approach diversifies the tax base, ensuring that all segments of society contribute fairly while also addressing economic inequality.

Moreover, the design of new taxation forms can offer innovative solutions to emerging challenges. Joint taxation of income and wealth, for example, integrates these two dimensions of economic well-being, providing a holistic approach to tax policy. By considering the interaction between income and wealth, joint taxation can enhance efficiency and improve equity.

However, in the face of fiscal pressure, the optimal design of taxes becomes even more critical. External shocks such as economic downturns, pandemics, or geopolitical tensions can strain government finances, necessitating adjustments to tax policies. Policymakers must carefully navigate these challenges, ensuring that tax systems remain equitable and efficient, retaining their optimal structure.

In the subsequent chapters, I delve deeper into these discussions, exploring the implications of different tax policies and their responses to fiscal pressure. By examining capital taxation, joint taxation of income and wealth, and the impact of fiscal challenges on optimal tax design, I aim to contribute to a more comprehensive understanding of taxation's role in shaping economic outcomes and social welfare.

How Should We Tax Capital? The first chapter of this thesis examines how capital should be taxed, utilizing a model, that crucially distinguishes between two asset classes: one yielding greater financial returns and the other providing flow utility. By integrating households with diverse preferences across time and asset classes alongside a government employing both capital income and wealth taxation, the chapter aims to explain in detail the nuances between these two tax forms and their implications on household behavior and optimal taxation policy.

In addressing this question, it is critical to understand the role taxes play in shaping the household decision-making process. The chapter begins by demonstrating the divergent impacts of wealth and capital income taxation on household decisions. A positive wealth wedge, serves to dissuade saving without perturbing portfolio choices, whereas a positive capital income wedge not only distorts saving decisions but also steers households towards assets yielding lower returns by skewing the relative prices.

Turning towards the government's problem, the chapter proceeds to solve for the optimal wedges necessary for welfare-maximizing allocations, particularly in the presence of preference heterogeneity among households. It reveals that in scenarios of heterogeneous preferences, optimal wealth and capital income distortions hinge on the nature and extent of this heterogeneity. Notably, if higher-income households exhibit greater patience, the government is advised to curb saving, leveraging this information. Conversely, if lower-income households lean more towards utility-yielding assets, introducing a positive capital income wedge becomes essential to affect portfolio allocation. The undesired impact of a positive capital income wedge on household saving behavior needs to be corrected by an appropriate negative wealth wedge.

By calibrating a life cycle model to the U.S. economy, with a focus on preference heterogeneity, the chapter provides insights deducted from simulated revenue-neutral tax reforms altering the capital taxation mix. The analysis underscores the inefficacy of relying solely on capital income taxation and it indicates the potential welfare gains from employing a combination of capital income taxes and wealth taxes. The optimal capital taxation reform entails the introduction of a wealth subsidy aimed at benefiting low-income households more due to preference heterogeneity, coupled with an increase in capital income taxes to finance it. Furthermore, under fiscal pressure, as defined by the need to generate additional tax revenue, the optimal taxation strategy pivots, suggesting a wealth tax implementation alongside a reduction in the capital income tax rate to ensure constant tax revenue. The implication is that fiscal pressure imposes constraints on the government's capacity to redistribute effectively.

Joint Taxation of Income and Wealth. The second chapter, which is based on joint work with Dominik Sachs, explores the integration of income and wealth taxation, analyzing the efficiency gains and social implications of such a combined approach.

Beginning with a simplified two-period model, the chapter investigates the impact of conditioning wealth taxation on labor income. Within this foundational framework, it becomes evident that state-dependent saving taxes based on current income have varying levels of distortion on the individual saving behavior. This variation provides an opportunity for governments to enhance social welfare through more efficient taxation.

Moving forward, the chapter analyzes the fiscal and social impacts of joint tax reforms, focusing on increasing the tax liability of a specific subgroup across the joint distribution of income and wealth. It investigates the consequences of conditioning the marginal tax rate of income on wealth, and vice versa, explaining in detail the tagging benefits and distortion costs involved, due to the endogeneity of the tagging mechanism. Formulas elucidating the marginal excess burden and welfare effects are derived, expressed in terms of the marginal excess burdens of separate income and wealth tax reforms, providing a comprehensive understanding of the implications of joint tax reforms. An important benchmark considered is the scenario where income and wealth are uncorrelated, highlighting that while no benefit from tagging exists, the secondary distortion persists.

Furthermore, the chapter applies the theoretical framework to quantify the fiscal and social impacts of integrating income and wealth taxation within the U.S. personal tax schedule. By identifying regions where joint tax reforms outperform separate reforms, the chapter offers valuable guidance for policymakers seeking to optimize tax policy outcomes. Moreover, the analysis demonstrates that joint tax reforms have the potential to enhance social welfare even when separate income and wealth tax reforms fall short.

Who Should Bear the Burden of Covid-19-Related Fiscal Pressure? The third chapter of this thesis, which is based on joint work with Lea Fricke, Clemens Fuest, and Dominik Sachs,[1] investigates how the optimal progressivity of the income tax-transfer system evolves in response to increased fiscal pressure induced by the COVID-19 pandemic, focusing on five European countries—France, Germany, Italy, Spain, and the U.K.

Employing an inverse-optimum approach, the chapter avoids reliance on specific social welfare functions. Instead, it calibrates Pareto weights under the assumption that pre-pandemic tax-transfer systems mirror social preferences for redistribution. Subsequently, the calibrated model assesses the implications of COVID-19-related fiscal pressure on tax progressivity, factoring in income effects and endogenous welfare weights. The analysis reveals a trend towards higher marginal and average tax rates, particularly affecting

[1] A version of this chapter has been published in the *European Economic Review*, Volume 153, Article 104381 in April 2023. See Ayaz et al. (2023) for the full reference

lower-income individuals. This shift implies a less progressive tax schedule, although higher-income individuals bear a larger absolute tax burden.

The findings suggest that there is a trade-off between the objectives of raising additional revenue and redistributing through a more progressive tax system. When confronted with fiscal pressure, governments face limitations in their capacity to redistribute effectively.

The chapter explains the underlying reasons for the decline in optimal progressivity, highlighting the significance of considering revenue-maximizing marginal tax rates. Notably, governments possess greater flexibility to increase marginal tax rates for low-income groups, as evidenced by the substantial difference between revenue-maximizing bounds and pre-pandemic marginal tax rates.

Results indicate a pronounced upward shift in marginal tax rates across all countries, particularly affecting low-income earners. The shift in marginal tax rates exhibits a U-shaped pattern, following the difference between revenue-maximizing bounds and pre-pandemic tax rates. Similarly, average tax rates exhibit a disproportionate increase for lower-income groups before tapering off with rising income levels.

The analysis highlights the necessity for substantial reductions in lump-sum transfers, albeit acknowledging potential political constraints. Imposing restrictions on governments to uphold consistent transfer levels leads to a more regressive shift in marginal tax rates, while the impact on average tax rates becomes less regressive.

Chapter 1

How Should We Tax Capital?

Interaction Between Capital Taxes and Saving Motives*

1.1 Introduction

Capital taxation has been a subject of debate among economists and policymakers for years. Despite constituting a smaller share of overall tax revenue compared to income taxes, the impact of capital taxation remains significant (Bastani and Waldenström, 2020). It serves as a potential tool for raising additional revenue and redistributing between households.

Capital income taxes and wealth taxes represent two distinct approaches to taxing capital. While both aim to generate revenue from capital stock, they diverge in their application. Capital income taxes target the returns generated from investments and other capital assets, whereas wealth taxes typically focus on the net worth of individuals or households.

In this study, I explore the similarities and differences between capital income taxation and wealth taxation; incorporating an element of asset heterogeneity. Specifically, I consider assets that yield greater financial returns alongside those that offer non-monetary flow utility to households.

In a hypothetical scenario where returns on capital are uniform across households, capital income taxes and wealth taxes would essentially yield similar outcomes. Theoretically, a capital taxation policy relying solely on capital income taxes could be mirrored by another policy based solely on wealth taxation. However, empirical evidence suggests that there is persistent heterogeneity in capital returns (Fagereng et al., 2020; Bach, Calvet and Sodini, 2020). Therefore, it becomes crucial to distinguish the similarities and differences between these two forms of capital taxation and understand their implications from a policy-making standpoint.

*This chapter is based on single-authored work.

A crucial factor contributing to heterogeneous returns is the variation in portfolio composition. For instance, Kuhn, Schularick and Steins (2020) emphasize the significance of household portfolio composition for wealth dynamics and inequality. They find that middle-income households' portfolios in the U.S. are primarily dominated by housing, whereas financial assets are more prevalent at the top income distribution. Hence, any heterogeneity in asset price changes or returns on these assets has a first-order effect on wealth distribution. Moreover, Bach, Calvet and Sodini (2020) find that the heterogeneity in returns is the main driver of the recent increase in the top wealth shares in Sweden. This underscores the importance of understanding how differences in portfolio composition contribute to disparities in wealth accumulation and distribution.[1]

One possible explanation of these systemic differences in portfolio compositions could be the heterogeneity in how households value different types of assets. Heterogeneity in the relative valuation of different assets would lead to differences in households' portfolio compositions. Otherwise identical households would choose to invest their capital in different assets due to this heterogeneity, consequently earning different returns on the same amount of capital.

Several asset classes offer persistently lower returns even after adjusting for the higher risk associated with higher-return assets, yet are heavily invested in by households. Housing provides an example of such an asset class. For instance, Flavin and Yamashita (2002) show that a minimum housing constraint must be added to support large shares of housing in households' portfolios. Yamashita (2003) adds to this hypothesis by stating that "overinvestment in housing affects the financial portfolio of homeowners." Additionally, Pelizzon and Weber (2008) conclude that portfolios with large shares of housing are not efficient.[2]

Large portfolio shares of lower-return assets raise the question of why people would invest in these assets that yield lower returns, even when accounting for the higher risk that comes with assets with higher returns. One plausible explanation for this phenomenon could be the intrinsic flow utility associated with assets offering lower returns. In essence, individuals may choose to save not solely to preserve or increase financial value, but also to derive satisfaction from ownership itself. This is akin to the utility-in-the-wealth approach, albeit focused on specific components of the overall portfolio. In this scenario, it becomes rational for individuals to invest in assets with lower returns, as they derive utility from owning these assets during their possession.

[1] The heterogeneity in returns on capital may also stem from scale-dependence, as suggested by Fagereng et al. (2020). This phenomenon could arise from fixed investment costs and learning-by-doing effects. Alternatively, certain innate characteristics may enable individuals to achieve higher returns on the same capital as in Guvenen et al. (2023). Schulz (2021) compares these two rationales and characterizes the optimal capital income tax rate based on sufficient statistics.

[2] Artwork is another example of an asset class with lower returns. Despite exhibiting lower risk-adjusted returns compared to other financial assets, there remains substantial demand for artwork (Baumol, 1986; Pesando, 1993; Mei and Moses, 2002; Korteweg, Kräussl and Verwijmeren, 2016).

To address the question of how capital should be taxed, I begin by presenting a simple and tractable model that combines households that have heterogeneous preferences across time and asset classes and a government that uses both capital income and wealth taxation to address capital stock, alongside labor income taxation. In this model, I explain the differences between the two taxation methods in terms of their effect on household saving behavior and portfolio allocation. Specifically, a positive wealth wedge discourages saving without affecting the portfolio decision, while a positive capital income wedge not only distorts the saving decision but also guides households towards investing more in assets with lower returns by altering the relative price of the two assets.

Then, I turn to the government's problem and solve for the welfare-maximizing allocations using appropriate wedges that distort household behavior. Without preference heterogeneity, the Atkinson-Stiglitz theorem applies and capital accumulation decisions of households should not be distorted (Atkinson and Stiglitz, 1976). In the case where households do not share the same preferences, I characterize the optimal wealth and capital income distortions depending on the nature and extent of preference heterogeneity. Specifically, I demonstrate that if higher-income households display greater patience, the government should discourage wealth accumulation to leverage this information. Conversely, if low-income households place a higher relative value on the utility asset, implementing a positive capital income wedge to distort portfolio allocation is warranted. To counterbalance the impact of the capital income wedge on saving decisions, a negative wealth wedge is necessary.

Subsequently, I calibrate a life cycle model to the U.S. economy, focusing on preference heterogeneity among households. The analysis reveals that households with higher labor productivity tend to exhibit greater patience in making inter-temporal decisions, therefore saving relatively more in the asset that yields greater financial returns. Leveraging this calibrated heterogeneity, I simulate the outcomes of revenue-neutral tax reforms that vary the capital taxation mix. The findings indicate that relying solely on capital income taxation is inefficient; the government can enhance social welfare by using capital income taxes and wealth taxes at the same time. The optimal reform strategy identified involves implementing a wealth subsidy alongside an increase in the capital income tax rate. The negative wealth tax rate serves as a redistributive mechanism, reallocating resources from higher-income households, who predominantly save in higher-return assets, towards lower-income households, who hold relatively more utility-yielding assets in their portfolio. Yet, under fiscal pressure, indicated by the necessity to increase tax revenue, the optimal reform takes a different direction. The government should implement a wealth tax while decreasing the capital income tax rate, ensuring tax revenue remains constant. This adjusted reform results in diminished redistribution from higher-income households to lower-income ones.

Related literature. This study contributes to four strands of the literature. The first pertains to optimal capital taxation. Earlier studies conclude that capital should not be taxed for efficiency reasons (Atkinson and Stiglitz, 1976; Judd, 1985; Chamley, 1986). However, subsequent research indicates that taxing capital may be desirable due to factors such as uncertain or evolving labor productivity (Golosov, Tsyvinski and Werning, 2006), incomplete insurance markets (Conesa, Kitao and Krueger, 2009), multi-dimensional heterogeneity (Piketty and Saez, 2013), and preference heterogeneity (Diamond and Spinnewijn, 2011; Saez and Stantcheva, 2018; Ferey, Lockwood and Taubinsky, 2023).[3] This study contributes by focusing on two different assets: one yielding greater financial return and the other providing larger flow utility.

Second, there is an emerging literature comparing capital income taxation with wealth taxation; however, it yields inconclusive results. For instance, Guvenen et al. (2023) suggests that replacing the current capital income tax in the U.S. with a wealth tax could enhance efficiency and welfare due to the "use-it-or-lose-it" effect, reallocating capital to individuals capable of generating higher returns. However, Boar and Midrigan (2023) argues that such a shift could result in equity losses outweighing efficiency benefits, as capital reallocation to successful entrepreneurs may exacerbate inequality and reduce social welfare. To contribute to this debate, I focus on preference heterogeneity as the underlying reason behind the heterogeneous returns on capital.

The third strand focuses on the effects of taxes on household portfolio allocation. Taxation, particularly capital taxation, significantly influences how households make portfolio allocation choices (Poterba and Samwick, 2003; Bergstresser and Poterba, 2004; Alan et al., 2010; Advani and Tarrant, 2021; Zoutman, 2018). This paper adds to this literature by studying the effects of both capital income and wealth taxation on household portfolio allocation.

The last strand pertains to wealth-in-the-utility. Fisher (1930) argues that people accumulate wealth for reasons beyond future consumption, such as increased social status, political influence, and satisfaction derived from the process of wealth accumulation itself, indicating a flow utility from wealth. This wealth-in-the-utility approach has been applied in various studies to explore asset pricing (Bakshi and Chen, 1996), unemployment in a business cycle model (Michaillat and Saez, 2022), optimal capital income taxation (Saez and Stantcheva, 2018), and the effects of wealth taxation (Jakobsen et al., 2020). This paper contributes by utilizing the wealth-in-the-utility approach to compare capital income and wealth taxes.

The remainder of this chapter is structured as follows. Section 1.2 introduces a two-period model and derives optimal allocations using a mechanism-design approach. In Section 1.3, a life cycle model is calibrated to the U.S. economy for determining the optimal

[3] See Bastani and Waldenström (2020) for a survey on optimal capital taxation.

mix of capital taxes through simulation analysis. Lastly, Section 1.4 presents concluding remarks.

1.2 Optimal Allocations in a Two-Period Model

In this section, I present a simple two-period model to explain the interaction between capital taxes and saving motives. The economy consists of two types of households: those with high labor productivity (denoted by θ_h) and those with low labor productivity (denoted by θ_l). The households maximize their lifetime utility given their type and prices in the economy, whereas the government maximizes social welfare.

1.2.1 Households' Problem

Households live for two periods. In the first period, they work and earn labor income. They consume a portion of their earnings in the first period and save the remainder. Two types of assets are available for households to save in. The first type is termed the return asset (denoted by a_R), which yields financial returns that can be consumed in the second period. The second type is referred to as the utility asset (denoted by a_U). While this asset does not generate any financial returns[4], it offers non-monetary utility benefits to households. There are no mortality, earnings, or return risks factored in the model. The lifetime utility of households is given by

$$U_i(y, c_1, c_2, a_U) = u(c_1) + \beta_i u(c_2) + \phi_i(a_U) - v\left(\frac{y}{\theta_i}\right) \qquad i = l, h,$$

where $u(c_1)$ and $u(c_2)$ represent the utility from consumption in periods one and two, respectively. The consumption utility function $u(\cdot)$ is increasing and concave. β_i denotes the time discount rate. The subscript i highlights that households may have different discount rates. a_U denotes the level of savings in the utility asset. $\phi_i(a_U)$ captures the utility derived from the utility asset. Different households possibly have different valuations for the same level of utility asset. Similar to the consumption utility, the utility from wealth $\phi_i(\cdot)$ is also increasing and concave. $v\left(y/\theta_i\right)$ denotes the effort cost of earning y for a household with labor productivity θ_i. This cost is increasing and concave in labor effort. Moreover, the way the function is set up means that to earn the same labor income, a household with a higher labor productivity needs to exert less effort.

In the first period, the households consume a portion of their labor income and save the remainder. They can save both in the return and utility assets. In the second period, the

[4]The fact that the utility asset does not yield financial returns serves as a normalization. Introducing different return rates for assets would yield similar insights. To align the model with reality, one might consider the return rate of the return asset in the model as the difference between the return rates of two assets in reality. Section 1.3 uses that approach.

households consume all their savings together with any financial returns. The optimization problem of households is given by

$$\begin{aligned} \max_{y, c_1, c_2, a_U, a_R} \quad & U_i(y, c_1, c_2, a_U) \\ \text{s. t.} \quad & c_1 = y - a_R - a_U \\ & c_2 = a_R(1 + r) + a_U \end{aligned} \tag{1.1}$$

where a_R denotes the savings in the return asset and r denotes the inter-period interest rate.

The existence of two assets with differing return rates introduces the possibility of return heterogeneity among households, measured relative to their total assets. A household that allocates a higher proportion of their savings to the return asset will receive greater financial returns in proportion to their overall assets. Return heterogeneity is also observed in other studies such as Guvenen et al. (2023), where it arises from individuals having different entrepreneurial productivities, and Schulz (2021), where it originates from size or type dependency.[5] In contrast, return heterogeneity arises from preference heterogeneity in this research.

Households make three decisions to solve the problem given in Equation (1.1): First, they decide on how much to earn and how much to enjoy leisure. Second, they decide on how much to consume in the first period and how much to save for the second period. Third, they decide on how to allocate their total savings in the return asset and utility asset. The first-order conditions with respect to labor income, return assets, and utility assets are given by

$$u'(c_1) - v'\left(\frac{y}{\theta_i}\right)\frac{1}{\theta_i} = 0 \tag{1.2}$$

$$-u'(c_1) + \beta_i u'(c_2)(1 + r) = 0 \tag{1.3}$$

$$-u'(c_1) + \beta_i u'(c_2) + \phi_i'(a_U) = 0 \tag{1.4}$$

respectively.

The first condition regarding labor income states that households need to balance the marginal benefit of earning one more unit and its associated marginal cost. In other terms, the increase in consumption utility resulting from higher earnings should be offset by the decrease in utility caused by increased effort. The second condition regarding the return asset states the importance of optimizing saving decisions to maximize utility inter-temporally. Specifically, individuals should equalize the marginal benefit of saving one more unit in the return asset, including its interest, against the marginal cost arising from

[5] Another paper that is closely related in this aspect is by Gahvari and Micheletto (2016). In their paper, the authors assume that individuals have exogenously different return rates and solve for the optimal capital income tax rate.

reduced consumption in the first period. The third condition regarding the utility asset combines inter-temporal maximization with the utility derived from savings, emphasizing the fact that the utility asset does not provide any interest but increases the lifetime utility.

Equations (1.3) and (1.4) can be combined the emphasize the portfolio decision choice. Substituting $u'(c_1)$ yields

$$-\beta u'(c_2)r + \phi_i'(a_U) = 0 \tag{1.5}$$

The equation above captures the cost and benefit of allocating one more unit of savings into the utility asset rather than the return asset. The household would incur a loss in terms of second-period consumption due to forgone interest but would gain non-monetary benefits from the utility asset.

By utilizing the first-order conditions and the portfolio decision condition given in Equation (1.5), three wedges can be defined. These wedges distort the three decisions households make.

$$t_y = 1 - \frac{v'\left(\frac{y}{\theta_i}\right)\frac{1}{\theta_i}}{u'(c_1)} \tag{1.6}$$

$$t_w = 1 - \frac{u'(c_1) - \phi_i'(a_U)}{\beta_i u'(c_2)} \tag{1.7}$$

$$t_k = 1 - \frac{1}{r}\frac{\phi_i'(a_U)}{u'(c_1) - \phi_i'(a_U)} \tag{1.8}$$

The first wedge (labor income wedge) governs the household's decision on labor supply. When $t_y = 0$, Equation (1.6) simplifies to the first-order condition with respect to labor supply, indicating that the labor supply decision remains undistorted. The second wedge (wealth wedge) concerns the consumption decision between periods. When $t_w = 0$, Equation (1.7) is analogous to the first-order condition of the utility asset. In this scenario, households freely allocate their savings to the utility asset. The last wedge (capital income wedge) is about the decision to earn more interest income. The larger t_k is, the more distorted the household's decision to earn interest income becomes.

One crucial distinction between the wealth wedge and the capital income wedge is in the decisions they distort. The wealth wedge concerns the inter-temporal decision-making process between the first and second periods. It does not affect the relative prices of different assets; therefore, it does not impact the portfolio allocation decision. Conversely, the capital income wedge alters these relative prices and does affect the portfolio decision. Moreover, in addition to this distortion, the capital income wedge also influences the inter-temporal decision by making second-period consumption relatively more expensive due to the lower after-tax returns of the return asset.

These wedges can be implemented using a tax function that depends on labor income, capital income, and wealth. Suppose that the tax payment is calculated as a function with three arguments. It is given as $T(y_L, y_K, w)$ where y_L is labor income, y_K is capital income, and w is wealth. Then, the wedges can be interpreted as marginal tax rates of this tax payment function. That is, $t_j = \frac{\partial T(y_L, y_K, w)}{\partial j}$.

1.2.2 Government's Problem

The government maximizes social welfare, defined as the weighted sum of households' utilities. It assigns welfare weights $\tilde{f}^i$ to each household which may be different than their population weight. The social welfare is given by

$$\mathcal{W} = \sum_{i=l,h} \tilde{f}^i U_i(y^i, c_1^i, c_2^i, a_U^i) \tag{1.9}$$

To achieve the welfare-maximizing allocation, the government employs a direct mechanism. In essence, it assigns a set $(y^i, c_1^i, c_2^i, a_U^i)$ to household i. However, due to information asymmetry, the government cannot directly observe the household's type (labor productivity). It can only observe outcome variables which are labor income, consumption, and savings. Therefore, the government offers the entire menu of allocations to every household, ensuring that each household is incentivized to truthfully report their type.

The optimization problem of the government reads as

$$\begin{aligned} \max_{y^i, c_1^i, c_2^i, a_U^i} \quad & \mathcal{W} = \sum_{i=l,h} \tilde{f}^i U_i(y^i, c_1^i, c_2^i, a_U^i) \\ \text{s. t.} \quad & \sum_{i=l,h} f^i y^i \geq \sum_{i=l,h} f^i \left(c_1^i + \frac{c_2^i}{1+r} + \frac{r a_U^i}{1+r} \right) \\ & U_h(y^h, c_1^h, c_2^h, a_U^h) \geq U_h(y^l, c_1^l, c_2^l, a_U^l) \end{aligned} \tag{1.10}$$

The first constraint of this problem is the resource constraint. The aggregate income in the economy (represented by the LHS) must be greater than or equal to the net present value of aggregate consumption (represented by the RHS). The return asset allocated to households appears in the resource constraint even though it is not part of consumption. This is because the term $\frac{r a_U^i}{1+r}$ accounts for the opportunity cost of the utility asset. It reflects the cost the government incurs by allocating utility assets instead of return assets. In other words, it captures the forgone interest resulting from not saving in return assets.

The second constraint is called the incentive compatibility constraint. The LHS of the constraint captures the utility of a truthful reporting household with high labor productivity. The RHS is their utility when they mimic a household with low labor productivity.[6] The incentive compatibility constraint states that the utility of truthful

[6]This can be seen by observing the mismatch between the subscript of the utility function and its arguments.

reporting for high-productivity households must be greater than or equal to mimicking low-productivity households.

There could be another incentive compatibility constraint for low-productivity households as well; however, one can show that only one constraint can be binding in the optimum. If the ratio $\frac{\tilde{f}^l}{f^l}$ is sufficiently high (the government wants to redistribute towards low-productivity households), then only the constraint for high-productivity households is binding.

1.2.3 Optimal Distortions

After defining the problems of households and the government, one can characterize the optimal allocation that maximizes social welfare. The concept of the marginal social welfare weight proves useful in outlining and interpreting the optimal wedges that distort households' decisions. Specifically, the marginal social welfare weight for low-productivity households is defined as follows.

$$g^l \equiv \frac{\frac{\partial U_l}{\partial c_1}}{\lambda} \frac{\tilde{f}^l}{f^l}$$

where λ is the Lagrange coefficient for the resource constraint in Equation (1.10).[7] The marginal social welfare weight for low-productivity households measures the increase in welfare, depending on the relative welfare weight when the household is given one more unit of consumption in the first period. This measure is in terms of public funds. The higher g^l is, the more the government wants to redistribute towards low-productivity households.

Proposition 1.1. *The decision-making process of households with high productivity remains undistorted in the optimal allocation.*

$$t_y^h = 0, \qquad t_w^h = 0, \qquad t_k^h = 0$$

Proof. See Appendix A.1. □

Proposition 1.1 summarizes the optimal allocation for high-productivity households. The solution to the government's optimization problem results in an allocation allowing them to make decisions without government intervention.

This finding is not unique, as the mechanism-design approach to redistributive taxation frequently yields the no-distortion-at-the-top result (for example, Mirrlees, 1971). Additionally, this result is local, applying only to the household with the highest productivity in cases involving more than two types of households.

[7] One interpretation of this coefficient is its representation of the marginal value of public funds. It quantifies the extent to which an additional unit of public funds can improve welfare. See Hendren and Sprung-Keyser (2020) for an overview.

Proposition 1.2. *All three decisions of households with low productivity need to be distorted in the optimal allocations. The optimal wedges are given by*

$$t_y^l = (g_l - 1)\frac{v'\left(\frac{y^l}{\theta_l}\right)\frac{1}{\theta_l} - v'\left(\frac{y^l}{\theta_h}\right)\frac{1}{\theta_h}}{u'(c_1^l)} \tag{1.11}$$

$$t_w^l = (g_l - 1)\left(\frac{\beta_h - \beta_l}{\beta_l} + \frac{\phi_h'(a_U^l) - \phi_l'(a_U^l)}{\beta_l u'(c_2^l)}\right) \tag{1.12}$$

$$t_k^l = -(g_l - 1)\frac{1+r}{r}\frac{\phi_h'(a_U^l) - \phi_l'(a_U^l)}{u'(c_1^l) - \phi_l'(a_U^l)} \tag{1.13}$$

Proof. See Appendix A.1. □

Proposition 1.2 outlines the optimal allocation for low-productivity households. To maximize social welfare, the government intervenes by distorting the decisions made by low-productivity households.

First, consider the labor income wedge. It is positive, assuming households do not share the same productivity level, implying that low-productivity households are incentivized to work less compared to a scenario without government intervention. This distortion is aimed at discouraging high-productivity households from mimicking low-productivity households. The larger the disparity between the marginal benefit of earning labor income and its associated marginal cost, the more costly it becomes for high-productivity households to mimic low-productivity ones.

Second, the wealth wedge is non-zero as long as there are differences between households in terms of discount rate or the valuation of the utility asset.[8]—unless two sources of heterogeneity exactly offset each other. The argument behind this is similar to the one concerning the labor income wedge. With heterogeneities in discount rates or valuations of the utility asset, high-productivity households would ideally prefer a different wealth level when mimicking low-productivity households. Therefore, distorting the wealth decision discourages high-productivity households from mimicking.

Third, the capital income wedge is non-zero if households differ in terms of the valuation of the utility asset. In this scenario, the government once again distorts the decision of low-productivity households to deter high-productivity households from mimicking them. By imposing a wedge in capital income, the government aims to create a disincentive for high-productivity households This distortion serves to maintain a more efficient allocation of resources across households.

[8]Note that β_h is not necessarily larger than β_l. The subscripts merely denote their association with households of high and low productivity, respectively. For instance, if low-productivity households are more patient, then $\beta_l > \beta_h$. The same principle applies to $\phi_i'(a_U)$.

From the optimal allocation, several insights emerge. First of all, in cases where households differ solely in terms of labor productivity and have identical preferences in other aspects, the only non-zero wedge is the labor income wedge. This implies that the government does not distort either the saving decision or the portfolio choice. This result aligns with the Atkinson-Stiglitz theorem (Atkinson and Stiglitz, 1976), which states that with utility functions exhibiting separable labor effort, welfare can be maximized solely through direct labor income taxes, without any need for indirect taxes.

Another crucial insight is that the nature of preference heterogeneity among households, if present, determines which decisions are distorted in the optimal allocation. This is because the presence of wealth and capital income wedges proves useful for the government insofar as they can relax the incentive compatibility constraint. Specifically, these wedges discourage the high-productivity households from mimicking, therefore extending the redistribution possibilities for the government.

Corollary 1.1. *Suppose that households differ in terms of labor productivity and discount rate but value the utility asset the same. Then, the wealth wedge is non-zero for the low-productivity household, whereas the capital income wedge is zero. If households with higher income are also more patient ($\beta_h > \beta_l$), then the wealth wedge is positive.*

Proof. Setting $\phi'_h(a_U) = \phi'_l(a_U)$ in Equations (1.12) and (1.13) yields the result. □

Corollary 1.1 addresses a scenario where preference heterogeneity between households is inter-temporal, indicating that one type of household places relatively more importance on one period. However, both types of households share the same relative valuation between the return asset and the utility asset. Therefore, the government should distort the inter-temporal decision, for which the wealth wedge is useful in this context. For instance, if high-productivity households are more patient ($\beta_h > \beta_l$), they would prefer to save more than low-productivity households when mimicking them. To discourage this behavior, the government distorts the inter-temporal decision of low-productivity households by introducing a positive wealth wedge. However, the government should not distort the portfolio choice in this scenario, thus the capital income wedge remains zero.

Corollary 1.2. *Suppose that households differ in terms of labor productivity and the valuation of the utility asset but share the same discount rate. Then, both the wealth wedge and the capital income wedge are non-zero for low-productivity households but with different signs. Moreover, their impact on the households' inter-temporal decision counteracts each other, leaving it undistorted. If households with lower income prefer the utility asset more ($\phi'_l(a_U) > \phi'_h(a_U)$), then the capital income wedge is positive and the wealth wedge is negative.*

Proof. Setting $\beta_h = \beta_l$ and plugging in the optimal wedges from Equations (1.12) and (1.13) into their definitions in Equations (1.7) and (1.8) yield the result. □

In another scenario where preference heterogeneity is in terms of relative asset valuation, Corollary 1.2 summarizes the optimal allocation. Here, one type of household values the utility asset relatively more (or less), while all households share the same valuation between different periods. Therefore, the government should alter the portfolio decision while keeping the inter-temporal decision undistorted. The capital wedge distorts the relative prices of different assets to achieve this goal; however, it also distorts the inter-temporal decision. The wealth wedge, appropriately sized, reverses this distortion on the inter-temporal decision, restoring it to its undistorted state.

Lastly, if households have different discount rates and valuations of the utility asset, both the inter-temporal decision and the portfolio decision should be distorted. The direction and magnitude of these distortions depend on the extent and direction in which households have different preferences.

1.3 Simulation Analysis

Governments often opt for simpler and more practical tax instruments over more complex and non-linear ones. The tax instrument used for the optimality analysis in Section 1.2 is an example of a highly complex approach. It requires the use of three non-linear taxes, which may depend on each other and all choices made in the current period as well as previous periods. In this section, I will present a numerical analysis where governments rely on simpler linear taxes that are not interdependent. The tax rates depend only on the current choice of households that is specific for that tax rate.

1.3.1 Model

In the model, households have a finite lifespan, which can be interpreted as a specific number of years. The households enter into the model without any assets. During the initial years of their life, they work and generate labor income. They have the option to save a portion of their earnings in either the return asset or the utility asset. Both types of assets accrue interest annually, with the return of the return asset assumed to be higher than that of the utility asset, that is, $r_R > r_U$. This assumption's critical implication is that households save in both types of assets in equilibrium as long as the marginal utility from the utility asset is decreasing and the largest for zero input.[9]

In the later stages of their life, households transition into retirement and cease earning labor income. Nonetheless, they continue to earn capital income through their savings each year. During retirement, households consume their accumulated savings and eventually die in a predetermined period without any mortality risk in earlier periods. Given that

[9]Put formally, $\phi_i''(a_U) < 0$ and $\lim_{a_U \to 0} \phi_i'(a_U) = +\infty$.

they have no incentive to retain positive assets at the end of their lives[10], they deplete their savings entirely in the final period.

Households maximize their lifetime utility subject to yearly budget constraints given tax rates, interest rates, and their preferences. The optimization problem is given by

$$
\begin{aligned}
\max_{y,c,a}\ & U^{LT} = \sum_{i=t}^{T_w} \beta_i^t \left[u(c_{w,t}) + \phi_i(a_{U,t}) - v\left(\frac{y_t}{\theta_i}\right)\right] + \sum_{t=T_w+1}^{T_w+T_r} \beta_i^t \left[(u(c_{r,t}) + \phi(a_{U,t}) \right] \\
\text{s. t. }\ & a_{R,0} = a_{U,0} = 0 \\
& y_t(1-\tau_y) + a_{R,t-1}\overline{R}_R + a_{U,t-1}\overline{R}_U = c_{w,t} + a_{R,t} + a_{U,t}, \quad t \in [1,2,\dots,T_W] \\
& a_{R,t-1}\overline{R}_R + a_{U,t-1}\overline{R}_U = c_{r,t} + a_{R,t} + a_{U,t}, \quad t \in [T_W+1, T_W+2,\dots,T_W+T_R]
\end{aligned}
\tag{1.14}
$$

where β_i is discount rate, θ_i is labor productivity, ϕ_i is utility from wealth function, y_t represents annual labor income, $c_{w,t}$ and $c_{r,t}$ represent annual consumption during working life and retirement, and $a_{R,t}$ and $a_{U,t}$ represent return and utility assets at the end of a year. Similar to Section 1.2, households may have preference heterogeneity in terms of labor productivity, discount rate, and valuation of the utility asset. τ_y is the constant marginal tax rate on labor income. $\overline{R}_i = (1-\tau_w)(1+r_i(1-\tau_k))$ represents the gross after-tax return of asset i. It depends on the before-tax return rate of the asset as well as both the capital income and wealth tax rates.

The first summation in the lifetime utility function captures the working life of households. It accounts for the fact that earning labor income incurs costs for households, with the level of costliness varying based on their labor productivity. In each year of their working life, households derive utility from their consumption as well as from the stock of their utility assets at the year's end. The second summation pertains to the retirement of households. Similar to their working life, during retirement, households continue to derive utility from their annual consumption and the stock of their utility assets at the end of each year.

The problem outlined above presents significant complexity, making it challenging to address both analytically and numerically. However, it is possible to simplify the problem by making several assumptions, thereby reducing its dimensions and allowing a more focused examination of the central question: What is the significance of households' saving motives in determining the approach governments should adopt in taxing capital?

One such assumption is to restrict households to choose only one labor income level throughout their working life.[11] This simplification helps abstract away from the

[10]Other than mortality risk, another reason why households may retain positive assets at the time of death is the bequest motive. This motive can help explain observed wealth inequality, as affluent households may be more inclined to accumulate and maintain larger asset holdings to pass on to future generations. (De Nardi, 2004)

[11]This assumption can be slightly relaxed by considering an evolving profile of earnings instead of assuming a constant income level throughout households' working lives.

complexities of life cycle considerations on labor supply, allowing for a simpler analysis of the interaction between saving motives and optimal capital taxation policies.

Another assumption is to set the net saving of households in both assets to be constant. This implies that households save a fixed portion of their earnings in return and utility assets each year, maintaining the same proportion consistently. Consequently, their annual consumption remains constant throughout their working life. Similarly, during retirement, households withdraw from their assets in a fixed amount and proportion to maintain constant annual consumption. This simplification streamlines the analysis by ensuring a stable consumption pattern within working life and retirement, yet allowing households to adjust their consumption between the two periods.

With the two assumptions explained above, the households' lifetime utility maximization problem can be simplified as follows:

$$\begin{aligned} \max_{y, c_w, c_r, a_U, a_R} \quad & \beta_i^w \left[u(c_w) - v\left(\frac{y}{\theta_i}\right)\right] + \beta_i^r \left[u(c_r)\right] + \beta_i^\phi \phi_i(a_U) + \phi_i^C \\ \text{s. t.} \quad & c_w = y(1-\tau_y) - \delta_R a_R - \delta_U a_U \\ & c_r = \sigma_R a_R + \sigma_U a_U \end{aligned} \tag{1.15}$$

where y, c_w, and c_r represent annual labor income, consumption during working life, and consumption during retirement, respectively. β_i^w and β_i^r are the composite discount rates of working life and retirement. These parameters not only capture time preference but also reflect the varying durations of working life and retirement. Findeisen and Sachs (2017) adopt a similar composite discount rate approach to accommodate the differing durations of education and working life. The composite discount rates are given by

$$\beta_i^w = \sum_{t=1}^{T_w} (\beta_i)^t, \qquad \beta_i^r = \sum_{t=T_w+1}^{T_w+T_r} (\beta_i)^t$$

β^ϕ is the lifetime discount rate of the utility from wealth. Similarly, ϕ_i^C is a constant term that depends not on the level but the life cycle pattern of the utility asset holdings. Therefore, ϕ_i^C also depends on tax and interest rates which determine this pattern.[12]

In the optimization problem, a_R and a_U denote the amount of savings households have at the time of retirement. The simplifying assumption of constant labor income and consumption allows for the characterization of the whole life cycle pattern of asset holdings. Hence, it is not necessary to keep track of the amount of savings at the end of each period. δ_i measures the necessary decrease in annual working life consumption to increase the households' holdings of asset i by unit at the time of retirement, or vice

[12]An explanation in detail regarding the life cycle pattern of utility asset holdings and the resulting discount rate can be found in Appendix A.2.

versa. Similarly, σ_i measures the resulting increase in annual retirement consumption when households hold one more unit of asset i at the time of retirement.

The ratio of $\frac{\sigma_i}{\delta_i}$ can be interpreted as the inter-period gross after-tax interest rate of asset i between retirement and working life. For instance, when a household decreases their annual working-life consumption by one unit to save more in the return asset, they can increase their annual retirement consumption by $\frac{\sigma_R}{\delta_R}$ units.

1.3.2 Calibration

To align the model with real-world data, I use the *Survey of Consumer Finances* (SCF) provided by the Federal Reserve, specifically the wave from 2019. This survey, conducted every three years, is a cross-sectional household survey that is representative of the entire population. In particular, the SCF data includes information on labor income and households' balance sheets. The latter is crucial in characterizing the type and extent of preference heterogeneity observed among households.

I partition the households' balance sheets into two distinct categories: the utility asset, which provides non-monetary benefits, and the return asset, which offers greater financial returns. The utility asset consists of primary residences along with any associated mortgages and home equity loans. The return asset includes all other items on the balance sheet, including financial assets (stocks, bonds, mutual funds, etc.), remaining non-financial assets (additional properties, business assets, etc.), and any remaining debts not associated with the primary residence.

In addition to the data from the SCF, several other parameters must be calibrated to fully characterize the model numerically. Table 1.1 provides the summary of these parameters.

Parameter		Value	Source
Labor income tax rate	τ_y	24.7%	OECD (2023)
Capital income tax rate	τ_k	20%	*Long-term capital gains tax rate*
Wealth tax rate	τ_w	0%	*No wealth taxation*
Interest of return asset	r_R	9.31%	Jordà et al. (2019)
Interest of utility asset	r_U	5.86%	Jordà et al. (2019)
Working life (yrs.)	T_w	42	Federal Reserve (2019)
Retirement (yrs.)	T_r	18	World Bank (2022)

Table 1.1: Calibration Parameters

Notes: The table presents the parameters used for the initial calibration of the observed data. The first panel details the tax and interest rates, while the second panel is about the life cycle parameters of households.

Among the most important parameters are the linear tax rates. For the linear labor income tax rate, I use data from the OECD to identify the average wage tax in the U.S. The linear capital income tax rate is given by the long-term capital income tax rate in the

U.S. tax code. As there is currently no wealth taxation in the U.S., the wealth tax rate is assumed to be zero.

For the interest rates of different assets, I rely on the findings of Jordà et al. (2019), who calculate the post-1980 return rate of equity to be 9.31% p.a., which I adopt as the interest rate of the return asset. Additionally, they estimate the return rate of housing to be 5.86% p.a. I use this value as the interest rate of the utility asset in my model.

I assume that households enter the model (and therefore the labor market) at the age of 20. With a median retirement age of 61 (Federal Reserve, 2019), the resulting length of the working life is 42 years. Considering an average life expectancy of 79 years (World Bank, 2022), the average length of retirement for U.S. households is 18 years.

The cross-sectional nature of the SCF data presents an additional challenge when using it to calibrate a life cycle model. To address this challenge, I employ the following method. Initially, I focus on the households whose heads are between 20 and 61 years old, as these individuals are considered to be in the labor market based on the model's calibrations. Additionally, households without any reported labor income are excluded from the analysis. By examining a household's labor income and savings alongside their age, I can extrapolate their savings and portfolio composition throughout their entire working life.[13] This extrapolation is made possible by assuming constant labor income and consumption levels throughout the working years. Subsequently, retirement consumption is estimated by assuming that households deplete their savings at the end of their life.

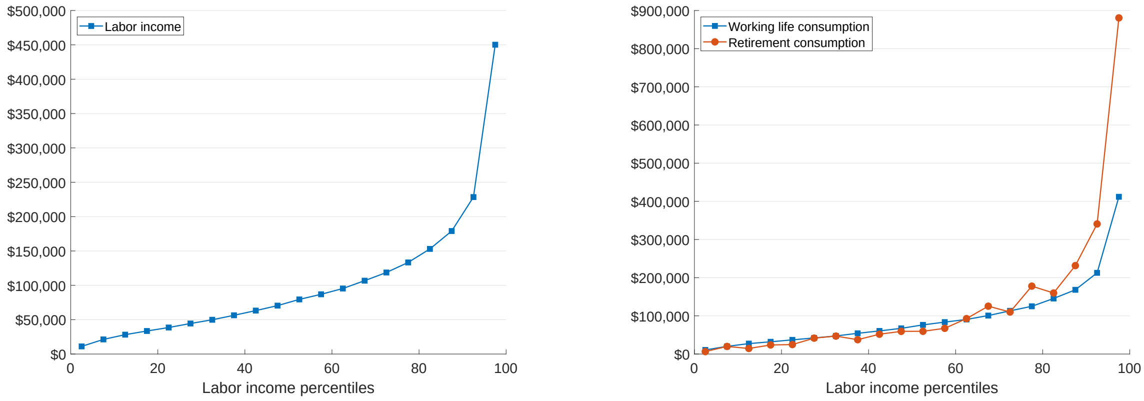
Another challenge posed by the SCF data is that different households are observed at different points in their labor market experience. To address this, the calibration strategy proceeds as follows: First, the relevant sample is identified and divided into four age groups. Then, households within each age group are ranked according to their position in the labor income distribution. For each point along this within-age-group labor income distribution, the labor income, assets at retirement, and implied consumption during working life and retirement are calibrated. Finally, the weighted average of these calibrations across different age groups yields the final results of the calibration.[14]

The left panel in Figure 1.1 illustrates the calibration results regarding labor income and consumption. The calibrated annual labor income of U.S. households spans from $11,000 for the bottom 5% to $490,000 for the top 5% of the labor income distribution, with a median household earning approximately $79,000 annually.

Unsurprisingly, the right panel in Figure 1.1 depicts a positive correlation between annual consumption levels and household rank in the labor income distribution. Higher

[13]In particular, this method may predict a negative level of working life consumption for households with significant savings and relatively lower labor income. In my sample, households with predicted negative consumption constituted around 1% of the entire dataset. These households are excluded from the analysis.

[14]See Figures A.2 and A.3 in Appendix A.4.1 for a comparison between this calibration method and a simpler one that uses a pooled sample.



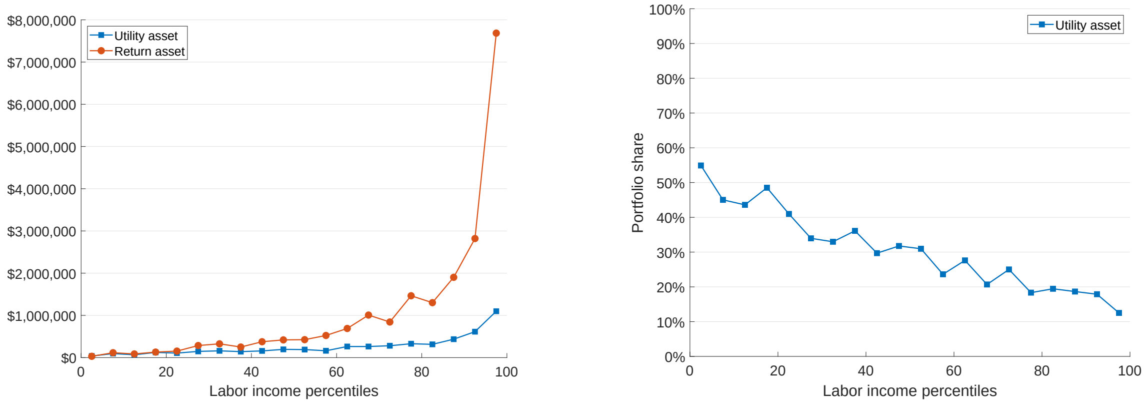
(a) Labor Income (b) Consumption

Figure 1.1: Calibrated Labor Income and Consumption

Notes: The left figure illustrates the calibrated annual labor income of households with respect to labor income percentiles. The right figure illustrates the calibrated annual consumption of households in working life and retirement with respect to labor income percentiles.

labor-income households are more likely to have higher consumption levels both during their working life and retirement.

Notably, the relationship between consumption levels during working life and retirement varies across different households. While households towards the lower end of the labor income distribution tend to consume more during their working life, those at the top consume significantly more during retirement relative to their working life. For instance, households with the highest labor income consume over twice as much in retirement compared to their working life—\$880,000 versus \$410,000, respectively.



(a) Assets at Retirement (b) Portfolio Share

Figure 1.2: Calibrated Assets

Notes: The left figure illustrates the calibrated values of household savings in the utility asset and the return assets with respect to labor income percentiles. The saving values are adjusted to represent the values at the time of retirement (i.e. the peak value of savings). The right figure illustrates the household portfolio composition, which is defined as the ratio of utility assets to the net worth, at the time of retirement with respect to labor income percentiles.

Figure 1.2 presents the calibration outcomes regarding household assets. In the left panel, the accumulated savings of households at retirement are depicted. The panel distinguishes between return and utility assets, giving an idea of households' portfolio allocation. As expected, a strong positive gradient in savings can be observed based on labor income. Lower-income households retire with minimal to no savings, while those at the upper end of the labor income distribution save significant amounts in both types of assets. For instance, households with the highest labor income retire with assets of more than \$8,700,000 in total.

The right panel of Figure 1.2 provides further insight into the variations in households' portfolio allocation. It depicts the portfolio share of the utility asset, calculated as the value of utility assets at retirement relative to net worth. A notable result of the calibration is as follows: households in the lowest 20% of the distribution allocate approximately half of their savings to utility assets, whereas this proportion decreases to around 20% for those in the highest 20%. This decline in the utility asset share persists across the entire distribution and exhibits an almost monotonic pattern.

The heterogeneity observed in portfolio allocation among households could arise from various factors. For instance, households with lower labor productivity may have a stronger preference for the utility asset. Alternatively, households with higher labor productivity may display greater patience, leading them to favor the return asset with higher financial returns in the future over the utility asset, which provides non-monetary utility earlier in life.

To shed light on the underlying reasons for the observed portfolio allocation heterogeneity, I utilize the results from Figures 1.1 and 1.2 and calibrate the simplified model outlined previously. To achieve this, I introduce further functional form assumptions to the lifetime utility function presented in Equation (1.15). Table 1.2 provides an overview of the utility parameter values obtained from the literature, which will be used in the calibration process.

Parameter		Value	Source
Frisch elasticity	ε	0.5	Chetty et al. (2011)
Curvature of consumption utility	γ	2	Calvet et al. (2021)
Curvature of wealth utility	μ	2	–

Table 1.2: Utility Parameters Used for Calibration

Notes: The table shows the utility parameters that are taken from the literature and the assumptions to calibrate labor productivity, discount rate, and relative utility from wealth.

Firstly, I assume that the utility of annual consumption follows a constant-relative-risk-aversion (CRRA) function with a curvature parameter (γ) set to 2, consistent with Calvet et al. (2021). The utility of annual consumption is given by

$$u(c) = \frac{c^{1-\gamma} - 1}{1 - \gamma}$$

Additionally, the work effort function is assumed to be iso-elastic with a Frisch elasticity (ε) of 0.5, following Chetty et al. (2011). The work effort function is represented as

$$v\left(\frac{y}{\theta_i}\right) = \frac{\left(\frac{y}{\theta_i}\right)^{1+\frac{1}{\varepsilon}}}{1 + \frac{1}{\varepsilon}}$$

As for the utility of wealth, there is no widely accepted functional form in the literature. Therefore, I assume that it also exhibits the CRRA property, similar to the utility of annual consumption, with the same curvature parameter. However, I introduce a coefficient (ξ_i) that multiplies the utility of wealth. This coefficient allows for different weights for utility from consumption and wealth. By allowing this parameter to vary across households, the model accommodates the possibility of heterogeneous preferences toward the utility asset. The utility of wealth is given by

$$\phi_i(a_U) = \xi_i \frac{a_U^{1-\mu} - 1}{1 - \mu}$$

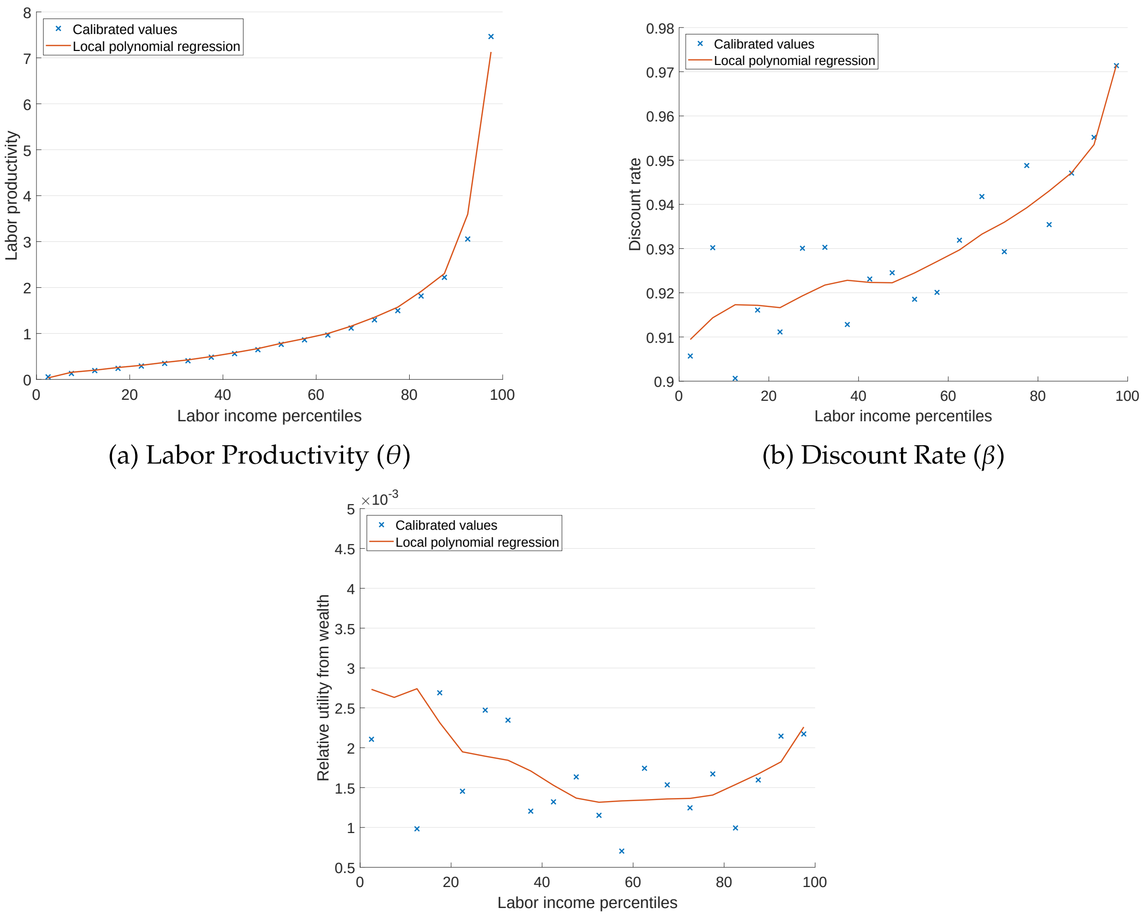
Three utility parameters still require calibration using data: labor productivity (θ_i), discount rate (β_i), and relative utility of wealth (ξ_i). While these parameters may vary among households, the three first-order conditions of households' optimization problem given in Equation (1.15) precisely determine the values of these utility parameters for each household.

Figure 1.3 illustrates the calibrated utility parameters across the labor income distribution. In the top left panel, the labor productivity is depicted, with calibrated values increasing monotonically with labor income. Additionally, the observed increase demonstrates a convex pattern, indicating a fatter right tail in the labor income distribution.

The top right panel illustrates the discount rate. The calibration reveals a clear positive correlation between labor income and the discount rate, indicating that higher labor productivity corresponds to a higher discount rate.[15] This implies that households with higher labor productivity tend to be more patient, assigning relatively greater importance to future periods.

In the bottom panel, the relative utility of wealth is depicted. Unlike labor productivity and discount rate, the relationship between the relative utility of wealth and labor income

[15]Indeed, the Pearson correlation coefficient between these two utility parameters is notably high at 81.4%,



(a) Labor Productivity (θ)

(b) Discount Rate (β)

(c) Relative Utility from Wealth (ξ)

Figure 1.3: Calibrated Utility Parameters

Notes: The blue markers in the top left figure illustrate the calibrated labor productivity values for each household, the ones in the top right figure illustrate the calibrated discount rate values for each household, and the ones in the bottom figure illustrate the calibrated relative utility from wealth values for each household. All figures are with respect to labor income percentiles. The red lines in all figures illustrate the estimated values using a first-order locally-weighted regression.

is not as strong. However, there is a weak U-shaped relationship between the relative utility of wealth and labor income.

The findings from Figure 1.3 suggest that the heterogeneity in portfolio allocation between households with different levels of labor income can be attributed to the heterogeneity in their levels of patience. Specifically, higher-income households, characterized by greater labor productivity, exhibit higher levels of patience. These households with higher discount rates place greater importance on their future consumption. As a result, they are inclined to allocate a larger proportion of their savings to the return asset rather than the utility asset, which brings higher financial returns in later periods of life.

1.3.3 Simulation

With the calibrated utility parameters[16] in hand, I now focus on the policy side. To determine the optimal capital taxation policy given households' preferences, I aim to compute the combination of capital income and wealth tax rates, that maximizes social welfare while keeping tax revenue constant. This approach abstracts from questions regarding tax revenue allocation and instead assumes that the government exogenously requires a predetermined amount of tax revenue. This amount is given by the total tax revenue the government raises in the baseline economy. This exercise can be interpreted as the search for the most efficient means of raising tax revenue using different capital taxation instruments.

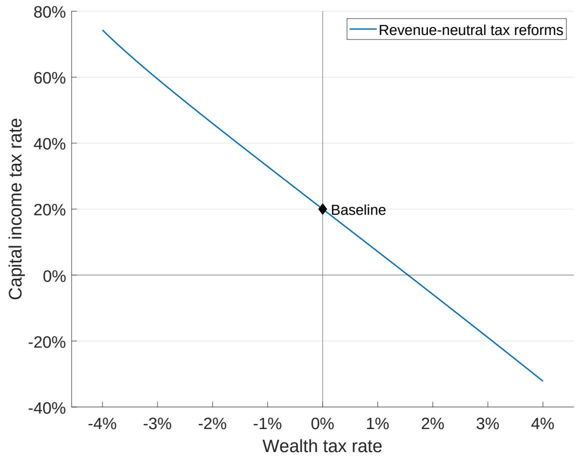


Figure 1.4: Revenue-Neutral Capital Taxation Reforms

Notes: The figure illustrates the family of wealth-capital income tax rate pairs where the total tax revenue remains constant. Any tax reform along the blue line, which involves an increase in the capital income tax rate coupled with a decrease in the wealth tax rate (or vice versa), does not change the total tax revenue. The black diamond denotes the current state, where the wealth tax rate is 0% and the capital income tax rate is 20%.

Figure 1.4 illustrates the pairs of capital income and wealth tax rates that maintain constant tax revenue. The labor income tax rate is assumed to remain constant. For a given wealth tax rate, the capital income tax rate that keeps the tax revenue constant is computed, considering households' re-optimization based on the new pair of capital tax rates. The numerical optimization method for households' utility maximization problem is detailed in Appendix A.3.

When implementing a tax reform that raises the wealth tax rate, it requires a corresponding reduction in the capital income tax rate to hold the level of tax revenue constant, and vice versa. The relationship between changes in these tax rates is predominantly linear. However, non-linearities become apparent near extreme values, such as when the capital income tax rate approaches 100%.

[16] I utilize smoothed utility parameters estimated through first-order locally-weighted regressions to simulate outcomes.

Optimal Capital Taxation Policy

To measure the impact of a particular revenue-neutral tax reform on social welfare, I employ a macro-level measure denoted as $\overline{CE}$. This measure represents a fixed proportional consumption transfer provided to every household in every year. The value of this transfer is calculated such that when it is distributed in the baseline economy, the resulting social welfare matches that of the economy following the tax reform.

$$\sum_i U_i(y_i', c_i', a_i') = \sum_i U_i(y_i, c_i \cdot (1 + \overline{CE}), a_i) \tag{1.16}$$

where (y_i, c_i, a_i) represents households' optimal choice in the baseline economy in terms of their labor income, consumption patterns, and portfolio decisions. (y_i', c_i', a_i') represents the re-optimized choices of the same households after a tax reform.

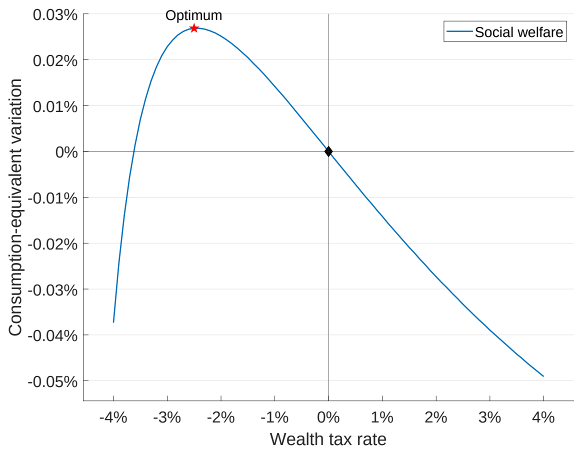


Figure 1.5: Social Welfare After Tax Reforms

Notes: The figure illustrates the social welfare, which is defined as the unweighted sum of all households' utilities, as a function of the wealth tax rate. For each wealth tax rate, the capital income tax rate is adjusted to maintain revenue neutrality. The y-axis represents the fixed proportional consumption transfer to all households such that the average lifetime utility is equal to that of the reform economy. The red star represents the optimal reform where the new wealth tax rate is -2.5%. The corresponding capital income tax rate is 52.6%.

Figure 1.5 illustrates the effect of revenue-neutral tax reforms on social welfare. First of all, it's evident that the baseline economy, without wealth taxation, is not the most efficient approach for raising tax revenue. By marginally subsidizing wealth while increasing the capital income tax rate to maintain constant tax revenue, social welfare can be increased. However, excessively subsidizing wealth and relying heavily on increased capital income tax revenue is not advantageous either, as it may lead to a decrease in social welfare, even below the baseline level. The optimal policy is given by an annual wealth subsidy rate of 2.5%, combined with a rise in the capital income tax rate to 52.6% to generate the additional tax revenue required. This optimal reform yields a welfare increase equivalent to a fixed proportional consumption transfer to all households by 0.027%.

At first glance, this finding may seem to contradict the predictions outlined in Section 1.2. The numerical calibration analysis reveals that there is a strong correlation between labor productivity and time preference of households. If households with higher income also exhibit greater patience, Corollary 1.1 states the optimal wealth wedge is positive while the optimal capital income wedge is zero. Nonetheless, it is crucial to acknowledge two significant distinctions between the approaches employed in the previous and current sections. Firstly, the theoretical analysis hinges on optimal distortions, which can solely be interpreted within the framework of non-linear tax rates, dependent on all observable variables simultaneously. Moreover, non-zero wedges prove useful insofar as they dissuade the high-productivity households from mimicking low-productivity households, unlike the linear tax rates studied in this section, which can facilitate redistribution. Secondly, Section 1.2 centers on the fully optimum solution, whereas this section focuses only on the optimal capital mix given the labor income tax rate and the exogenous revenue requirement.

The main channel through which capital income and wealth tax rates affect social welfare is through the variation in after-tax returns of different assets. In the baseline economy, the annual after-tax return of the return asset is 7.45%, while that of the utility is only 4.69%.[17] Following the optimal reform involving a wealth subsidy and a higher capital income tax rate, the after-tax return of the return asset decreases more than 40 basis points to 7.02%. Conversely, the after-tax return of the utility asset increases by almost 70 basis points to 5.35%.[18] The reason why the after-tax return of the return asset decreases after the optimal reform, while that of the utility asset increases, is that the return asset yields greater before-tax returns. Therefore, the change in its after-tax returns due to the increase in the capital income tax rate overcomes the effect of the increase in the wealth subsidy rate.

Redistributive Effects

To investigate the redistributive impacts of the optimal tax reform, I slightly adjust the macro-level measure used previously to assess the effect of a tax reform on social welfare. Instead, I employ a household-level measure, denoted by CE_i. This measure evaluates the effect of a reform on one household, representing a proportional consumption transfer to that household in every year. Similar to $\overline{CE}$, this measure is calculated such that when it is paid to a household, the resulting lifetime utility of that household is equivalent to that of the economy following the tax reform.

$$U_i(y_i', c_i', a_i') = U_i(y_i, c_i \cdot (1 + CE_i), a_i) \qquad \forall i \tag{1.17}$$

[17] Note that the annual before-tax returns of the return and utility assets are calibrated at 9.31% and 5.86%, respectively.

[18] See Figure A.4 in Appendix A.4.2 for an illustration of how a given revenue-neutral capital taxation reform alters the after-tax return rates.

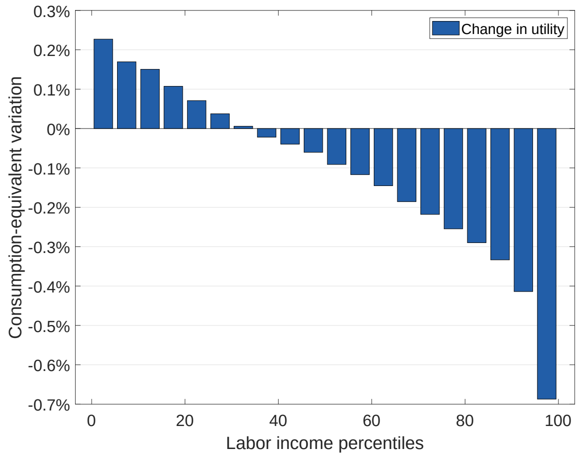


Figure 1.6: Change in Household Utility

Notes: The figure illustrates the change in household lifetime utility after the optimal reform with respect to the baseline. The y-axis represents the proportional consumption transfer to each household such that their lifetime utility is equal to that in the economy after the optimal reform.

Figure 1.6 illustrates how the optimal reform impacts households across various points of the labor income distribution. Households with lower labor incomes benefit from the reform, while those at the top of the labor income distribution experience a decrease in utility. Specifically, households in the bottom 5% of the labor income distribution require a consumption transfer of more than 0.2% of their annual consumption, indicating an improvement in their utility. Conversely, households at the very top incur a loss equivalent to about 0.7% of their annual consumption.

The initial observation of Figure 1.6 might suggest a decrease in social welfare after the optimal reform, given that more households experience a loss compared to those that gain, and the absolute value of the equivalent variation for those who lose is larger. However, it's important to consider that an additional unit of consumption holds greater importance when the initial consumption level is low, as is the case for households at the bottom of the distribution. Therefore, the increase in welfare resulting from a consumption transfer to low-income households outweighs the decrease in welfare due to reduced consumption among high-income households. To make a fair comparison of CE_i values across different households, they should be weighted by the corresponding households' marginal utility of consumption. Indeed, the macro-level measure $\overline{CE}$ indicates that the positive impact on low-income households outweighs the negative impact on high-income households after the optimal reform.

Figure 1.7 provides a breakdown of the utility change illustrated in Figure 1.6, differentiating between various decisions of households. This breakdown helps explain how the optimal reform can enhance social welfare while maintaining constant tax revenue.

All households enjoy an increase in lifetime utility thanks to an increase in their utility asset. Following the reform, the higher after-tax return of the utility asset makes it more

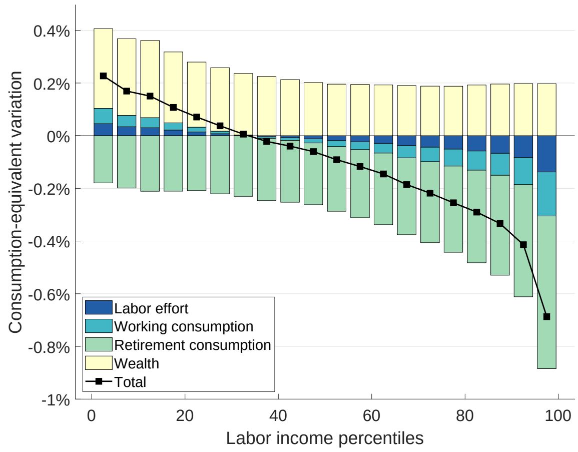


Figure 1.7: Changes in Sub-utilities

Notes: The figure illustrates the decomposed change in household lifetime utility after the optimal reform with respect to the baseline. The decomposition captures the changes in each part (consumption, wealth, and labor effort) of the lifetime utility. The y-axis represents the proportional consumption transfer to each household such that their lifetime utility is equal to that in the economy after the optimal reform. The black line represents the net change in households' lifetime utility.

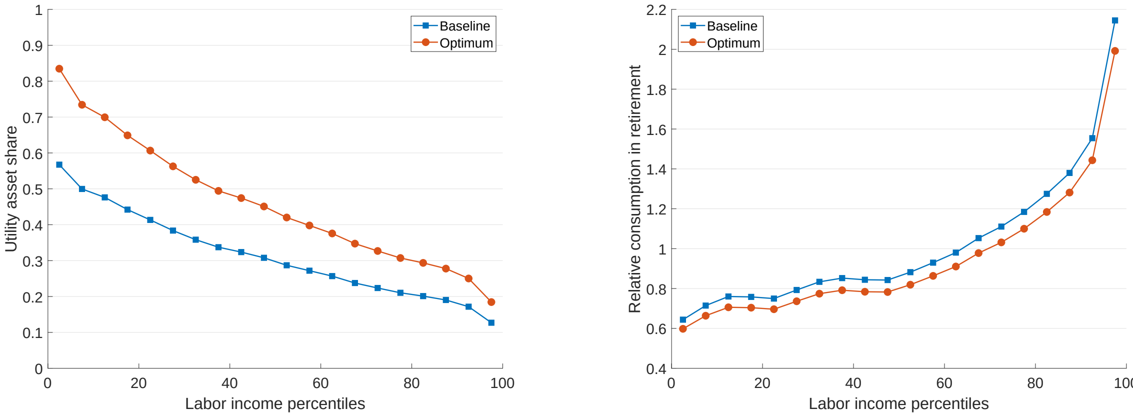
attractive for households. Another common adjustment across households is the reduction in retirement consumption. This reduced consumption arises from the transition from the return asset, whose after-tax return decreases after the reform, to the utility asset. However, since the after-tax return of the return asset is still greater than that of the utility asset, households forgo the difference as the opportunity cost, resulting in lower levels of consumption in retirement.

Additionally, households with higher incomes find it optimal to increase their labor supply while reducing their working-life consumption. Conversely, lower-income households work less and yet consume more during their working life. These behavioral changes can be attributed to income effects. Households at the top of the income distribution hold a substantial amount of return assets, resulting in higher tax burdens post-reform due to the raised capital income tax rate. With a decrease in their lifetime resources, they choose to work more and also save more for their retirement. On the other hand, households at the bottom of the income distribution, who hold relatively more utility assets, see an increase in their after-tax return. With this boost in lifetime resources, they choose to work less and save less.[19]

In essence, the optimal reform, which involves raising the capital income tax rate while providing a wealth subsidy, facilitates a redistribution from households with a relatively larger share of return assets in their portfolio, to those with a larger share of utility assets. Given that households with higher labor productivity tend to hold more return assets in

[19]The effects that stem from the changes in household behavior are smaller in magnitude compared to the direct mechanical effects resulting from the changes in the after-tax return rates. See Figure A.5 in Appendix A.4.3 for a decomposition.

their portfolio, the optimal reform effectively transfers resources from these higher-income households to those with lower labor income.



(a) Change in Utility Asset Share

(b) Change in Relative Consumption

Figure 1.8: Changes in Portfolio Composition and Saving Behavior

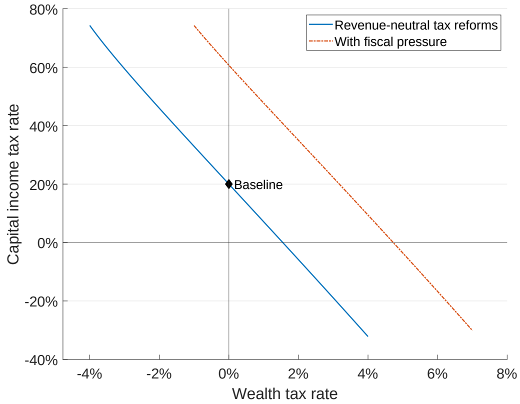
Notes: The left figure illustrates the change in the household portfolio composition, which is defined as the ratio of utility assets to the net worth, after the optimal reform with respect to the baseline. The right figure illustrates the change in household consumption composition after the optimal reform with respect to the baseline. The y-axes represent the ratio of average annual consumption during retirement to the average annual consumption during working life.

Figure 1.8 provides further insights into how households adjust their behavior following the optimal reform. In the left panel, the portfolio share of the utility asset is depicted for households across the labor income distribution in both the baseline economy and the economy resulting from the reform. All households increase their allocation to the utility asset as it becomes more desirable post-reform. Notably, lower-income households exhibit a larger increase in the utility asset's portfolio share compared to higher-income households. For instance, the utility asset constitutes over 80% of the portfolio for households at the bottom of the income distribution, while it represents less than 20% for the highest-income households.

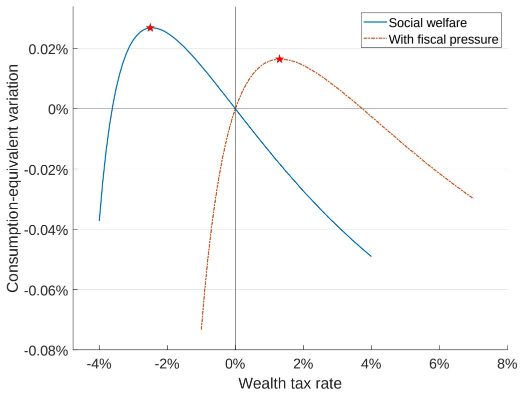
In the right panel of Figure 1.8, the change in relative consumption during retirement is depicted, defined as the ratio of annual retirement consumption to annual working-life consumption. With the relative price of the return asset increasing after the reform, all households reduce their relative consumption in retirement. Households with higher labor income continue to consume significantly more annually during retirement——almost twice as much for households with the highest labor income. This is because they value consumption in later periods more due to high discount rates.

Effects of Fiscal Pressure

To investigate the impact of fiscal pressure on the government, defined as the necessity to raise more tax revenue, I conduct a follow-up numerical analysis. Using the same baseline calibration and utility parameters as before, I examine a scenario where the government is required to raise an additional 20% tax revenue to cover an additional exogenous spending requirement.



(a) Revenue-Neutral Tax Reforms



(b) Social Welfare After Tax Reforms

Figure 1.9: Impact of Fiscal Pressure

Notes: The figure illustrates the impact of fiscal pressure. The left panel depicts the families of revenue-neutral wealth-capital income tax rate pairs in both the baseline scenario and a scenario with a 20% higher revenue requirement. The right panel displays social welfare in both scenarios. The reference case for the baseline scenario is the current state with a 0% wealth tax rate and a 20% capital income tax rate. In contrast, the reference case for the fiscal pressure scenario is where the capital income tax rate is increased to 60.1% to generate a 20% increase in total tax revenue.

Figure 1.9 illustrates the impact of a 20% additional revenue requirement on revenue-neutral capital taxation reforms and social welfare. In the left panel, it is observed that in the absence of wealth taxation, the capital income tax rate needs to rise to 60.1% to fulfill the additional revenue requirement.[20] Consequently, the graph of the family of revenue-neutral reforms shifts to the upper right due to fiscal pressure. In the fiscal pressure scenario, the capital income tax rate that balances the budget, given a wealth tax rate, is higher compared to the baseline scenario.

A significant finding emerges from the right panel. As previously discussed, in the baseline scenario, the optimal tax reform involves implementing a negative wealth tax rate (a wealth subsidy) alongside an increased capital income tax rate to maintain the same tax revenue. However, the same does not hold under fiscal pressure. If the government is required to generate 20% additional tax revenue, the optimal capital reform takes the opposite trajectory. In this scenario, the government should introduce a positive wealth tax while reducing the capital income tax rate.

In the baseline scenario, the optimal reform enhances welfare by serving as a redistributive mechanism. This reallocation effectively shifts resources from higher-income households to lower-income households. On the other hand, Ayaz et al. (2023) argue

[20]This considerable increase in the capital income tax rate stems from the smaller share of capital tax revenue relative to labor income tax revenue.

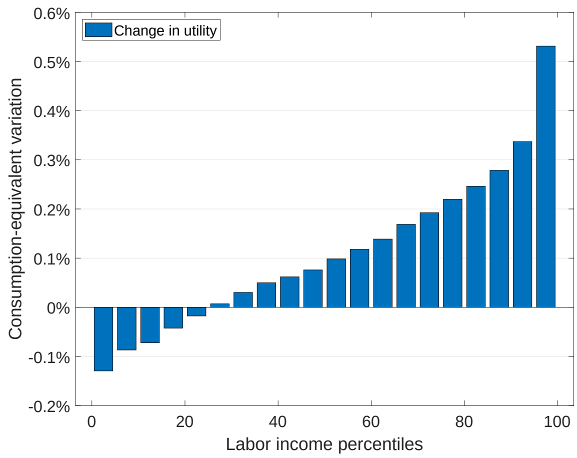


Figure 1.10: Change in Household Utility in Case of Fiscal Pressure

Notes: The figure illustrates the change in household lifetime utility after the optimal reform with respect to a scenario where the capital income tax increased to 60.1% to generate a 20% increase in total tax revenue. The y-axis represents the proportional consumption transfer to each household such that their lifetime utility is equal to that in the economy after the optimal reform.

that raising additional tax revenue and redistributing between households present two conflicting objectives in tax-transfer system design. Examining Figure 1.10, it becomes evident that the same dichotomy applies when considering how to tax capital. After implementing the optimal reform, the utility of higher-income households improves, whereas those with lower incomes experience losses. The need to raise additional tax revenue limits the government's redistributive capacity. Consequently, the optimal reform decreases redistribution under fiscal pressure.

1.4 Conclusion

In this study, I investigate the optimal taxation policy within an economy where households make decisions about labor supply, consumption, and portfolio allocation. A key premise of the analysis is to distinguish between two different types of assets. One type yields greater financial returns, while the other provides flow utility to households as long as it remains in their portfolio. The analysis reveals several important insights into how capital taxation affects households and what the optimal capital taxation policy should be given households' preference heterogeneity.

First, I found that wealth taxation distorts households' inter-temporal decisions while leaving their portfolio allocation decisions unaffected. On the other hand, capital income taxation impacts both inter-temporal decision-making and portfolio allocation. Therefore, the selection of the appropriate capital taxation strategy depends on the underlying preference heterogeneity among households. If temporal preferences vary but relative asset valuations remain consistent across households, wealth taxation proves effective, distorting the inter-temporal margin, while preserving the portfolio allocation margin. Conversely, when households exhibit heterogeneous valuations towards different assets but share the same inter-temporal preferences, capital income taxation becomes useful to address this heterogeneity. Then, its inter-temporal distortion should be corrected by using wealth taxation appropriately.

Second, the calibration of a life cycle model with linear taxes to the U.S. economy reveals that, aside from labor productivity, households mainly differ in their discount rates. Those with higher labor productivity exhibit higher valuations for later periods of their life. As a result, lower-income households tend to hold more of the asset that brings them flow utility over the other generating greater financial returns. In this case, the government has the potential to enhance welfare, while maintaining the same tax revenue, by implementing a dual approach: subsidizing wealth alongside an increase in capital income taxes. This proposed reform acts as a transfer mechanism, redirecting resources from households primarily invested in assets yielding higher returns to those inclined towards assets providing flow utility. In contrast, when faced with an additional revenue requirement, the government's redistributive capacity is constrained, leading to a reversal in the optimal reform direction. In the scenario, where the government aims to increase tax revenue by 20%, the optimal approach involves introducing a positive wealth tax alongside a reduction in the capital income tax rate, effectively reducing the redistribution.

The differences between the outcomes of the theoretical and numerical approaches stem from their focus on different tax instruments. In the theoretical analysis, the emphasis lies on the optimal allocation, where non-linear labor income taxes are particularly effective in achieving desired redistribution outcomes. Both capital income taxes and wealth taxes prove useful insofar as they discourage households with higher labor productivity from mimicking those with lower labor productivity. However, in the simulation analysis, a linear labor income taxation is utilized, which is not as effective. In this context, the optimal mix of capital taxation can significantly enhance welfare by redistributing resources more efficiently.

The findings of this study have important implications for policymakers. By understanding how different capital taxation policies affect household behavior, policymakers can design more efficient and/or equitable tax systems. Moreover, the simulation results highlight a possible efficiency improvement in the U.S. economy. It is possible to enhance social welfare while achieving the same level of tax revenue.

While this study provides valuable insights, it is not without limitations. The theoretical analysis focuses on complex and interdependent tax instruments that might be hard to implement. On the other hand, the simulation analysis focuses on separable linear tax functions, which, may oversimplify real-world tax systems. Striking a balance between tax systems that are too complex to implement and too simple to achieve better outcomes is crucial for designing effective tax policies.

In conclusion, this study contributes to the literature on optimal capital taxation by providing an analysis of different capital taxation methods. By considering a distinction between asset types and preference heterogeneity among households, it offers valuable insights into how capital taxes should be designed taking preference heterogeneity into account.

Chapter 2

Joint Taxation of Income and Wealth*

2.1 Introduction

Taxes are core elements of fiscal policy, providing the necessary revenue to fund public goods and provide essential services. They play a crucial role in resource allocation, economic behavior, income and wealth distribution, and overall social welfare. At their core, taxes are a tool for governments to achieve various economic, social, and fiscal objectives.

Traditionally, taxation has focused primarily on income, with progressive income tax systems designed to redistribute wealth from higher-income individuals to lower-income individuals through a system of tax brackets and deductions. However, wealth taxation has received increasing attention in recent years as a means of addressing the concentration of wealth among the richest members of society, largely sparked by the influential work of Piketty (2014).

We aim to uncover how and why combining wealth taxation with income taxation can be beneficial. In particular, we investigate the efficiency gains and social implications associated with integrating income and wealth taxation systems. By examining theoretical frameworks and empirical evidence, we provide insights into the potential advantages and challenges of joint tax reforms. Additionally, our analysis considers the distributional effects of such reforms and their implications for social welfare.

Firstly, we examine a simplified two-period model where labor income is uncertain. This model strikes a balance between analytical clarity and substantive implications, providing a foundational framework to explore the impact of conditioning wealth taxation on labor income. In scenarios of uncertain labor income, the veil of ignorance argument suggests a governmental incentive to act as an insurer, allocating greater resources to individuals with lower labor income (Farhi and Werning, 2013). We demonstrate that implementing state-dependent saving taxes based on income levels leads to varying levels

*This chapter is based on joint work with Dominik Sachs.

of distortion in saving behavior. This prompts governments to adjust saving taxes beyond the typical insurance motive. Our findings indicate that lowering state-dependent saving taxes for individuals with lower incomes and raising them for those with higher incomes enhance social welfare through more efficient taxation.

Secondly, we study the fiscal and social impacts of joint tax reforms. Building upon the elementary tax reforms proposed by Golosov, Tsyvinski and Werquin (2014), we investigate the implications of conditioning the marginal tax rate of income on wealth, and vice versa. Such conditioning offers tagging benefits if income and wealth are correlated (Cremer, Gahvari and Lozachmeur, 2010); however, an additional distortion arises due to the endogeneity of the tag provided by joint taxation.

Consider, for instance, an income tax increase that is conditioned on having a certain level of net worth. As the income distribution conditional on higher net wealth has a fatter right tail, given a positive correlation between income and wealth, using high net worth as a tag for income taxation can increase its efficiency. However, this approach also creates an incentive for individuals to decrease their net worth, thereby introducing additional distortion costs.

We derive formulas for the marginal excess burden and welfare effects of joint tax reforms, expressing them in terms of the marginal excess burdens of separate income and wealth tax reforms. We then decompose these formulas into a tagging component, capturing the fiscal gains from better targeting, and a distortion component, capturing the secondary distortion of such reforms.

As an important benchmark, we consider the scenario where income and wealth are uncorrelated, demonstrating that while there is no benefit from tagging, the secondary distortion still exists. In this case, we show that the marginal excess burden of joint reforms is the sum of the excess burdens of separate income and wealth tax reforms.

Subsequently, we apply our theoretical framework to quantify the fiscal and social impacts of integrating income and wealth taxation within the U.S. personal tax schedule. Our analysis reveals that joint tax reforms may result in a lower marginal excess burden compared to standalone income and wealth tax reforms, depending on the local correlation between income and wealth. We identify regions where joint tax reforms outperform separate income and wealth tax reforms in terms of their fiscal impact. Notably, we find that the tagging benefit of joint tax reforms is most pronounced in the middle of income and wealth distributions. Conversely, distortion costs are most pronounced for tax reforms targeting the lower end of income and wealth distributions, distorting labor supply or wealth accumulation decisions.

Lastly, we address how joint tax reforms affect social welfare without adopting a normative viewpoint on society's preference for redistribution. Instead, we assume that the separate income and tax schedules we observe are individually optimal. Utilizing the inverse-optimum approach introduced by Bourguignon and Spadaro (2012), we estimate the marginal social welfare weights along the income and wealth distributions separately. Combining these welfare weights, we demonstrate that joint tax reforms enhance welfare, even though separate tax reforms on income and wealth are not inherently able to do so by construction.

Related literature. The optimal income taxation problem has been extensively explored in the literature, with Mirrlees (1971) pioneering foundational work in this area. His work has since been refined and expanded upon, as evidenced by subsequent studies such as Diamond (1998) and Saez (2001), which have further clarified and improved upon Mirrlees' framework. Moreover, the analysis has been extended to encompass various dimensions of adjustments, including the choice of whether to work at all at the extensive margin (Kleven and Kreiner, 2006; Jacquet, Lehmann and der Linden, 2013; Hansen, 2021), general equilibrium effects (Stiglitz, 1982; Rothschild and Scheuer, 2013; Sachs, Tsyvinski and Werquin, 2020), couples taxation (Kleven, Kreiner and Saez, 2009), and considerations of fiscal pressure, defined as the need to generate additional revenue (Heathcote and Tsujiyama, 2021*a*; Ayaz et al., 2023). Regarding capital income taxation, despite initial theoretical arguments against it in the long run, (Judd, 1985; Chamley, 1986), subsequent studies have presented compelling reasons for positive capital taxation (Conesa, Kitao and Krueger, 2009; Piketty and Saez, 2013; Saez and Stantcheva, 2018; Straub and Werning, 2020; Ferey, Lockwood and Taubinsky, 2023).

Wealth taxation has gained traction as a means to counter rising wealth inequality, particularly influenced by Piketty (2014). His work highlights historical wealth trends and proposes progressive wealth taxation to address inequality. Saez and Zucman (2019) further advocate for progressive wealth taxation, suggesting policies to tax various forms of wealth more effectively. Recent literature has explored the middle and long-run effects of wealth taxation (Seim, 2017; Jakobsen et al., 2020; Brülhart et al., 2022; Zoutman, 2018; Advani and Tarrant, 2021). For a comprehensive review of global wealth taxation policies and a survey of arguments for and against wealth taxation, see Scheuer and Slemrod (2021). Additionally, in the realm of politics, Senators Elizabeth Warren and Bernie Sanders, two prominent contenders in the 2020 U.S. presidential election, included wealth taxation as a key component of their campaign platforms.

We aim to bridge the gap between the strands of literature on income and wealth taxation by investigating the consequences of their integrated implementation. While Golosov, Kocherlakota and Tsyvinski (2003) and Albanesi and Sleet (2006) approach this issue through a mechanism-design lens, Golosov, Tsyvinski and Werquin (2014) introduce a variational approach that underpins our analysis of joint tax reforms. While other studies have investigated the optimal taxation of multiple variables (Jacquet and Lehmann, 2021; Spiritus et al., 2022), we focus on the intuitive understanding of the underlying implications of joint taxation of income and wealth.

Moreover, we add to the discourse on the concept of tagging. Akerlof (1978) first highlighted the advantages of incorporating correlated observables into optimal income taxation, a notion expanded upon by subsequent studies (Cremer, Pestieau and Rochet, 2003; Boadway and Pestieau, 2006). While tagging variables such as height (Mankiw and Weinzierl, 2010), gender (Alesina, Ichino and Karabarbounis, 2011), and age (Bastani, Blomquist and Micheletto, 2013) have been explored, our contribution lies in examining wealth as an endogenous tag for income taxation, offering a novel perspective to this strand of literature.

The remainder of this chapter is structured as follows. Section 2.2 focuses on the foundational two-period model and highlights the efficiency benefits of joint taxation. Then, in Section 2.3, the theoretical framework for the analysis of joint taxation reforms is provided. Following that, Section 2.4 combines the theoretical results with U.S. data. Finally, Section 2.5 concludes the chapter.

2.2 State-Dependent Saving Taxation

In this section, we present a simple two-period model to demonstrate the effects of implementing joint taxation. The model is intentionally kept simple to streamline the analysis, but it can be expanded to incorporate additional factors, such as endogenous labor supply, time preference, or interest.

2.2.1 Individual Optimization

All individuals receive the same endowment in the first period. They consume a portion of their endowment in the first period and save the remainder for the second period. The labor productivity in the second period is stochastic, with individuals experiencing either lower or higher productivity levels. After learning their labor productivities, individuals provide an exogenous unit of labor to earn labor income. Their savings from the first period are taxed in the second period depending on the productivity shock individuals receive. If individuals have low labor productivity, their savings are taxed at a rate of τ_l. If they have the higher labor productivity, then the tax rate on savings is τ_h. The expected lifetime utility maximization problem of individuals can be formulated as

$$\begin{aligned}
\max_{a} \quad & U = u(c_1) + \mathbb{E}\left[u(c_{2i})\right] \\
\text{s. t.} \quad & c_1 = I - a \\
& c_{2i} = \begin{cases} a(1-\tau_l) + \theta_l, & \text{if } i = l \\ a(1-\tau_h) + \theta_h, & \text{if } i = h \end{cases}
\end{aligned} \tag{2.1}$$

where $u(c_1)$ and $u(c_{2i})$ are increasing and concave functions that denote the utility derived from consumption in the first and second periods, respectively. The consumption in the second period depends on the productivity shock individuals receive for two reasons. Firstly, individuals with varying levels of productivity earn different amounts of labor income. Secondly, they face different tax rates based on their labor productivity. Here, I represents the heterogeneous endowments individuals receive in the first period, while a represents the chosen level of savings. Parameters θ_l and θ_h capture labor productivity in the event of a low-productivity shock and a high-productivity shock, respectively.

In this simplified context, the only decision individuals make is the consumption-saving choice in the first period. They determine how much to save for the second period considering the uncertainty in their future productivity. The optimality conditions for this problem are expressed as follows.

$$\phi(a) = -u'(c_1) + \sum_{i=l,h} p_i u'(c_{2i})(1-\tau_i) = 0 \tag{2.2}$$

$$\psi(a) = u''(c_1) + \sum_{i=l,h} p_i u''(c_{2i})(1-\tau_i)^2 < 0 \tag{2.3}$$

where, p_l denotes the probability of receiving the low-productivity shock, and $p_h = 1 - p_l$ represents the probability of the high-productivity shock. The function $\phi(a)$ represents the first-order condition, while $\psi(a)$ captures the second-order condition. The first-order condition highlights the trade-offs associated with saving an additional unit for the second period. Choosing to save one additional unit results in a decrease in utility from first-period consumption but an increase in expected utility in the second period. Concerning the second-order condition, the concavity of the consumption utility function ($u''(c) < 0$) ensures its satisfaction.

To measure how individuals adjust their choices in response to changes in taxation, we compute the elasticity of saving concerning both the low-state net-of-tax rate $(1-\tau_l)$ and the high-state net-of-tax rate $(1-\tau_h)$. This is achieved by applying the implicit function theorem to the first-order condition of individuals. The elasticity of savings with respect to either of the net-of-tax rates is given by

$$\varepsilon_{a,1-\tau_i} = \frac{p_i(1-\tau_i)u'(c_{2i})}{-\psi(a)a}\left(1 + \frac{u''(c_{2i})}{u'(c_{2i})}a(1-\tau_i)\right), \qquad i = l, h \tag{2.4}$$

Adjusting tax rates has two opposing effects on individual saving levels, each represented by an additive term in brackets. The first effect, stems from changes in the relative prices of consumption between the two periods. If either of the state-dependent net-of-tax rates increases, first-period consumption becomes relatively more expensive compared to second-period consumption. Consequently, individuals allocate more consumption to the second period by increasing their savings. This effect is referred to as the substitution effect. The second effect, captured by $\frac{u''(c_{2i})}{u'(c_{2i})}a(1-\tau_i)$, arises due to changes in lifetime resources. An increase in net-of-tax rates expands the available resources in the second period. To smooth this increase over their lifetime, individuals reduce their savings and consume some of these extra resources in the first period already. This effect is known as the income effect.

For sufficiently high levels of elasticity of intertemporal substitution, the substitution effect outweighs the income effect. In the case where individuals exhibit constant elasticity of intertemporal substitution, the condition becomes $\sigma > 1 - \frac{\theta_i}{c_{2i}}$, where σ is the elasticity of intertemporal substitution of individuals. This indicates that for the logarithmic utility case ($\sigma = 1$), which is widely assumed in the literature, the substitution effect prevails over the income effect, leading to a negative distortion of savings in response to an increase in state-dependent saving taxation. If the elasticity of intertemporal substitution is higher than the threshold, an increase in saving taxes discourages saving.

The ratio of the saving elasticity with respect to the high-state net-of-tax rate to that with respect to the low-state net-of-tax rate is a crucial measure that captures how individuals respond to state-dependent taxation. This ratio, pivotal for later analysis, is given by

$$\frac{\varepsilon_{a,1-\tau_h}}{\varepsilon_{a,1-\tau_l}} = \frac{p_h(1-\tau_h)}{p_l(1-\tau_l)} \cdot \frac{u'_{2h}}{u'_{2l}} \cdot \frac{1 + \frac{u''(c_{2h})}{u'(c_{2h})}a(1-\tau_h)}{1 + \frac{u''(c_{2l})}{u'(c_{2l})}a(1-\tau_l)} \tag{2.5}$$

The intertemporal elasticity of substitution also affects the relationship between the two elasticities. Suppose that the probability of receiving each shock is equal to each other, as well as the saving tax rate applied after receiving each shock. If labor income in the second period constitutes a significant portion of individuals' consumption in that period, the saving elasticity with respect to the low-state net-of-tax rate is higher than that with respect to the high-state net-of-tax rate. In the case of constant elasticity of intertemporal substitution, this condition translates to

$$\sigma > \frac{a(1-\tau_i)}{\theta_i} \tag{2.6}$$

where σ denotes the elasticity of intertemporal substitution.

2.2.2 Optimal State-Dependent Tax Rates

Similar to the analysis of individual behavior, the welfare analysis is also streamlined to highlight the insights of state-dependent taxation. The government's objective is to maximize social welfare while simultaneously meeting an exogenously determined revenue requirement in the second period. This is achieved through the imposition of state-dependent saving taxation. That is, individuals' savings are taxed based on their labor productivity in the second period. The government's welfare maximization problem reads as

$$\begin{aligned} \max_{\tau_l,\tau_h} \quad & u(c_1) + \sum_{i=h,l} p_i u(c_{2i}) \\ \text{s. t.} \quad & G \leq (p_l \tau_l + p_h \tau_h) a \end{aligned} \tag{2.7}$$

where G is the exogenous revenue requirement. The law of large numbers ensures that the ratio of individuals experiencing low or high-productivity shocks in the second period equals the probability of receiving each shock.

Proposition 2.1. *The optimal tax rates that solve the optimization problem the government are given by*

$$\frac{\tau_l}{1-\tau_l} = \frac{1}{\varepsilon_{a,1-\tau_l}} \cdot \left(1 - \frac{u'(c_{2l})}{\lambda}\right) \cdot \frac{p_l}{p_l + p_h \frac{\tau_h}{\tau_l}} \tag{2.8}$$

$$\frac{\tau_h}{1-\tau_h} = \frac{1}{\varepsilon_{a,1-\tau_h}} \cdot \left(1 - \frac{u'(c_{2h})}{\lambda}\right) \cdot \frac{p_h}{p_l \frac{\tau_l}{\tau_h} + p_h} \tag{2.9}$$

where λ captures the marginal value of public funds.

Proof. See Appendix B.1. □

The optimal state-dependent saving tax rates are determined by three key factors.[1] The first determinant of the optimal tax rates is the saving elasticity. Greater responsiveness to saving taxation in one state leads to a larger decrease in tax revenue due to behavioral changes in response to increased state-dependent taxes. Consequently, optimal tax rates decrease as saving elasticity increases. Another determinant is the impact of tax rates on expected utility in terms of public funds. An increase in a state-dependent saving tax rate decreases expected utility, thereby limiting the optimal tax rate. Lastly, the balance between these effects determines optimal tax rates. The numerator of the third term captures the proportion of individuals directly affected by the respective state-dependent tax rate, while the denominator reflects the change in the effective tax base resulting from a unit change in savings.

The impact on the optimal tax rates due to changes in expected utility can be conceptualized through an insurance motive of the government.[2] Since individuals are identical a priori, the government is motivated to act as an insurer by regulating their consumption levels after experiencing different productivity shocks. If the marginal utility from consumption decreases with the level of consumption, this creates an incentive to increase the tax rate for individuals experiencing high-productivity shocks and decrease the tax rate for those experiencing low-productivity shocks.

[1]The optimal tax formulas provided in Equations (2.8) and (2.9) bear resemblance to the optimal income taxation formulas outlined by Diamond (1998). Indeed, the three effects determining the optimal tax rates in this study are analogous to those in his paper.

[2]For a more detailed analysis, see Farhi and Werning (2013).

For further analysis, it is possible to eliminate the impact of the insurance motive on optimal tax rates. Assuming that the marginal value of public funds is significantly greater than any of the individual marginal utilities results in a solution where the government's primary concern is tax revenue alone. Consequently, the insurance motive is not effective on optimal tax rates anymore.

The other effect stemming from the variability in saving elasticity is particularly intriguing. Each tax rate introduces a distortion in individual savings; however, the magnitude of this distortion differs between the tax rates applied in the high-productivity shock scenario and the low-productivity shock scenario. If individuals exhibit differing responses to changes in the tax rate in different scenarios, the government must take that into account.

This variability in saving elasticity highlights a crucial distinction between two interpretations of marginal tax rates. Firstly, marginal tax rates on savings determine the extent to which government tax revenue changes when individuals adjust their savings. This interpretation is independent of individual utilities but depends on the relative prevalence of each state in the economy. Secondly, marginal tax rates distort individual decision-making and influence the optimal level of saving for individuals. This interpretation, however, relies on the well-being of individuals in different states, particularly the marginal effects on their well-being in each scenario. These two interpretations diverge in scenarios where marginal utilities are not constant and there is uncertainty in how consumption evolves over time, as is the case within the framework of this section.

Two optimal tax rate formulas outlined in Equations (2.8) and (2.9) can be combined to provide further insight into how the two tax rates should be set optimally in relation to each other.

$$\frac{1-\frac{u'_{2h}}{\lambda}}{1-\frac{u'_{2l}}{\lambda}} = \frac{\varepsilon_{a,1-\tau_h}}{\varepsilon_{a,1-\tau_l}} \frac{p_l(1-\tau_l)}{p_h(1-\tau_h)} \tag{2.10}$$

Corollary 2.1. *Suppose that the condition outlined in Equation* (2.6) *holds. Then, not utilizing the state-dependency of saving taxation, despite its availability, leads to a sub-optimal solution.*

Proof. Setting $\tau_l = \tau_h = \tau$, the right-hand side of Equation (2.10) is smaller than one. However, the diminishing marginal utility implies that the left-hand side is larger than one. Therefore, $\tau_l = \tau_h$ cannot be optimal. □

Corollary 2.1 provides an insight into the advantages of leveraging state-dependency of saving taxation. Not utilizing state-dependent saving taxation still yields sub-optimal outcomes. This result can be attributed to the insurance and efficiency channels on the optimal tax rates discussed earlier. Setting the two tax rates equal to each other implies that the government does not provide any insurance for the productivity shock. Moreover, given that one of the state-dependent saving taxes results in a larger distortion, the government must consider this factor when setting the tax rates optimally.

Corollary 2.2. *Suppose that the condition outlined in Equation* (2.6) *holds and the government is not utilizing the state-dependency of saving taxation. Then, increasing the tax rate applied in the high-productivity shock scenario and decreasing the one applied in the low-productivity shock scenario such that the immediate effects on tax revenue cancel each other out, lead to an improvement. This result holds even if the government's sole concern is tax revenue.*

Proof. See Appendix B.2 □

Corollary 2.2 builds upon the previous result, highlighting that the efficiency gains arising from heterogeneous saving elasticities provide a valuable channel to increase tax revenues. This stems from the divergence between the additional revenue effect of state-dependent saving tax rates and their distortion on individual decision-making. Despite both tax rates in different states generating the same amount of additional tax revenue,[3] the tax rate applied in the low-shock scenario induces greater distortion. Consequently, marginally replacing the more distortive tax rate with the less distortive one enhances taxation efficiency. Moreover, this finding holds true regardless of whether the government aims to provide insurance for productivity shocks.

2.3 Theoretical Framework: Joint Tax Reforms

In this section, our analysis shifts to another perspective, where we integrate income and wealth taxation. We examine a static model incorporating a joint distribution of income and wealth, employing a reduced-form approach to study taxation. We focus on the joint tax functions of income and wealth, characterized by bivariate tax payment functions. Last but not least, we rely on elasticities of income and wealth with respect to net-of-tax rates, which serve as sufficient statistics for measuring the impacts of tax reforms.

2.3.1 Bivariate Tax Payment Functions

The bivariate tax payment functions we study are mathematical functions that determine the total tax liability owed by individuals based on two variables: income and wealth, denoted by $T(y, a)$ where y represents taxable income and a represents net wealth. These functions take both income and wealth as inputs and yield the corresponding tax liability.

Marginal tax rates of a bivariate tax payment function are calculated as the partial derivative of the function with respect to either of its inputs. The marginal income tax rate measures how the tax liability changes when taxable income increases by one unit. Similarly, the marginal wealth tax rate captures the change in tax liability resulting from a

[3]This statement overlooks the impact of the prevalence of different shocks, which influences the relative distortion in the same proportion.

unit change in net wealth.

$$\tau_Y(y,a) \equiv \frac{\partial T(y,a)}{\partial y}$$
$$\tau_A(y,a) \equiv \frac{\partial T(y,a)}{\partial a}$$

For instance, a bivariate tax payment function may represent a tax system where income and wealth are taxed separately. In this scenario, we can express the bivariate tax payment as the sum of two univariate tax payment functions: one for income taxation and one for wealth taxation. In this case, the bivariate tax payment function is given by

$$T(y,a) = T_Y(y) + T_A(a)$$

where $T_Y(y)$ and $T_A(a)$ represent the univariate tax payment functions for income and wealth, respectively. With such bivariate tax payment functions, the marginal income and wealth tax rates are solely determined by the respective univariate tax functions.

$$\tau_Y(y) = \frac{\partial T_Y(y)}{\partial y}$$
$$\tau_A(a) = \frac{\partial T_A(a)}{\partial a}$$

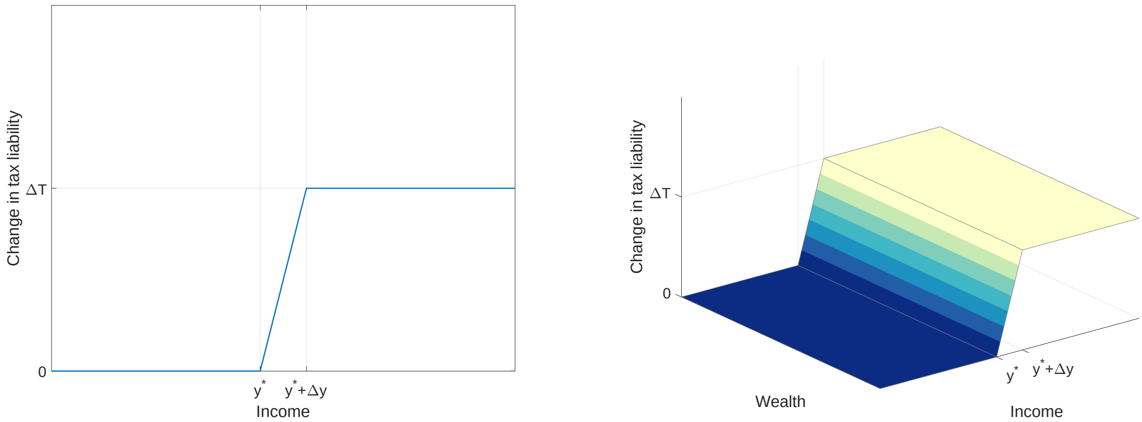
Furthermore, if the bivariate tax function is simply the summation of two univariate tax functions, the cross-marginal rates are zero. This implies that the marginal tax rate of one argument (e.g., income) does not depend on the other argument (e.g., wealth). Mathematically, this condition is expressed as

$$\frac{\partial^2 T(y,a)}{\partial y \partial a} = 0$$

Alternatively, a bivariate tax function could represent a system where income and wealth taxation are interdependent. In such a scenario, the bivariate tax payment function cannot be expressed as the simple summation of univariate tax functions. Crucially, in this context, the cross-marginal tax rates are not zero everywhere, indicating that the marginal tax rate of one argument (e.g., income) may depend on the other argument (e.g., wealth), and vice versa.

2.3.2 Elementary Tax Reforms

The utilization of elementary tax perturbations is a widely adopted approach to analyze the effects of univariate tax reforms. Saez (2001) popularized this method by employing it to study optimal income taxation relying on income elasticity, which serves as a sufficient statistic for measuring the effects of income tax reforms. In this context, an income tax perturbation refers to an infinitesimal increase in the marginal income tax rate within a small interval along the income distribution. Perturbation analysis yields insightful results as any differentiable tax function can be reconstructed through a linear combination of these reforms at various points on the income distribution, along with a lump-sum adjustment that modifies the tax liability at any given point on the income distribution.



(a) Two-Dimensional Representation (b) Three-Dimensional Representation

Figure 2.1: Elementary Income Tax Reform

Notes: The left panel illustrates the change in tax liability along the income distribution after an elementary income tax reform. It is represented in a 2D graph, where the x-axis represents taxable income and the y-axis represents the change in tax liability. The right panel presents the same information in a 3D format. Here, the x-axis represents taxable income, the y-axis represents net wealth, and the z-axis denotes the change in tax liability.

Figure 2.1 depicts the impact of an elementary income tax reform on tax liability. The income distribution is divided into three distinct regions, each experiencing varying effects from the reform.

In the first region, comprising incomes below the threshold at which the reform is implemented, individuals are unaffected by the reform and thus do not change their behavior. This is based on the assumption that they are rational optimizers.

The second region encompasses a small interval immediately above the threshold income level. Here, individuals face higher marginal tax rates post-reform, leading to a decrease in labor supply. This response is captured by the income elasticity. The decrease in individuals' labor supply results in a reduction in tax revenue, referred to as efficiency costs (denoted by ΔR^E). Importantly, assuming the change in the marginal tax rate is infinitesimal, their utility remains unchanged due to the envelope theorem.

The third and final region includes incomes exceeding the threshold level. Individuals in this category experience an increase in tax liability, resulting in a reduction in utility. The higher tax liabilities of these individuals increase tax revenue (denoted by ΔR^M). However, without income effects, individuals' labor supply remains unchanged from pre-reform levels.

The marginal excess burden of elementary income tax reforms, defined as the loss in tax revenue due to individuals' response to taxation per unit of extra tax revenue, can be calculated. It represents the ratio of the loss in tax revenue due to individuals in the second region decreasing their labor supply to the increase in tax liability of individuals in the third region. Mathematically, it can be expressed as

$$MEB_Y(y^*) = -\frac{\Delta R^E(y^*)}{\Delta R^M(y^*)} = \varepsilon_{y,1-T_y'}(y^*)\frac{\tau_Y(y^*)}{1-\tau_Y(y^*)}\frac{y^* f_Y(y^*)}{1-F_Y(y^*)} \tag{2.11}$$

Here, y^* represents the threshold at which the tax reform is applied. $\varepsilon_{y,1-T_y'}$ captures the elasticity of taxable income with respect to the net-of-income tax rate. $F_Y(y)$ is the cumulative distribution function of the income distribution, and $f_Y(y)$ is the density function.

Attaching a normative average welfare weight to individuals whose tax liability increases post-reform allows for assessing the welfare effects of elementary income tax reforms. Mathematically, the total welfare effect per unit of tax revenue becomes

$$\Delta W_Y(y^*) = \frac{(1-\overline{g_Y}(y^*))\Delta R^M(y^*) + \Delta R^E(y^*)}{\Delta R^M(y^*)} \tag{2.12}$$

where $\overline{g_Y}(y^*)$ represents the average welfare weight of individuals whose tax liability increases in terms of public funds.[4]

A similar elementary tax reform, focusing on wealth taxation, can be defined in parallel to the one applied to income taxation.[5] Notably, Saez and Stantcheva (2018) utilize such reforms to investigate optimal capital income taxation.

Unlike univariate tax functions, linear combinations of elementary tax reforms for income and wealth, along with a lump-sum adjustment, are insufficient for reproducing any given bivariate tax payment function. Specifically, these combinations fail to generate cross-marginal tax rates.[6] Another elementary reform that leverages the bivariate nature of the tax function is necessary for the complete reconstruction of any given function.

Figure 2.2 depicts the impact of an elementary joint tax reform on tax liability. Golosov, Tsyvinski and Werquin (2014) utilize similar reforms to analyze multivariate tax functions. This reform segments the joint distribution of income and wealth into four distinct regions.

[4]Essentially, the weights reflect how the welfare of the population segment above a specific income is valued relative to the average welfare of the entire population.

[5]These reforms yield analogous results to income tax reforms regarding their marginal excess burden and welfare effect.

[6]Formally, the impact of univariate elementary reforms is limited to altering the diagonal variables of the Hessian matrix of the tax payment function.

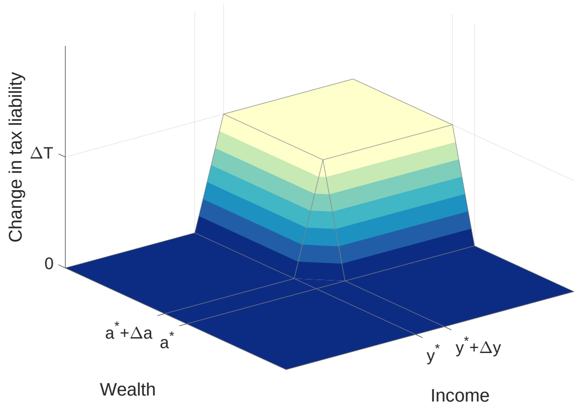


Figure 2.2: Elementary Joint Tax Reform

Notes: The figure illustrates the change in tax liability after an elementary joint tax reform. The x-axis represents taxable income, the y-axis represents net wealth, and the z-axis denotes the change in tax liability.

The first region encompasses points along the joint distribution where either income or wealth is smaller than their respective threshold point at which the joint reform occurs. Similar to univariate tax reforms, individuals in this region neither face a different marginal tax rate nor experience an increase in their tax liability post-reform.

The second region comprises points exactly at the income threshold but larger than the wealth threshold. Here, individuals face an increase in the marginal income tax rate, leading them to decrease their labor supply. The resulting efficiency cost in tax revenue due to income distortion is denoted by ΔR_Y^E.

The third region mirrors the second, including points exactly at the wealth threshold but larger than the income threshold. Individuals in this region face higher wealth taxes after the reform and decrease their wealth accumulation. This distortion causes another efficiency cost, denoted by ΔR_A^E.

The impact on individuals located precisely at both the income and wealth thresholds is of second order and therefore negligible. This analysis is carried out considering the limit $(\Delta y, \Delta a) \rightarrow (0, 0)$, implying that the region where both thresholds intersect diminishes at a much faster rate compared to other regions.

We opt to abstract from cross-elasticities, assuming that a change in the marginal income tax rate does not affect wealth accumulation, and vice versa. We have two primary reasons for this approach. Firstly, we aim to maintain simplicity in our expressions while conveying the fundamental insights of joint taxation of income and wealth. Secondly, accurately measuring cross-elasticities presents a challenge, and the empirical literature lacks consensus on their magnitude. Hence, by disregarding cross-elasticities, we focus on the core dynamics of income and wealth taxation interactions without introducing unnecessary complexity.

Lastly, the fourth region consists of points that exceed both the income and wealth thresholds. While individuals in this region will pay more taxes after the reform, their behavior in terms of labor supply and wealth accumulation remains unchanged from pre-reform levels. The additional tax revenue collected from these individuals is denoted by ΔR^M.

This family of joint reforms can also be referred to as double-progressive tax reforms. This is because, following these reforms, income taxation becomes more progressive when wealth is high, and conversely, wealth taxation becomes more progressive when income is high.

The marginal excess burden of a joint reform can be defined similarly to that of univariate reforms. It entails weighing the additional revenue generated from individuals in the fourth region, whose tax liability increases post-reform, against the loss in tax revenue resulting from distortions on labor supply in the second region and on wealth accumulation in the third region.

$$MEB_{\text{joint}}(y^*, a^*) = -\frac{\Delta R_Y^E(y^*, a^*) + \Delta R_A^E(y^*, a^*)}{\Delta R^M(y^*, a^*)} \tag{2.13}$$

Proposition 2.2. *Suppose the initial bivariate tax payment function is separable, and the elasticities of income and wealth remain constant. In this case, the marginal excess burden of an elementary joint reform can be expressed as a weighted sum of the marginal excess burdens of the univariate reforms that occur at the same levels of income and wealth. Specifically,*

$$MEB_{joint}(y^*, a^*) = w_Y(y^*, a^*)MEB_Y(y^*) + w_A(y^*, a^*)MEB_A(a^*) \tag{2.14}$$

where $w_Y(y, a)$ and $w_A(y, a)$ denote the weights determined by the joint distribution of income and wealth, respectively. They are defined as follows.

$$w_Y(y^*, a^*) = \frac{f_Y(y^*|a > a^*)}{1 - F_Y(y^*|a > a^*)} \frac{1 - F_Y(y^*)}{f_Y(y^*)} \tag{2.15}$$

$$w_A(y^*, a^*) = \frac{f_A(a^*|y > y^*)}{1 - F_A(a^*|y > y^*)} \frac{1 - F_A(a^*)}{f_A(a^*)} \tag{2.16}$$

where $F_Y(y|a > a^*)$ is the conditional cumulative income distribution function given wealth exceeds the threshold a^*. Similarly, $F_A(a|y > y^*)$ is the conditional cumulative wealth distribution function given income exceeds the threshold y^*.

Proof. See Appendix B.3. □

Proposition 2.2 addresses a scenario wherein the bivariate tax function comprises two separate univariate tax functions. In this context, the marginal excess burden of joint reforms can be computed using the marginal excess burdens of univariate reforms, along with weights that solely depend on the joint distribution of income and wealth. Importantly, these weights remain independent of the initial tax schedule.

The hazard rate, which measures the density at a specific value relative to the probability of the random variable exceeding that value, emerges as a crucial parameter for assessing the impact of tax reforms (Diamond, 1998). This statistic is pivotal because it identifies the number of individuals who face higher marginal tax rates and those whose tax liability increases.

The weights that scale the effects of univariate marginal excess burdens precisely quantify how the hazard rates of unconditional and conditional distributions interrelate. For instance, $w_Y(y^*, a^*)$ quantifies the hazard rate of the conditional income distribution relative to the unconditional case. This comparison helps assess the efficiency costs of joint reforms in relation to the additional tax revenue they generate.[7]

Another approach to conceptualizing elementary joint reforms involves starting with an elementary univariate tax reform and extending it with a threshold. For example, consider an elementary wealth tax reform. Setting an income limit above which this reform applies creates the elementary joint reform. To maintain the continuity of the tax payment function, the marginal income tax rate must increase within a small interval around the income limit. Limiting the wealth tax reform based on income gives rise to two additional effects beyond the effects of the univariate wealth tax reform.

Firstly, the income limit restricts the number of individuals whose tax liability increases and those who face higher marginal wealth tax rates. Individuals who exceed the wealth threshold but remain below the income limit do not experience a change in their liability. Similarly, individuals who are at the original wealth threshold but remain below the income limit do not face higher marginal tax rates either. Reducing the number of people who pay more taxes post-reform contributes to a higher marginal excess burden. However, reducing distortion by not increasing the marginal wealth tax rate acts as a counterforce towards a lower marginal excess burden. If wealth and income are positively correlated, income acts as a tag, and the positive effect via lower distortion overcomes the negative effect via lower tax revenue (Akerlof, 1978). Therefore, the overall effect becomes positive. We refer to this channel as the *"tagging benefit."*

Secondly, as income is an endogenous variable, using it as a tag and creating higher marginal income tax rates for a portion of the population comes at a cost. Individuals who face higher marginal income tax rates as a result of the joint reform respond to the reform by reducing their labor supply. This creates another source of distortion for joint tax reforms, which increases the marginal excess burden. We refer to this channel as the *"distortion cost."*

[7] An alternative method of defining the weights in Proposition 2.2 involves using conditional probabilities. The weight for the marginal excess burden of income tax reforms can be expressed equivalently as $w_Y(y^*, a^*) = \frac{\Pr(a>a^*|y=y^*)}{\Pr(a>a^*|y>y^*)}$. This expression reflects the scaling of additional tax revenue relative to the scaling of efficiency costs.

The identity provided in Equation (2.14) can be rewritten to reflect this alternative conceptualization of joint reforms explained above.

$$MEB_{\text{joint}}(y^*, a^*) = MEB_A(a^*) \underbrace{-(1 - w_A(y^*, a^*))MEB_A(a^*)}_{\text{Tagging benefit}} \underbrace{+w_Y(y^*, a^*)MEB_Y(y^*)}_{\text{Distortion cost}} \quad (2.17)$$

If wealth and income are positively correlated, the hazard rate of the unconditional wealth distribution is larger than that of the conditional wealth distribution. This implies that $w_A(y^*, a^*)$ is less this one. Consequently, the tagging benefit is negative, decreasing the excess burden. On the other hand, $w_Y(y^*, a^*)$ is larger than zero unless wealth and income are perfectly correlated. Therefore, the distortion cost is positive, increasing the excess burden.

If wealth and income are positively correlated, the hazard rate of the unconditional wealth distribution is greater than that of the conditional wealth distribution. Consequently, $w_A(y^*, a^*)$ is less than one. This implies tagging benefit term is negative, which decreases the excess burden. On the other hand, $w_Y(y^*, a^*)$ is greater than zero unless wealth and income are perfectly correlated. Therefore, the distortion cost is positive, resulting in an increased excess burden.

This conceptualization does not have to start with a univariate wealth tax reform. In fact, a mirroring argument can be made stating with a univariate income tax reform, extended with a wealth limit.

In the scenario of perfect correlation between wealth and income, one of the weights equals zero while the other equals one. The determination of which weight equals one depends on the location of the joint reform. If $w_A(y^*, a^*) = 1$ and $w_Y(y^*, a^*) = 0$, the tagging benefit vanishes, and there is no distortion cost. Conversely, if $w_A(y^*, a^*) = 0$ and $w_Y(y^*, a^*) = 1$, the tagging benefit perfectly offsets the initial distortion, and the distortion cost is equivalent to the marginal excess burden of the income reform.

It is worthwhile to consider another case where the distributions of income and wealth are independent, meaning that the joint distribution of income and wealth equals the product of the marginal income and wealth distributions. Mathematically, this is expressed as $f(y, a) = f_Y(y) \cdot f_A(a)$. In this scenario, the conditional and unconditional distributions are identical. Consequently, both weights provided in Equations (2.15) and (2.16) are equal to one. The marginal excess burden of joint reforms is then given by the unweighted sum of marginal excess burdens of univariate reforms.

$$MEB_{\text{joint}}(y^*, a^*) = MEB_Y(y^*) + MEB_A(a^*) \quad (2.18)$$

Intuitively, this result suggests that in the absence of a correlation between wealth and income, there is no tagging benefit. The distortion cost is equivalent to the marginal excess burden of the univariate income tax reform. Consequently, the excess burden of joint reforms always exceeds that of either separable reform alone.[8]

This finding is consistent with the conclusions reached by Albanesi and Sleet (2006), who suggest that cross-marginal tax rates should be negative in situations where income and wealth are uncorrelated. In the context of this study, elementary joint reforms lead to an increase in cross-marginal tax rates. In scenarios characterized by uncorrelated distributions, these reforms are less favorable compared to univariate tax reforms in terms of revenue effects.

Similar to univariate tax reforms, the total welfare effect of joint tax reforms can be computed with the inclusion of normative welfare weights. The equation is formulated as

$$\Delta W_{\text{joint}}(y^*, a^*) = \frac{(1 - \overline{g}(y^*, a^*))\Delta R^M(y^*, a^*) + \Delta R^E_Y(y^*, a^*) + \Delta R^E_A(y^*, a^*)}{\Delta R^M(y^*, a^*)} \tag{2.19}$$

where $\overline{g}(y^*, a^*)$ represents the average welfare weight of individuals who exceed both thresholds at which the joint tax reform is implemented.

2.4 Numerical Analysis

In the previous section, we derived formulas to assess the impact of integrating jointness into the tax system, which initially consists of two separate univariate tax functions. We demonstrated that the marginal excess burden of elementary joint reforms depends on both the marginal excess burden of univariate tax reforms and the joint distribution of income and wealth. Furthermore, we showed that joint reforms are less favorable than univariate reforms when the distributions of income and wealth are independent.

In this section, we apply our theoretical findings to real-world data and evaluate the effects of elementary joint reforms. To accomplish this, we utilize the *Survey of Consumer Finances* (SCF) provided by the Federal Reserve. This triennial cross-sectional household survey offers a representative sample of the entire U.S. population. The SCF dataset is particularly valuable for our analysis because it includes household income and net wealth, allowing for the estimation of the joint distribution of income and wealth, which is essential for our study.

2.4.1 Joint Distribution of Income and Wealth

The SCF provides comprehensive data on household income and net wealth breakdowns. In our analysis, we define income as the total of wages, salaries, business income, and transfers. Notably, we exclude capital gains we use long-term capital gains taxation to

[8] Unless one of the marginal burdens of univariate tax reforms is negative, which would indicate that a Pareto improvement is possible by decreasing the univariate tax rates.

construct our baseline wealth taxation system, as will be elaborated shortly. Wealth is defined as the sum of financial and non-financial assets, excluding retirement savings, minus total household debt. This measure represents a household's net worth.

	Income	Wealth
Mean	\$107,700	\$831,400
Median	\$62,100	\$161,700
Gini coefficient	0.550	0.821
Top-10% share	44.0%	73.9%
p90/p50 ratio	3.23	8.26

Table 2.1: Descriptive Statistics of Income and Wealth Distributions

Notes: The table summarizes the key statistics of the income and wealth distributions using the 2019 wave of the Survey of Consumer Finances. The top panel provides the mean and median variables of each distribution, while the bottom panel presents three measures of inequality.

Table 2.1 shows that wealth exhibits significantly greater inequality compared to income. The Gini coefficient of the wealth distribution exceeds that of income by 27.1 percentage points. Similarly, households within the top 10% of the wealth distribution possess nearly 74% of all wealth owned by U.S. households, whereas those within the top 10% of the income distribution garner less than half of the total income.

		Wealth groups		
		Bottom 50%	Mid 40%	Top 10%
Income groups	Bottom 50%	35.6	14.0	0.4
	Mid 40%	14.1	22.3	3.6
	Top 10%	0.3	3.7	6.0

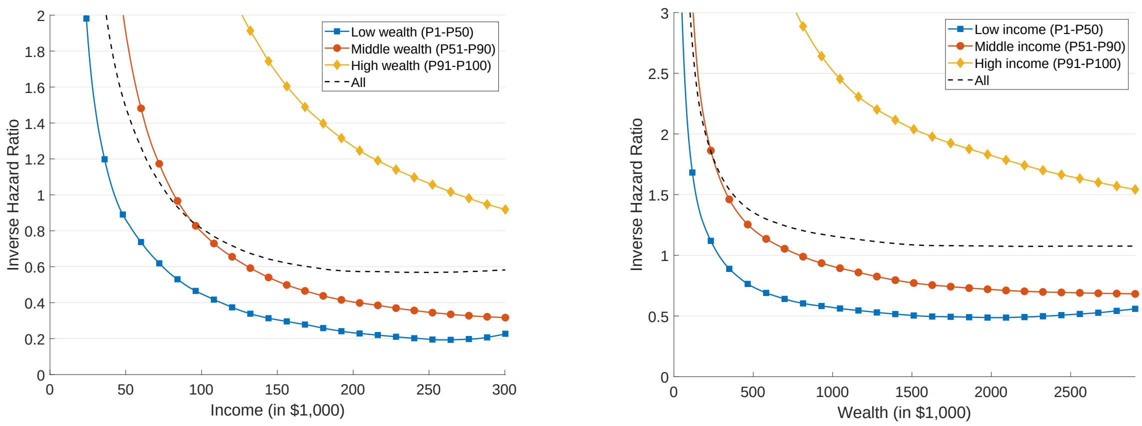
Table 2.2: Joint Distribution of Income and Wealth

Notes: The table summarizes the joint distribution of income and wealth from the 2019 wave of the Survey of Consumer Finances. The income distribution is divided into three bins. The bottom 50% represents households up to the 50th percentile, the mid 40% represents households between the 50th and 90th percentile. The top 10% represents households above the 90th percentile of the income distribution. The same division is applied to the wealth distribution as well. The numbers in each cell represent the percentage of households in the respective joint bin.

Table 2.2 provides insight into the joint distribution of income and wealth, highlighting a strong correlation between the two variables in U.S. households. For instance, conditional on being within the top 10 percent of the income distribution, there is a 60% likelihood that a household also falls within the top 10 percent of the wealth distribution, while only a 4% chance exists that they are in the bottom 50%. Similarly, over 70% of households within the bottom 50% of the income distribution are also within the bottom 50% of the wealth distribution, with a mere 0.8% presence within the top 10% of the wealth distribution.

The total correlation between household income and wealth, as measured by Kendall's τ coefficient,[9] stands notably high at 0.617.

To estimate the joint distribution of income and wealth, we utilize the kernel density estimation method. This non-parametric technique is employed to estimate the probability density functions of one or more random variables. Its non-parametric nature allows us to refrain from making assumptions about any underlying distributions. Additionally, given that the correlation between income and wealth is pivotal for the analysis, not assuming any specific functional form of correlation is a more robust approach.



(a) Across Income Distribution

(b) Across Wealth Distribution

Figure 2.3: Conditional Inverse Hazard Rates

Notes: The left panel illustrates the scaled inverse hazard rate of the income distribution, denoted by $\frac{1-F_Y(y)}{y f_Y(y)}$, for both the unconditional income distribution and income distributions conditional on three distinct wealth groups. The right panel illustrates the scaled inverse hazard rate of the wealth distribution, expressed as $\frac{1-F_A(a)}{a f_A(a)}$, for both the unconditional wealth distribution and wealth distributions conditional on three different income groups.

Cremer, Gahvari and Lozachmeur (2010) demonstrate the significant role played by the scaled inverse hazard rate in shaping optimal marginal tax rates. Specifically, they highlight the positive gains from tagging when hazard rates differ across subgroups. Figure 2.3 presents these metrics for both unconditional and conditional income and wealth distributions. Conditioning the income distribution on being within the top 10% of the wealth distribution results in substantially higher inverse hazard rates across all income levels compared to the unconditional scenario. These elevated inverse hazard rates suggest a need for higher marginal tax rates for the high-wealth group in the absence of distortion costs. Conversely, focusing solely on the lower wealth group reduces the inverse hazard rates across all income levels, thereby lowering optimal marginal tax rates for this demographic. A similar pattern emerges when examining the wealth distribution: the

[9]It is a statistic used to measure the ordinal association between two measured quantities. Mathematically, it is given by $\tau = \frac{2}{n(n-1)} \sum_{i<j} \operatorname{sgn}(y_i - y_j) \operatorname{sgn}(a_i - a_j)$ where sgn represents the signum function.

higher the income level within a subpopulation, the greater the inverse hazard rates across all wealth levels.[10]

2.4.2 Baseline Tax System

Determining the baseline tax system over which a tax reform is applied is crucial in assessing the fiscal effects of the reform. This is because the efficiency costs resulting from changes in household behavior heavily depend on the baseline tax system. When there is a decrease in labor supply or wealth accumulation, the resulting decrease in tax revenue is directly influenced by the marginal tax rates.

To measure the impact of the joint reforms we study, we assume that the U.S. household taxation system consists of two separable univariate tax functions: one depending on income, excluding capital gains, and the other depending on wealth.

Currently, there is no wealth taxation in the U.S. Therefore, we substitute capital gains taxation with wealth taxation, assuming a constant yearly return on capital. This substitution relies on the assumption that the returns to capital are homogeneous. In such a scenario, the substitution is given by

$$\tau_A = \frac{r\tau_K}{1+r}$$

Combining the 20% long-term capital gains tax rate with an average annual return of 6.3% (Jordà et al., 2019) is equivalent to an annual wealth tax rate of 1.19%. This serves as the baseline wealth taxation system in the analysis.

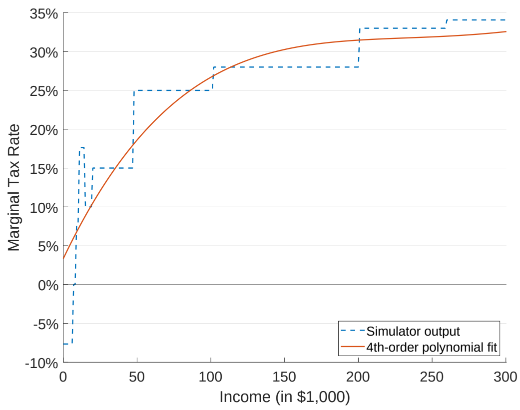


Figure 2.4: Estimated Marginal Income Tax Rates

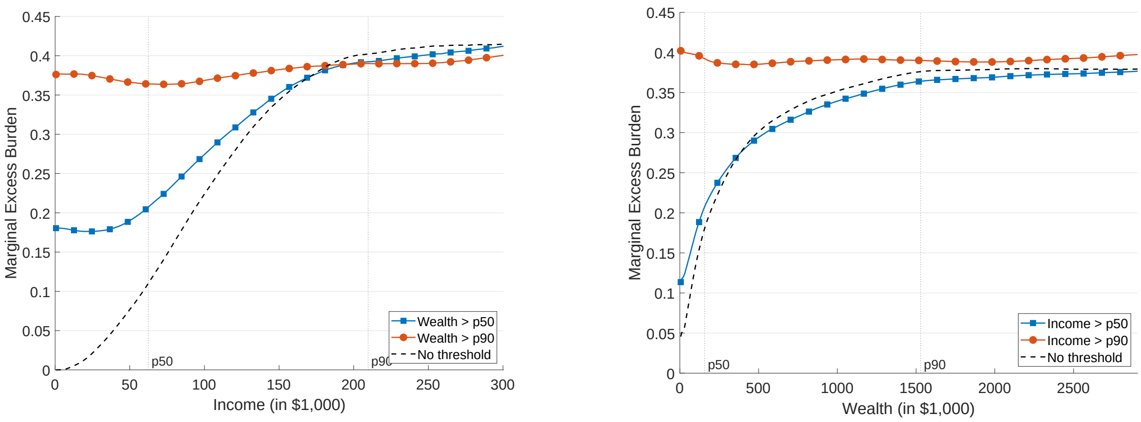
Notes: The figure illustrates the estimation process of the baseline marginal income tax rates. The blue dashed line represents the output from the NBER's tax liability simulator, while the red line depicts the 4th-order polynomial fit.

[10]The non-crossing nature of hazard rates across different subgroups is also significant. In the absence of additional distortion costs, the subgroup with lower inverse hazard rates benefits from tagging, whereas the group with higher rates experiences losses (Cremer, Gahvari and Lozachmeur, 2010).

To estimate the income taxation system, we rely on TAXSIM, the National Bureau of Economic Research's (NBER) tax liability simulator (Feenberg and Coutts, 1993).[11] Through the simulator, the federal marginal income tax rate is computed at various points along the income distribution. A 4th-order polynomial fit is then employed to derive the baseline income taxation for the analysis. Figure 2.4 illustrates the simulator output as well as the result of the polynomial fit we utilize in the analysis.

2.4.3 Marginal Excess Burden

Once we've estimated the joint distribution of income and wealth and established the baseline taxation system, we can apply our formulas from Equations (2.14), (2.15), and (2.16) to compute the marginal excess burden of any univariate elementary income or wealth tax reform, as well as any elementary joint tax reform. We derive the income and wealth elasticities from existing literature. Specifically, we assume the elasticity of taxable wealth to be 0.50, in line with findings from Chetty et al. (2011). Furthermore, we adopt the baseline 4-year elasticity of taxable wealth reported by Brülhart et al. (2022), which amounts to 34.



(a) Across Income Distribution

(b) Across Wealth Distribution

Figure 2.5: Marginal Excess Burden of Elementary Joint Tax Reforms

Notes: The left panel illustrates the marginal excess burden of tax reforms carried out at different income levels. The black dashed line represents univariate income tax reforms. Blue and red lines represent joint reforms with wealth thresholds set at the 50th and 90th percentiles. The right panel illustrates the marginal excess burden of tax reforms carried out at different wealth levels. A black dashed line represents univariate wealth tax reforms. Blue and red lines represent joint reforms with income thresholds set at the 50th and 90th percentiles.

Figure 2.5 summarizes our results in terms of the fiscal effects of joint and univariate tax reforms. It should be noted that the same joint tax reform may appear in both Figure 2.5a and 2.5b. For instance, consider a joint tax reform implemented at the 50th percentile

[11] The version of the simulator we use, TAXSIM v32, is accessible at `http://www.nber.org/~taxsim/taxsim.html`.

of the income distribution and the 90th percentile of the wealth distribution. In the left panel, this reform is represented by the red line (corresponding to the 90th percentile of the wealth distribution). Observing this line's value at the 50th percentile of the income distribution reveals that the marginal excess burden of this reform is 36 cents per dollar of tax revenue. Similarly, in the right panel, reading the value of the blue line (corresponding to the 50th percentile of the income distribution) at the 90th percentile of the wealth distribution yields the same result of 36 cents.

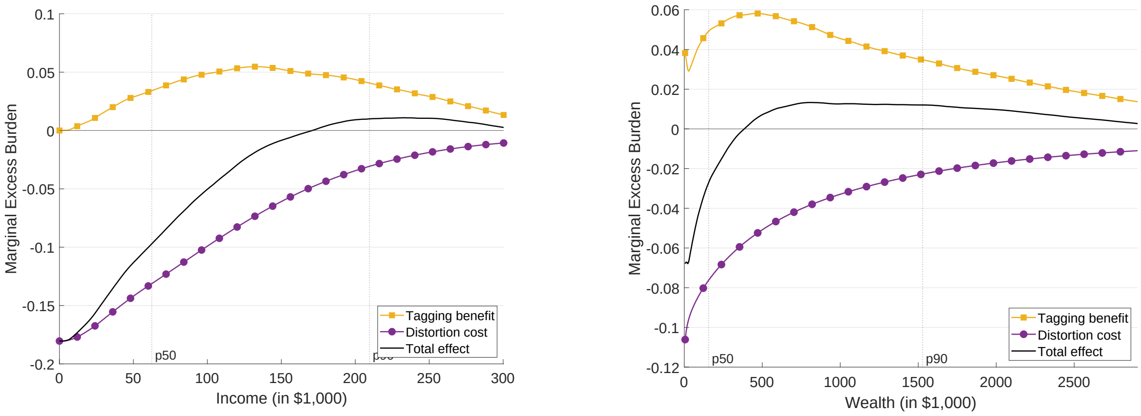
We find that, depending on the location of the reform, joint reforms may have smaller or larger efficiency costs than univariate tax reforms. For instance, a univariate income tax reform at the 50th percentile of the income distribution incurs an efficiency cost of 11 cents per dollar of tax revenue. Appending this reform with a wealth threshold at the 50th percentile of the wealth distribution increases the cost to 21 cents per dollar of tax revenue. This increase is due to the larger distortion cost around the wealth threshold outweighing the tagging benefit.

Conversely, setting the same wealth threshold at the 50th percentile reduces the efficiency costs from 40 cents to 38 cents per dollar of tax revenue if the income threshold is placed at the 90th percentile of the income distribution. For the top 10% of the income distribution, an elementary joint reform incurs lower efficiency costs than a univariate income tax reform because the positive tagging benefit can counteract the distortion cost.

The right panel of Figure 2.5 offers a similar story. Limiting a wealth tax reform to the upper half of the income distribution increases the efficiency cost from 18 to 21 cents per dollar if the wealth tax reform is implemented at the 50th percentile of the wealth distribution. However, the same limitation decreases efficiency costs from 37 to 36 cents if the wealth tax reform is implemented at the 90th percentile.

Figure 2.6 provides additional insight into the fiscal impact of joint reforms by decomposing their effects into tagging benefit and distortion cost. In the left panel, the effect of extending income tax reforms with a wealth threshold at the 50th percentile is illustrated, while the right panel focuses on extending wealth tax reforms with an income threshold at the 50th percentile. Essentially, the left panel decomposes the difference between the blue line and the black dashed line from Figure 2.5a, and the right panel decomposes the difference between the blue line and the black dashed line from Figure 2.5b.

We observe that the distortion cost of joint reforms decreases monotonically with increasing income and wealth. In the case of income taxation, this suggests that the additional distortion on wealth accumulation decreases as the level at which the income tax reform is implemented increases. This occurs because the additional revenue scales down slower than the efficiency costs via wealth accumulation, given the positive correlation between income and wealth. A similar argument applies to wealth tax reforms.



(a) Across Income Distribution

(b) Across Wealth Distribution

Figure 2.6: Decomposition of Tagging Benefit and Distortion Cost

Notes: The left panel illustrates the decomposition of the impact of extending univariate income tax reforms with a wealth threshold set at the 50th percentile of the wealth distribution. Conversely, the right panel illustrates the decomposition of the impact of extending univariate wealth tax reforms with an income threshold at the 50th percentile of the income distribution. In both panels, the yellow and purple lines represent the tagging benefit and distortion cost, respectively.

In contrast, the tagging benefit exhibits an inverse U-shape in both cases. This suggests that the correlation between income and wealth is strongest in the middle of the income and wealth distributions, resulting in a peak tagging benefit for joint tax reforms.

Combining these two effects yields the total impact of joint tax reforms compared to univariate tax reforms. In both cases, the efficiency costs of joint reforms are higher if the reform targets the low-to-middle part of the respective distribution. However, joint reforms provide a fiscal benefit compared to univariate reforms if they target the upper part of the income or wealth distributions.

2.4.4 Welfare Effects

We can also compute the welfare effects of univariate and joint reforms using our theoretical framework. This necessitates adopting a normative stance on society's preference for redistribution. Rather than assuming a specific social welfare function like utilitarianism or Rawlsianism, we posit that the baseline taxation, consisting of two distinct univariate tax functions, reflects society's preference for redistribution. We assume that these univariate tax functions are separately calibrated to maximize social welfare.

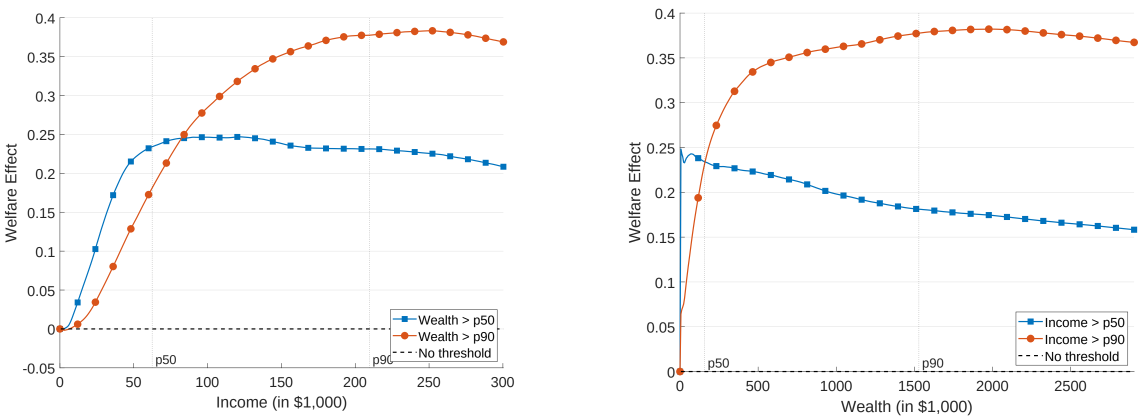
With this assumption of separable optimality, any elementary univariate tax reform should theoretically have a neutral effect on social welfare ($\Delta W_Y(y) = 0$). Therefore, Equation (2.11) allows us to derive the normative welfare weights across the entire income distribution.[12]

$$\overline{g_Y}(y) = 1 + \frac{\Delta R^E(y)}{\Delta R^M(y)} \tag{2.20}$$

where $\overline{g_Y}(y) = \frac{\int_y^\infty g_Y(y')f_Y(y')dy'}{1-F_Y(y)}$ is the average welfare weight of those who have a higher income than y. Similarly, the corresponding condition for univariate wealth tax reforms enables the derivation of welfare weights ($\overline{g_A}(a)$) across the entire wealth distribution.[13]

Constructing joint welfare weights ($g(y,a)$) at a specific point along the joint distribution of income and wealth is not straightforward. Firstly, given the separate welfare weights determined using the separable optimality assumption, the set of joint weights is not unique. One approach to deriving these joint weights is to assume that the relative weights at distinct points along the income distribution are independent of wealth, and vice versa. Mathematically, this assumption is expressed as

$$\overline{g}(y,a) = \overline{g_Y}(y) \cdot \overline{g_A}(a) \tag{2.21}$$



(a) Across Income Distribution

(b) Across Wealth Distribution

Figure 2.7: Marginal Excess Burden of Elementary Joint Tax Reforms

Notes: The left panel illustrates the welfare effect per dollar of revenue of tax reforms carried out at different income levels. The black dashed line represents univariate income tax reforms. Blue and red lines represent joint reforms with wealth thresholds set at the 50th and 90th percentiles. The right panel illustrates the welfare effect per dollar of revenue of tax reforms carried out at different wealth levels. A black dashed line represents univariate wealth tax reforms. Blue and red lines represent joint reforms with income thresholds set at the 50th and 90th percentiles.

Figure 2.7 visually summarizes our findings regarding the welfare effects of joint and univariate reforms in terms of public funds. Univariate income and wealth tax reforms without thresholds are depicted as having a neutral effect on social welfare. This outcome

[12]This approach is referred to as the inverse-optimum approach and used in the literature to estimate the redistributive preferences of political parties (Jacobs, Jongen and Zoutman, 2017) or to study the effects of fiscal pressure (Ayaz et al., 2023).

[13]See Appendix B.4.2 for an illustration of the estimated welfare weights across the income and wealth distributions.

is inherent in the assumption that separate univariate tax functions are optimized to calculate distinct welfare weights, implying that any elementary univariate tax reform neither enhances nor diminishes social welfare.

Analyzing income tax reforms extended with a wealth threshold unveils their potential to enhance welfare, a benefit not achievable by univariate income tax reforms across the income distribution. Furthermore, setting the wealth threshold higher at the 90th percentile instead of the 50th percentile amplifies this improvement. However, it's essential to note that the welfare effects are expressed per dollar of tax revenue, and the absolute effects of these reforms may differ. For instance, considering an income tax increase at the 50th percentile of the income distribution, limiting this reform above the 50th percentile of the wealth distribution reduces the additional revenue by 30.3%, while setting a wealth limit at the 90th percentile decreases the additional revenue by 81.4%.

Extending wealth tax reforms with an income threshold similarly demonstrates the potential to enhance welfare. Under the separate optimality assumption, joint tax reforms characterized by a wealth threshold at the 90th percentile of the wealth distribution can improve welfare by 8 to 24 cents per dollar of tax revenue depending on the chosen level for the income threshold.

2.5 Conclusion

We explore the implications of integrating income and wealth taxation, highlighting key reasons why governments may find it advantageous to design these systems in tandem.

Firstly, we demonstrate the efficiency benefits of linking wealth taxes to current income using a simplified two-period model. In scenarios where labor income is uncertain, applying wealth taxes based on varying income levels results in different levels of distortion on saving behavior. This approach provides an additional incentive for governments to adjust saving taxes, lowering them for individuals with lower incomes and raising them for those with higher incomes, beyond the typical insurance motive.

Secondly, we investigate the fiscal and social impacts of joint tax reforms employing a sufficient-statistic approach based on elasticities of taxable income and wealth. By deriving theoretical formulas for the marginal excess burden and welfare effects of joint reforms based on those of univariate income and wealth tax reforms, we argue that the classical "tagging benefit" logic applies when income and wealth are positively correlated. However, the joint reforms we analyze also introduce additional "distortion costs," the dominance of which depends on the joint distribution of income and wealth, particularly the strength of their correlation.

Subsequently, our empirical analysis reveals that employing joint tax reforms may be preferable to univariate reforms, particularly in regions where the correlation between income and wealth is stronger. By leveraging our theoretical formulations on real-world data, we observe that joint reforms incur lower efficiency costs in such regions. Furthermore, we compute the welfare effects of joint reforms without adopting a normative stance regarding redistribution preferences. Instead, we assume that the observed separate systems for income and wealth taxation reflect society's preferences. Our computations indicate that even in the absence of univariate welfare-improving tax reforms, joint tax reforms have the potential to further enhance social welfare.

Chapter 3

Who Bears the Burden of COVID-19-Related Fiscal Pressure?

An Optimal Income Taxation Perspective*

3.1 Introduction

The COVID-19 pandemic will leave us with a considerable stock of additional government debt. Further, the economic fallout of the Ukraine war will lead to an additional burden on public finances, as spending on defense, energy security, and help for refugees surges. Servicing this debt will limit the fiscal leeway in the future and force governments to spend less or raise more revenue, probably both. The view is widespread that it is important to distribute the burden of servicing the additional debt fairly, suggesting that taxes should become more progressive.[1] For instance, in a recent paper on tax policy, the IMF argues that "countries have multiple options to enhance the effective progressivity of their tax systems" (de Mooij et al., 2020, p.1) and adds that "options include more progressive personal income tax systems" (de Mooij et al., 2020, p.3). However, the paper also reminds policymakers that "the optimal degree of progressivity should strike a balance between equity and efficiency."(de Mooij et al., 2020, p.4)

How does the optimal degree of income tax progression change if governments need to raise more revenue? Somewhat surprisingly, this issue has received rather little attention in the optimal income tax literature à la Mirrlees. An exception is a recent paper by Heathcote and Tsujiyama (2021*a*) who elaborate on the role of fiscal pressure for the optimal shape

*This chapter is based on joint work with Lea Fricke, Clemens Fuest, and Dominik Sachs. A version of this chapter has been published in the *European Economic Review*, Volume 153, Article 104381 in April 2023. See Ayaz et al. (2023) for the full reference.

[1]There are different ways to define progressivity. In this paper, when we speak of a tax system becoming more progressive (regressive), we refer to average tax rates increasing more (less) strongly for higher incomes than for lower incomes. Hence our benchmark is to define progressivity in terms of average tax rates. Sometimes, we also refer to progressivity in terms of marginal tax rates; in these cases, we explicitly mention that we refer to marginal tax rates.

of marginal tax rates.[2] For the U.S., they find that an increase in fiscal pressure pushes the optimal tax schedule from a progressive shape of marginal tax rates, first to a flat and then to a U-shaped schedule of optimal marginal tax rates. This analysis helps to reconcile different quantitative findings in the literature, e.g. the fact that Saez (2001) found very high marginal tax rates at the bottom compared to Heathcote and Tsujiyama (2021*a*).

In this paper, we take the workhorse optimal income taxation model to ask how the optimal progressivity of the tax-transfer system changes due to a COVID-19-related increase in fiscal pressure. We study five European countries: France, Germany, Italy, Spain and the UK. For all these countries, we find that marginal and average tax rates should increase in particular for lower incomes. This implies that the tax schedule should become less progressive. Nevertheless, in terms of absolute tax payments, higher incomes will bear a larger burden.

Why does optimal progressivity fall in response to higher revenue requirements? We show that considering Laffer bounds on marginal tax rates helps to understand the implications of fiscal pressure. We find that the additional leeway governments have for rising marginal tax rates is significantly higher for low incomes: the difference between Laffer bounds for marginal tax rates and actual marginal tax rates is highest for low incomes.

Our simulations for different European countries show that the change in optimal tax progressivity depends on country-specific properties of the tax-transfer system, though it is quantitatively significant for all countries. Importantly, we do not rely on a particular social welfare function that may imply different preferences for redistribution than those of current governments. Instead, we use an inverse-optimum approach (Bourguignon and Spadaro, 2012). We calibrate the Pareto weights for which the pre-pandemic tax-transfer systems are optimal. Then we ask how the optimal progressivity of the tax-transfer system should change due to COVID-19-induced fiscal pressure given these welfare weights.

We start the paper with a refresher about optimal nonlinear income taxation. First, we consider a simple benchmark without income effects and exogenous marginal social welfare weights. In this case, an increase in fiscal pressure does not affect the progressivity of marginal tax rates. It solely results in a decrease in the lump-sum transfer and hence, the schedule of average taxes becomes less progressive.

This 'irrelevance result' for marginal tax rates can be overcome by either one normative or one positive feature. The normative feature is to endogenize marginal social welfare weights which can be achieved e.g. by a classical Utilitarian objective and decreasing marginal utility of consumption. This implies that the desire to redistribute between two individuals does not only depend on the difference in their consumption but also on the

[2] Lorenz and Sachs (2011), who consider the optimality of the EITC in a model with intensive and extensive margin responses, is also an exception. Heathcote, Storesletten and Violante (2017) study the role of fiscal pressure for optimal tax progressivity for a parametric tax function that implies a constant rate of progressivity that is often labeled as HSV tax function.

level. The positive feature is to account for income effects: a decrease in the lump-sum transfer leads to an increase in labor supply of individuals if leisure is assumed to be a normal good, ceteris paribus. This induces a change in the income distribution and thus, optimal marginal tax rates adjust.

We calibrate the model with income effects and endogenous welfare weights to the pre-pandemic situation in five European countries. We account for the whole tax-transfer system including income taxes, social insurance contributions, and income transfer payments as well as the phasing out of these transfers (everything based on the micro-simulation model EUROMOD). We calibrate the income distributions based on EU-SILC data. This allows us to 'invert' the optimal income tax approach, and ask for which Pareto weights the pre-pandemic tax-transfer systems were optimal.

In the next step, we calibrate the implied fiscal pressure due to COVID-19 debt and consider two different repayment scenarios. We then ask how the optimal schedule of marginal and average tax rates changes due to this increase in fiscal pressure. For all countries, we find that the schedule of marginal tax rates is pushed upwards in a U-shaped fashion. Marginal tax rates should particularly increase for low incomes. For average tax rates, we find that the increase in average tax rates is highest for low incomes and then strictly declines in income.

Our results indicate that the lump-sum transfers should be decreased substantially. However, we also inspect the possibility of a constitutional or political constraint that prohibits governments from decreasing transfers. In this case, we find an even more regressive change in marginal tax rates. However, the change in average tax rates is less regressive. Yet, the overall conclusion is very similar.

Related Literature. The optimal income tax problem (Mirrlees, 1971; Diamond, 1998; Saez, 2001) has been extended in many directions, such as to account for different labor supply margins (Kleven and Kreiner, 2006; Jacquet, Lehmann and der Linden, 2013), taxation of couples (Kleven, Kreiner and Saez, 2009) and general equilibrium effects (Rothschild and Scheuer, 2013; Sachs, Tsyvinski and Werquin, 2020). Heathcote and Tsujiyama (2021*a*) is the first paper to thoroughly elaborate on the role of fiscal pressure in a Mirrleesian framework. They find that fiscal pressure has a strong influence on the shape of the optimal tax schedule. Governments facing a low level of fiscal pressure will set an optimal tax schedule with increasing marginal tax rates. Higher marginal tax rates at low incomes lead only to small redistributive gains as lump-sum transfers are already relatively high. Increasing fiscal pressure first flattens the optimal tax schedule and then leads to a U-shape pattern. Optimal lump-sum transfers get smaller and redistributive gains at low incomes are larger. Thus, higher marginal tax rates at low-income levels are optimal. Heathcote, Storesletten and Violante (2017) investigate the relationship between an increase in government consumption and the progressivity of the tax system as well but consider a parametric tax function with a constant rate of progressivity in a richer equilibrium model. They find that both, theoretically and numerically, an increase in government consumption leads to a less progressive tax system.

We provide an applied contribution to this literature by elaborating the implications of COVID-19-related fiscal pressure using an inverse-optimum approach. For this purpose, we deploy Laffer bounds of marginal tax rates as defined in Lorenz and Sachs (2016). We show that Laffer bounds provide a straightforward way to interpret the implications of fiscal pressure as they reflect the leeway for increasing marginal tax rates for different income levels. Further, Laffer bounds are easy to implement as they are expressed in closed form. We show that the increase in marginal tax rates follows closely the difference in the Laffer bounds of marginal tax rates and current marginal tax rates. Finally, we generalize the approach of the literature and consider the case where governments cannot adjust the lump-sum element. Once the lump-sum transfer is not allowed to be changed, the incidence of fiscal pressure is less regressive.

3.2 The Workhorse Model of Optimal Income Taxation

We briefly review the workhorse model of nonlinear income taxation and discuss how the optimality conditions are affected by fiscal pressure. We start with a pedagogical irrelevance benchmark: without income effects on labor supply and with constant marginal utility, optimal marginal tax rates are independent of fiscal pressure. We then introduce two relaxations: decreasing marginal utility and income effects on labor supply.

3.2.1 Irrelevance Benchmark – No Income Effects and Exogenous Welfare Weights

We first consider iso-elastic preferences of the form: $u(c,l) = c - \frac{l^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}}$, where c is consumption, l is labor supply and ε is the elasticity of labor supply. Denote productivity by w, the cumulative distribution function by $F(w)$ and the density by $f(w)$. The income of an individual is the product of her labor supply and her productivity, $y = lw$. The government maximizes the weighted utilitarian welfare function with type-specific Pareto weights[3] which is given by:

$$W = \int_{\underline{w}}^{\overline{w}} u(c(w), l(w))s(w)f(w)dw,$$

[3]Here we assume that $u(\cdot)$ is the individual utility and $s(w)$ are exogenous type-specific Pareto weights. We explore different possibilities for welfare functions with the form of $W = \int G(u(w))dw$ where $G(u(w)) = u(w)^{\xi}s(w)f(w)$. With different values of ξ, we can assume varying degrees of curvature for the welfare function. (See Section 3.5.4)

where we normalize the Pareto weights $s(w)$ such that $\int_{\underline{w}}^{\overline{w}} s(w)f(w)dw = 1$. To obtain a desire for redistribution, we need $s'(w) < 0$. The important aspect of this welfare function is that the marginal social welfare weights are independent of consumption.

Government Problem. The government chooses a nonlinear tax-transfer system $T(\cdot)$. The government's problem reads as:

$$\max_{T(\cdot)} \int_{\underline{w}}^{\overline{w}} u((l(w)w - T(l(w)w), l(w))s(w)f(w)dw$$

subject to individual optimality

$$l(w) = \arg\max_{l} u((l(w)w - T(l(w)w), l(w))$$

and budget feasibility

$$\int_{\underline{w}}^{\overline{w}} T(l(w)w)f(w)dw \geq E,$$

where E is the exogenous revenue requirement.

It is a standard exercise to show that the formula for optimal marginal tax rates reads as:

$$\frac{T'(y(w))}{1 - T'(y(w))} = \left(1 + \frac{1}{\varepsilon}\right) \frac{\int_{w}^{\overline{w}} (1 - s(x)) f(x)dx}{f(w)w}. \tag{3.1}$$

where $y(w)$ is the income of an individual with productivity w who maximizes her utility. That is, $y(w) = l(w)w$.

Note that this expression provides a closed form for the optimal marginal tax rate for a given productivity level w. The respective lump-sum element $T(0)$ then follows from budget feasibility. A change in fiscal pressure which is captured by an increase in the revenue requirement E only affects the lump-sum element $T(0)$ and nothing else. The schedule of optimal marginal tax rates is unaffected by fiscal pressure: both the RHS of (3.1) and the income levels $y(w)$ are exogenous with respect to the lump-sum element.

3.2.2 Endogenous Welfare Weights

Now, we consider the same economy as before, but the utility function reads as

$$u(c, l) = U\left(c - \frac{l^{1+\frac{1}{\varepsilon}}}{1 + \frac{1}{\varepsilon}}\right),$$

where $U' > 0, U'' < 0$. This utility function still abstracts from income effects but implies decreasing marginal utility of consumption.

For ease of notation, let $u(w)$ to denote the utility of an individual with productivity w who maximizes her utility. That is, $u(w) = u(c(w), l(w))$. Then, it is simple to show that the formula for the optimal marginal income tax rate reads as

$$\frac{T'(y(w))}{1 - T'(y(w))} = \left(1 + \frac{1}{\varepsilon}\right) \frac{\int_w^{\overline{w}} \left(1 - \frac{u_c(x)s(x)}{\lambda}\right) f(x)dx}{f(w)w}$$

where the marginal value of public funds, λ, is given by

$$\lambda = \int_{\underline{w}}^{\overline{w}} u_c(z)s(z)f(z)dz.$$

which follows from the transversality condition.

It is almost equivalent to (3.1), only the element that captures the desire to redistribute is now endogenous with respect to the revenue requirement:

$$\int_w^{\overline{w}} \left(1 - \frac{u_c(x)s(x)}{\int_{\underline{w}}^{\overline{w}} u_c(z)s(z)f(z)dz}\right) f(x)dx.$$

Note that this element captures how much the social planner wants to redistribute from those with income higher than $y(w)$ to those with income lower than $y(w)$. This depends on the ratios of marginal utilities and is endogenous with respect to the lump-sum transfer. A decrease in the lump-sum element increases the desire to redistribute from above $y(w)$ to below $y(w)$. This role of fiscal pressure is discussed in detail in Section 5.2 of Heathcote and Tsujiyama (2021*a*).

3.2.3 Income Effects

With income effects, fiscal pressure influences optimal tax progressivity beyond the endogenous welfare weights channel: as soon as the lump-sum element gets adjusted, the labor supply of individuals adjusts. If leisure is a normal good, individuals will ceteris paribus work more due to fiscal pressure.

Formally, consider the widely used preferences:

$$u(c, l) = \frac{c^{1-\gamma}}{1-\gamma} - \frac{l^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}},$$

where γ is the constant relative risk aversion and ε captures the Frisch elasticity of labor supply.

It is simple to show that in this case the optimal tax schedule is characterized by:

$$\frac{T'(y(w))}{1-T'(y(w))} = \left(1+\frac{1}{\varepsilon}\right)\frac{\int_{w}^{\overline{w}}\left(1-\frac{u_c(x)s(x)}{\tilde{\lambda}}+\eta(x)T'(y(x))\right)f(x)dx}{f(w)w}, \tag{3.2}$$

where $\eta(w) = \frac{\partial y(w)}{\partial T(0)}$ is the income effect parameter which captures the absolute change in income if the lump-sum element of the tax schedule is increased by one unit.[4]. Further, we have to scale the marginal value of public funds to account for income effects.

$$\tilde{\lambda} = \frac{\int_{\underline{w}}^{\overline{w}} u_c(z)s(z)f(z)dz}{1+\int_{\underline{w}}^{\overline{w}} T'(y(z))\eta(z)f(z)dz}.$$

Obtaining comparative statics for how fiscal pressure affects optimal tax progressivity is challenging. Even if one finds assumptions for which the behavior of certain elements of the RHS of (3.2) can be described, one cannot conclude anything on the adjustment of marginal tax rates immediately since the optimal marginal tax rates are a nonlinear transformation of the RHS of (3.2). Therefore, a computational analysis is required. Before we move to the quantification of the model, we introduce the concept of Laffer bounds in this environment, which turns out to be helpful to understand the quantitative results below.

Laffer bounds. If the government increases marginal tax rates to deal with fiscal pressure, it is constrained by the Laffer bound on marginal tax rates. Those are e.g. defined in Lorenz and Sachs (2016) or Bierbrauer, Boyer and Peichl (2021) and are given by:

$$\frac{T'_{\text{Laffer}}(y(w))}{1-T'_{\text{Laffer}}(y(w))} = \left(1+\frac{1}{\varepsilon}\right)\frac{\int_{w}^{\overline{w}}\left(1+\eta(x)T'(y(x))\right)f(x)dx}{f(w)w}. \tag{3.3}$$

Note that we set welfare weights above w to zero. Hence, this is the marginal tax rate that a social planner would obtain – holding marginal tax rates fixed at other levels – if the goal was to raise as much tax revenue as possible from individuals with income above $y(w)$. As we show below, these Laffer bounds are a useful benchmark to understand the implications of fiscal pressure. They show how much leeway a government still has in increasing marginal tax rates for certain income levels.

[4]Another way to write to optimal tax rate formula in (3.2) would be the following: $\frac{T'(y(w))}{1-T'(y(w))} = \left(1+\frac{1}{\varepsilon}\right)\frac{\int_{w}^{\overline{w}}\frac{u_c(w)}{u_c(x)}\left(1-\frac{u_c(x)s(x)}{\tilde{\lambda}}\right)f(x)dx}{f(w)w}$ (see Kaplow (2008)). With this version of the optimal tax rate formula, income effects are incorporated using the fact that the marginal utility of consumption is different for different income levels.

3.3 Calibration

We calibrate the model with income effects and endogenous welfare weights to match five European countries: France, Germany, Italy, Spain, and the UK. In the first step, we calibrate the income distributions based on EU-SILC data. Then, we calibrate the tax-transfer systems by using the tax-benefit microsimulation model EUROMOD. Based on the assumed utility function, we then calibrate the skill distributions as in Saez (2001). Finally, we calibrate our measure for COVID-19-induced fiscal pressure based on OECD data and the IMF World Economic Outlook.

Income Distributions. To obtain country-specific income distributions we use data on annual incomes from the 2018 cross-sectional European Union Statistics on Income and Living Conditions (EU-SILC). EU-SILC contains annual income data in a harmonized framework which allows for cross-country comparisons. Annual incomes are reported for the previous year of the survey leading to 2017 as the reference year for the income distribution. To calibrate the country-specific distributions, we apply a standard kernel density estimation to get a smooth distribution. For incomes above €150,000, we append a Pareto distribution where the Pareto parameter decreases linearly between €150,000 and €250,000.[5] The Pareto parameter at the income threshold of €150,000 is chosen such that the ratio $\frac{f(y)y}{1-F(y)}$ is continuous as in Sachs, Tsyvinski and Werquin (2020). For incomes above €250,000, we leave the Pareto parameter constant at the country-specific values from Atkinson, Piketty and Saez (2011). Finally, we smooth the resulting distributions to ensure differentiability of the hazard ratios at €150,000 and €250,000. We assume that a fixed mass of the population earns an income of zero. The fixed shares are chosen to match the country-specific shares of recipients of disability benefits as in Mankiw, Weinzierl and Yagan (2009).[6] Table 3.1 contains the country-specific values used in the calibration of the income distributions.[7] Figure C.1 in Appendix C.1.2 illustrates the country-specific income distributions.

Current Tax-Transfer Systems. We approximate the current income tax systems with the tax-benefit microsimulation model EUROMOD and EU-SILC as the underlying input

[5]The second threshold of €250,000 is chosen based on the estimation of Pareto parameters in the UK by Jenkins (2017). His estimation results show that the Pareto parameter of the 2010 income distribution stays constant above an income of approximately £250,000 (see Appendix H-8). Our results are not sensitive w.r.t to that assumption.

[6]We utilize data from the Employment Outlook of the OECD (OECD, 2009). The most recent available data refers to the year 2007. Unfortunately, there are no country-specific shares of recipients of disability benefits for France. Thus, we use the average across OECD countries for France. In Section 3.5.4 we provide robustness for the calibration of these shares.

[7]See Appendix C.1.1 and C.1.2 for details on the underlying data and the kernel density estimation, respectively.

data.[8] First, we simulate effective marginal tax rates based on the 2017 tax-transfer system and calculate average marginal tax rates for income bins with a size of €5,000. The simulated effective marginal tax rates include taxes, means-tested benefits, pensions, and social insurance contributions. To smooth the average marginal tax rates, we perform a second-order local weighted regression (LOESS) with a constant extrapolation for income values outside the covered income range of EU-SILC data. Afterwards, we employ a constrained quadratic B-spline to overcome the kink at the income level where the extrapolation starts.[9] The simulated and smoothed marginal tax rates are illustrated in Figure C.2 in Appendix C.1.3.

Skill Distributions. We infer the skill distributions from the income distributions and the simulated effective marginal tax rates by inverting the individual labor supply first-order condition as in Saez (2001). We assume that all countries have the same Frisch elasticity of labor supply of $\varepsilon = 0.2$.[10] For the utility function, we adopt the specification of preferences with income effects of Section 3.2.3, i.e. $u(c,l) = \frac{c^{1-\gamma}}{1-\gamma} - \frac{l^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}}$, with $\gamma = 1$.[11] The first-order condition also depends on the individual's consumption, which is calculated as the difference between income and paid taxes plus a lump-sum transfer. The lump-sum transfers are set to match the average minimum income protection in each country.[12] Table 3.1 contains details on the used country-specific values of the lump-sum transfer in the simulations.

Fiscal Pressure. To simulate the fiscal pressure governments face as a result of the COVID-19 pandemic, we use the following approach. First, we compute the total additional amount of debt governments accumulated and are expected to accumulate between 2020 and 2022 compared to the average deficit levels before COVID-19. For these calculations, we rely on actual government data from the OECD (OECD, 2019) as well as forecast data from the IMF World Economic Outlook (International Monetary Fund, 2021), see Appendix C.1.4 for details. Then, we assume that governments are required to pay back this additional stock of debt in varying periods, namely five and ten years. This means we abstract from additional spending needs caused by the Ukraine war. We do so for

[8]For detailed information about the tax-benefit calculator EUROMOD and how to obtain effective marginal tax rates, see Sutherland and Figari (2012) and Jara and Tumino (2013).

[9]In particular, we apply the quadratic B-spline only in the interval of 30 grid points before and after the starting point of the extrapolation. We set up the constraint of the quadratic B-spline such that the fitted value goes through the smoothed marginal tax rate from the LOESS regression at an income of 30 grid points before and after the starting point of the extrapolation.

[10]In Section 3.5.2, we also consider a higher Frisch elasticity of labor supply of $\varepsilon = 0.54$ (Chetty et al., 2011).

[11]In Section 3.5.4, we try another empirically plausible value for individual risk aversion by setting $\gamma = 1.5$.

[12]Specifically, we use the average minimum income protection from the 2017 Social Assistance and Minimum Income Protection Interim Dataset and convert them into euros. We took a simple average that is based on the minimum income protection of three different categories, namely single, single parents, and two-parent families. Our results for the implications of fiscal pressure for tax progressivity are not sensitive w.r.t. to the calibration of the lump-sum component.

	France	Germany	Italy	Spain	UK
Calibration					
Pareto Threshold Start	€150,000	€150,000	€150,000	€150,000	€150,000
Pareto Threshold Constant	€250,000	€250,000	€250,000	€250,000	€250,000
Pareto Parameter Start	2.8	2.95	2.56	2.21	2.34
Pareto Parameter Constant	2.20	1.67	2.22	2.11	1.78
Mass of People with No Earnings	5.6%	4.4%	3.2%	3.8%	7.0%
Lump-Sum Transfer	€13,347	€20,763	€2,540	€6,991	€15,037
Measure of Fiscal Pressure					
5-year Payback	2.65%	2.96%	3.52%	3.58%	4.90%
10-year Payback	1.32%	1.48%	1.76%	1.79%	2.45%

Table 3.1: Parameters for Calibration

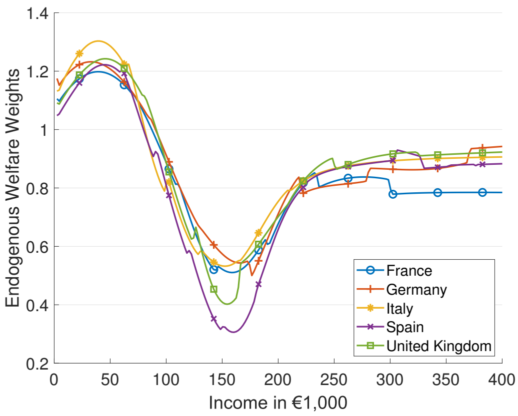
Notes: The constant threshold of €250,000 is chosen based on the estimation by Jenkins (2017). The starting Pareto parameter at the income threshold of €150,000 is chosen such that the hazard rate $\frac{f(y)y}{1-F(y)}$ is continuous as in Sachs, Tsyvinski and Werquin (2020). The values of the constant Pareto parameters are from Atkinson, Piketty and Saez (2011). The mass of people with zero earnings matches the shares of recipients of disability benefits reported by OECD (2009). For France, we use the average across OECD countries. The values of the lump-sum transfer match the average minimum income protection from the 2017 Social Assistance and Minimum Income Protection Interim Dataset and are converted into Euro. The 5-year (10-year) payback measure denotes a scenario where governments are required to pay back the additional stock of debt in five (ten) years. Both measures for fiscal pressure are expressed as a percentage of GDP.

two reasons. First, the size of this burden is still uncertain. Second, our assumptions for the payback period of five and ten years for COVID-19-related debt are already quite restrictive.

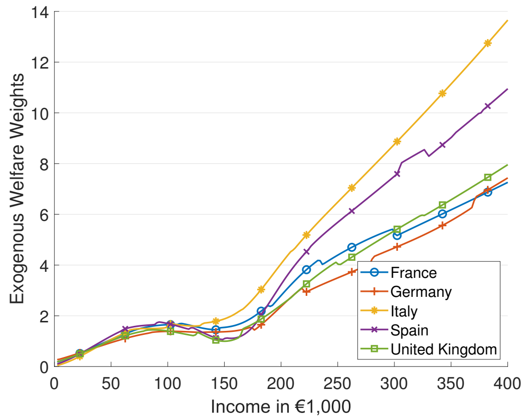
Table 3.1 shows the fiscal pressure that governments face. As expected, paying back the additional debt in five years puts a significant strain on government expenditure. It ranges from 2% of GDP for France to 4.90% of GDP for the UK. Paying back the debt in ten years halves the fiscal pressure. Lastly, the expenditure forecast in 2023 shows that the expenditure numbers will be similar to the two hypothetical fiscal pressure specifications, except for France and the UK.

In a low-interest rate environment, an additional stock of debt does not really hurt the balance between expenditures and revenue in governments' budget. However, with higher interest rates an additional stock of debt matters for the balance between expenditures and revenues. Therefore, we think that our scenarios for fiscal pressure are an interesting benchmark, even if the magnitude is debatable.

Inverse-Optimum Weights. Maximizing the welfare of an economy requires the definition of welfare weights for different levels of skills. Instead of imposing exogenous welfare weights, we employ an inverse optimum approach (Bourguignon and Spadaro, 2012; Lockwood and Weinzierl, 2016; Jacobs, Jongen and Zoutman, 2017): we invert the optimal tax formula to calibrate the Pareto weights that governments were implicitly using before the pandemic. In particular, we calibrate the endogenous welfare weights such that our simulated marginal tax rates by EUROMOD are optimal given the income distributions and the assumed utility function. Figure 3.1a shows the endogenous welfare weights $U'(w)\frac{s(w)}{\lambda}$ as a function of income. First, note that our calibrated weights increase for low incomes. A similar finding has been shown by Jacobs, Jongen and Zoutman (2017) in the Dutch context and has described the fact that middle incomes have higher weights than low incomes as the tyranny of the middle class. At around €50,000 all weights start to decrease before they start to increase for incomes above €150,000 again. The reason for this increase is our calibration of the income distribution. Revenue maximizing tax rates remain constant for incomes above €200,000 and are significantly lower at around €140,000. This contrasts with real-world tax schedules, where marginal tax rates do not quickly increase between €140,000 and €200,000. Finally, note that our weights show small kinks and discontinuities. This is due to the fact that our calibrated tax functions are not as smooth as the calibrated income distributions.



(a) Endogenous Welfare Weights



(b) Pareto Weights

Figure 3.1: Calibrated Welfare Weights

Notes: The left panel shows the calibrated endogenous welfare weights $U'(\omega)\frac{s(\omega)}{\lambda}$ and the right panel shows the Pareto weights $s(\omega)$ as a function of income.

Figure 3.1b shows the implied Pareto weights $s(w)$ which depend on the curvature of the underlying utility function. Overall, these weights increase in income which implies that governments have a smaller desire for redistribution than a classical Utilitarian planner under the same utility function.

3.4 Quantitative Results

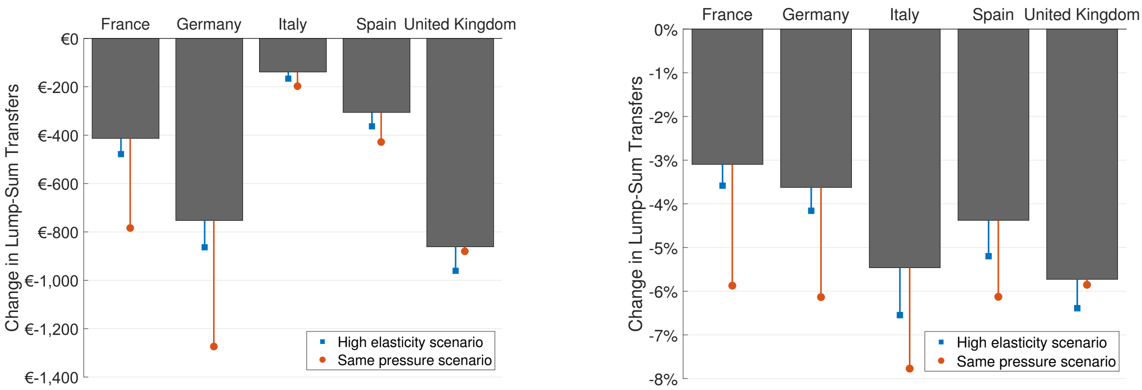
We now present our quantitative results for how the different countries should adjust their tax systems as a response to the increase in fiscal pressure.[13] We first consider the

[13]We use a fine income grid which allows us to use standard optimal income taxation formulas. See Bastani (2015) and Heathcote and Tsujiyama (2021*b*) for elaborations on simulating the Mirrlees model with different degrees of grid coarseness. See Appendix C.1.2 for details of our grid.

adjustment of lump-sum transfers, then the adjustment of marginal tax rates, and finally the resulting changes in average tax rates and absolute tax payments. For illustrative purposes, we focus on the case with strong fiscal pressure where the governments repay the additional debt within five years. The other case of ten-year repayment is discussed in Appendix C.2.

To better understand the cross-country differences, we also construct a scenario where all countries face the same increase in fiscal pressure measured as a share of GDP. We choose 5% for the harmonized value.

3.4.1 Adjustment of Lump-Sum Transfers



(a) Absolute Decrease (b) Relative Decrease

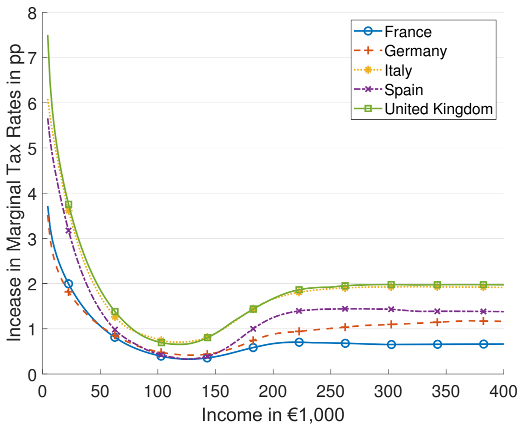
Figure 3.2: Decrease in Lump-Sum Transfers for 5-Year Repayment Scenario

Notes: The left panel shows the change in the lump-sum transfer due to fiscal pressure in absolute values and the right panel shows the change as a percentage of the initial transfer. The red circles correspond to a scenario where all countries face the same increase in fiscal pressure of 5% and the blue squares correspond to a scenario where the Frisch elasticity of labor supply takes a value of $\varepsilon = 0.54$ (Chetty et al., 2011). See Section 3.5 for a discussion of the latter.

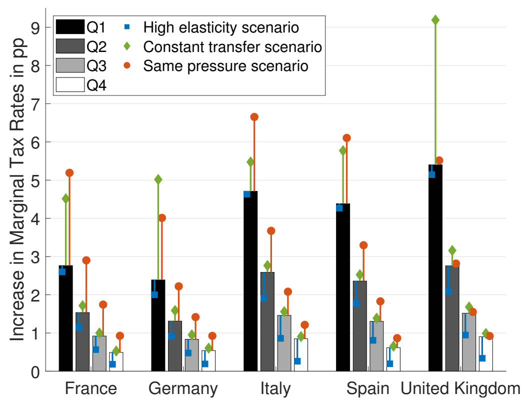
Figure 3.2 shows how much the lump-sum elements should change. The relative decrease of the lump-sum elements in Figure 3.2b mirrors the increase in fiscal pressure: in percentage terms, the lump-sum element decreases more strongly in countries with a higher increase in fiscal pressure. Italy is an exception. This is a consequence of the lower baseline value of the lump-sum transfer in Italy. The red circles in Figure 3.2 show our results for the case of harmonized fiscal pressure. There we find that the relative decrease of the lump-sum transfer is very similar across the countries. Italy is again a slight outlier: the relative decrease in the lump-sum element is larger, which reflects again the low baseline value of the lump-sum transfer.

3.4.2 Adjustment of Marginal Tax Rates

The increase in marginal tax rates is illustrated in Figure 3.3. In the left panel, we can see that the increase in marginal tax rates follows a U-shape pattern with high increases at low incomes. The tax rate changes are significant. For instance, for the lowest income quartile in the UK, the marginal tax rate increases from 29% to 35%. The increase for the top quartile is much smaller. In the right panel, we illustrate the average increases for different quartiles of the income distribution. Here, the U-shape cannot be seen since the increasing part of the U is already in the top quartile for all countries.



(a) Increase in Marginal Tax Rates as a Function of Income



(b) Increase in Marginal Tax Rates

Figure 3.3: Increase in Marginal Tax Rates for 5-Year Repayment Scenario

Notes: The left panel shows the change in the optimal marginal tax rates in percentage points due to fiscal pressure up to an income level of €400,000. The right panel shows the average change in the optimal marginal tax rates in percentage points for all quartiles of the income distribution. The red circles correspond to a scenario where all countries face the same increase in fiscal pressure of 5%, the blue squares correspond to a scenario where the Frisch elasticity of labor supply takes a value of $\varepsilon = 0.54$ (Chetty et al., 2011) and the green diamonds correspond to a situation where lump-sum transfers remain constant. See Section 3.5 for a discussion of the latter two.

To understand the intuition behind the result, recall the discussion in Section 3.2.2: lower lump-sum payments increase the marginal value from redistribution and hence, optimal marginal tax rates increase. Further, the additional leeway for increasing marginal tax rates differs along the income distribution. In Figure 3.4, we illustrate the Laffer bounds for marginal tax rates as defined in Section 3.2.3. The Laffer bounds have the typical U-shape which reflects well-understood properties of income distributions (Saez, 2001). The leeway to further increase marginal tax rates is then given by the difference in the Laffer values of marginal tax rates and the current marginal tax rates. This explains the U-shape of the increase in marginal tax rates.

Another way of interpreting this regressive increase is through the lens of the social objective. An increase in revenue requirement decreases consumption of all individuals.

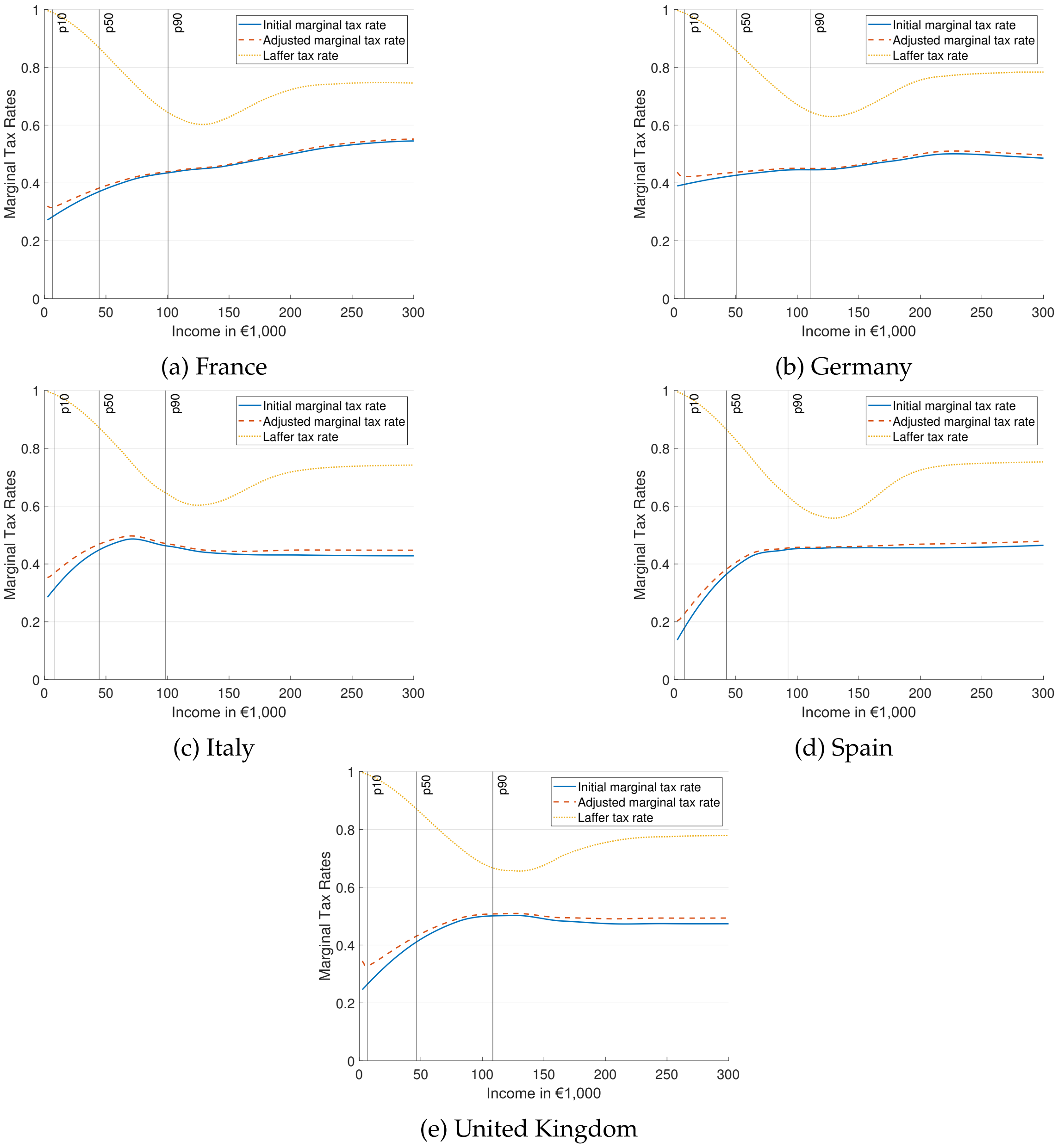


Figure 3.4: Laffer Bounds and Current Tax Schedules

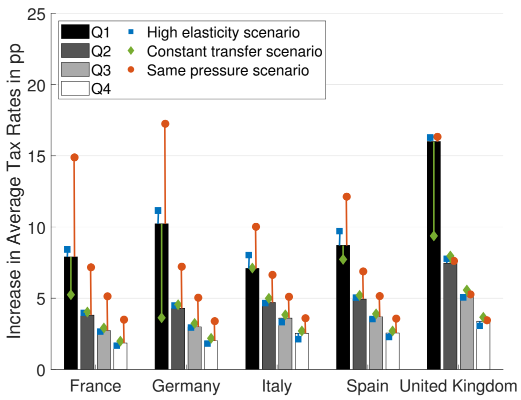
Notes: The yellow dotted curves illustrate the Laffer bounds as defined in (3.3). The blue bold curves illustrate the current schedule of marginal tax rates calibrated by a second-order local weighted regression (LOESS) with a constant extrapolation based on a EUROMOD simulation of effective marginal tax rates and the red curves illustrate the fiscal pressure adjusted optimal marginal tax rates. See Section 3.3 for a detailed explanation of the tax system calibration.

In particular, it increases the share of low-income individuals to high-income individuals. Since we have a weighted utilitarian welfare function with type-specific weights, this means that the relative social weights of low incomes will increase. Effectively, the social objective will get closer to a Rawlsian objective with higher welfare weight for low incomes.

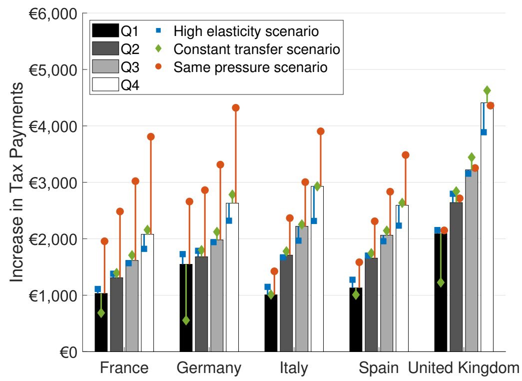
As Saez (2001) shows, the optimal marginal tax rates should be more regressive for a Rawlsian welfare objective than a utilitarian welfare objective.

Despite these similarities, there are some differences between the countries. For example, the U-shape is much more pronounced for the UK and Spain. This can be well understood by the fact that baseline marginal tax rates for low incomes are lower in these countries (see Figure 3.4). Once we harmonize fiscal pressure, our results are very similar again, see the yellow circles in Figure 3.3b. The increase in marginal tax rates is regressive and marginal tax rates for the lowest quartile increase by 4-7 percentage points whereas they only increase by about 1 percentage point or less for the highest quartile.

3.4.3 Adjustment of Average Tax Rates and Tax Payments



(a) Average Tax Rates



(b) Absolute Tax Payments

Figure 3.5: Increase in Average Tax Rates and Absolute Tax Payments for 5-Year Payback Scenario

Notes: The left panel shows the average change in the optimal average tax rates in percentage points due to fiscal pressure for all quartiles of the income distribution and the right panel shows the change in the absolute tax payments. The red circles correspond to a scenario where all countries face the same increase in fiscal pressure by 5%, the blue squares correspond to a scenario where the Frisch elasticity of labor supply takes a value of $\varepsilon = 0.54$ (Chetty et al., 2011) and the green diamonds correspond to a situation where lump-sum transfers remain constant. See Section 3.5 for a discussion of the latter two.

Combining the changes in the lump-sum transfers and the marginal tax rates, we can also calculate the implied change in average tax rates. Figure 3.5a shows the implied change in average tax rates. The decrease in the lump-sum transfers and the regressive increase in marginal tax rates both imply a regressive increase in average tax rates. For the 5-year payback scenario that we consider here, the increases are substantial and up to 16 percentage points, whereas it is only 3 percentage points for the highest quartile.[14] Considering the normalized fiscal pressure scenario, we see that average taxes for the lowest

[14]It should be kept in mind that average tax rates are predominantly negative for low incomes due to received lump-sum transfers. For example, the average tax rate for the lowest income quartile in the UK increases from -144% to -128% as a result of the decrease in lump-sum transfers. For lower incomes, the increase in average tax rates is much smaller if governments are not allowed to change lump-sum transfers.

quartile increase 2-5 times as much as average taxes for the highest quartile. The increase in average tax rates is more regressive in France, Germany, and the UK as compared to Italy and Spain. The reason is that lump-sum elements are lower in the latter two countries and therefore the absolute adjustments are smaller.

Figure 3.5b shows how this translates into an increase in absolute tax payments. The additional tax burden increases in income even though the increase in average tax rates is stronger for lower incomes. The top quartile has to pay around twice as much as the bottom quartile.

3.5 Robustness

Now, we explore the sensitivity of our results to alternative specifications of the model.

3.5.1 Constant Lump-Sum Transfers

So far, governments could respond to fiscal pressure along two margins. First, by adjusting the lump-sum transfer and second, by adjusting marginal tax rates. Now, we consider a scenario where governments can only modify marginal tax rates. Such a setting corresponds to situations where constitutional or political restrictions do not allow for changing lump-sum transfers. For example, countries are compelled to guarantee a minimum subsistence level.

In Figures 3.3b and 3.5 the green diamonds show the changes in optimal marginal tax rates, average tax rates, and absolute tax payments triggered by fiscal pressure. With only one adjustment margin, the change in marginal tax rates is larger and more regressive compared to the baseline setting with two adjustment margins. However, the increase in average taxes and the amount of paid taxes is more progressive as compared to the case with variable lump-sum elements.

3.5.2 Elasticity

Now, we increase the Frisch elasticity of labor supply to $\varepsilon = 0.54$ following Chetty et al. (2011). Note that with a higher elasticity, the increase in labor supply induced by income effects is also larger. The blue squares in Figures 3.2, 3.3b and 3.5 show the change in the lump-sum transfer, marginal tax rates, average tax rates, and absolute tax payments triggered by fiscal pressure. Optimal lump-sum transfers are decreased by a larger extent compared to the baseline simulation. Further, governments should increase optimal marginal tax rates to a smaller extent. Taken together, this implies that the increase in

Otherwise, the average tax rate for the highest income quartile increases only from 27% to 30%. This change is not significantly affected by the assumption of a fixed lump-sum transfer.

marginal, average, and absolute taxes is more regressive than in the benchmark scenario with a lower elasticity.

3.5.3 Wealth Distribution Shocks

Angelopoulos et al. (2021) show that COVID-19 led to an uneven change in the wealth distribution in the UK. In particular, individuals with an income above the median experienced a persistent increase in wealth, while individuals with an income below the median experienced a persistent decrease in wealth. Now, we integrate the increase in wealth inequality into our analysis.

To calibrate the level of net wealth across the income distribution, we use data on the average net wealth for six points of the income distribution from the 2017 Household Finance and Consumption Survey together with a shape-preserving piecewise cubic interpolation. This gives us country-specific distributions of wealth conditional on income.[15] Figure C.5 in Appendix C.3 shows the calibrated average net wealth levels across the income distribution. To get an approximation for the change in the wealth distribution induced by COVID-19, we use the simulation results of the dynamic evaluation of the wealth distribution for the UK from Angelopoulos et al. (2021).[16] To the best of our knowledge, there exists no detailed evidence for France, Germany, Italy, and Spain. Thus, we assume that the change in the wealth distribution in these countries is the same as in the UK. Figure C.6 in Appendix C.3 shows the expected percentage change in wealth in 2023 induced by the outbreak of COVID-19.

Given that we consider a static model, it is not obvious how to incorporate the changes in wealth inequality in our analysis. Our approach is to assume that individuals either save a part of their income to restore their wealth before the pandemic or consume the extra wealth that is accumulated during the pandemic. To be consistent with our assumption regarding the fiscal pressure, we assume that this saving or dissaving process also takes 5 years. In essence, the inclusion of the wealth shock implies an increase in consumption inequality. This is because lower-income households are negatively affected by the wealth shock and have to save a part of their income to restore their wealth, whereas higher-income households are able to consume more thanks to their positive wealth shock.

To focus on the implied increase in consumption inequality, we consider a utility specification without income effects for this robustness exercise.[17] As in the main specification in Section 3.3, we then calibrate the skill distributions using EUROMOD data and calculate

[15]See Table C.1 in Appendix C.3 for the mean net wealth across the income distribution taken from the 2017 Household Finance and Consumption Survey. To ensure that the interpolation does not lead to negative wealth values, we set the average net wealth of the lowest income to zero in Germany. Unfortunately, the Household Finance and Consumption Survey contains does not contain data for the UK. Thus, we use the average of the Euro area countries for the UK.

[16]In particular, we use the results shown in Figure 4 in Angelopoulos et al. (2021) for the year 2023.

[17]To shut down income effects, we cannot simply use the utility specification that we use in Section 3.2.1, because we want to preserve the decreasing marginal utility of consumption and the endogeneity of welfare

the inverse-optimum Pareto weights. Then, to model the effects of COVID-19, we add the wealth shocks together with the fiscal pressure shock that is also present in our baseline analysis.

Figure C.7 in Appendix C.3 shows how lump-sum transfers and optimal marginal tax rates adjust if one takes into account the increase in wealth inequality. The fact that lower-income households are affected negatively by the wealth shock limits governments' ability to conduct a regressive tax reform to finance the extra debt caused by COVID-19. This results in smaller decreases in transfers and less regressive increases in marginal tax rates. As a result, tax payments of higher income households increase more compared to our baseline scenario.

3.5.4 Further Robustness

We document various further robustness checks in Appendix C.4 and show that the main message barely changes.

Utility Function. First, we increase the risk-aversion of individuals by setting $\gamma = 1.5$. Second, we consider a different utility function with the following form $u(c,l) = \left(\frac{c^{1-\gamma}}{1-\gamma} - \frac{l^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}}\right)^{\xi}$, where ξ describes the overall concavity of the utility function. This parameter alters the risk aversion of individuals but does not affect their labor supply behavior. Another way to interpret the same parameter is through the overall welfare. Instead of thinking ξ as a parameter of individual utility, we can think of it as a parameter of social welfare. For example, $\xi = 1$ corresponds to weighted utilitarian welfare, and decreasing ξ puts more relative weight on lower incomes. We can slightly relax our assumption of linear welfare function with type-specific weights by applying a non-linear transformation to individual utilities. We try $\xi = 0.5$ and $\xi = 2$. For both alternative specifications, our main results are very similar. Fiscal pressure leads now to a slightly smaller decrease in lump-sum transfers and a slightly larger change in optimal marginal tax rates in the first case and in the second case with higher ξ, and vice versa with lower ξ.

Initial Lump-Sum Transfer. Instead of matching the initial lump-sum transfer to the average minimum income protection in each country, we assume that the lump-sum transfer takes a value of €10,000 in all countries. Now, an increase in fiscal pressure leads to a similar proportional adjustment of lump-sum transfers across countries.

Mass of People with Zero Earnings. Instead of calibrating the mass of people with zero earnings to match the country-specific shares of disability benefit recipients, we assume

weights. Therefore, we use the utility specification from Section 3.2.2 with the following functional form, $u(c,l) = \log\left(c - \frac{l^{1+\frac{1}{\varepsilon}}}{1+\frac{1}{\varepsilon}}\right)$, where $\varepsilon = 0.2$.

that in each country 5% of the population always earns an income with zero earnings. Our results are not sensitive to this assumption.

3.6 Conclusion

This paper investigates how an increase in the tax revenue requirement due to COVID-19 affects the optimal progressivity of the income tax system for five European countries. We apply an inverse-optimum approach and find that optimal progressivity declines. There is a trade-off between the objectives of raising revenue and redistributing through the tax system by making it more progressive. This suggests that governments may face difficult choices when it comes to financing the burden of the additional debt incurred as a result of the COVID-19 pandemic. To what extent the policy implications will be amplified by the ongoing war in Ukraine is still unclear because the size of the additional burden is uncertain at the moment.

Our approach was welfarist and based on the inverse-optimum approach. Alternative approaches would, for example, be to follow an equal-sacrifice approach (Weinzierl, 2014) or fairness approaches (Fleurbaey and Maniquet, 2006).

Of course, our analysis has focused on the income tax only. In the debate on who bears the cost of the crisis, other taxes also play a role, in particular wealth taxes, inheritance taxes, and taxes paid by multinational firms. Whether it is optimal to increase income taxes or make wealth and inheritance taxes more progressive is beyond the analysis in this paper.

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Appendix A

Appendix to Chapter 1

A.1 Solution to the Government's Problem

Recall the government's welfare maximization problem in the simple model with two households using the mechanism-design approach. The problem is spelled out in (1.10). The Lagrange function for this optimization problem is given by

$$
\begin{aligned}
\mathcal{L}(y^i, c_1^i, c_2^i, a_U^i; \lambda, \mu) = & \sum_{i=l,h} \tilde{f}^i U_i(y^i, c_1^i, c_2^i, a_U^i) \\
& + \lambda \left[\sum_{i=l,h} f^i \left(y^i - c_1^i - \frac{c_2^i}{1+r} - \frac{r a_U^i}{1+r} \right) \right] \\
& + \mu \left[U_h(y^h, c_1^h, c_2^h, a_U^h) - U_h(y^l, c_1^l, c_2^l, a_U^l) \right] \qquad \text{(A.1)}
\end{aligned}
$$

Eight first-order conditions need to hold at the optimum. They are with respect to labor income, first-period consumption, second-period consumption, and the utility asset for both households with high and low labor productivity. The conditions are given by

$$
y^h: \quad -\tilde{f}^h v' \left(\frac{y^h}{\theta_h} \right) \frac{1}{\theta_h} + \lambda f^h - \mu v' \left(\frac{y^h}{\theta_h} \right) \frac{1}{\theta_h} = 0 \qquad \text{(A.2a)}
$$

$$
c_1^h: \quad \tilde{f}^h u'(c_1^h) - \lambda f^h + \mu u'(c_1^h) = 0 \qquad \text{(A.2b)}
$$

$$
c_2^h: \quad \tilde{f}^h \beta_h u'(c_2^h) - \lambda f^h \frac{1}{1+r} + \mu \beta^h u'(c_2^h) = 0 \qquad \text{(A.2c)}
$$

$$
a_U^h: \quad \tilde{f}^h \phi_h'(a_U^h) - \lambda f^h \frac{r}{1+r} + \mu \phi_h'(a_U^h) = 0 \qquad \text{(A.2d)}
$$

$$
y^l: \quad -\tilde{f}^l v' \left(\frac{y^l}{\theta_l} \right) \frac{1}{\theta_l} + \lambda f^l + \mu v' \left(\frac{y^h}{\theta_l} \right) \frac{1}{\theta_l} = 0 \qquad \text{(A.2e)}
$$

$$
c_1^l: \quad \tilde{f}^l u'(c_1^l) - \lambda f^l - \mu u'(c_1^l) = 0 \qquad \text{(A.2f)}
$$

$$
c_2^l: \quad \tilde{f}^l \beta_l u'(c_2^l) - \lambda f^l \frac{1}{1+r} - \mu \beta_h u'(c_2^l) = 0 \qquad \text{(A.2g)}
$$

$$a_U^l: \quad \tilde{f}^l \phi_l'(a_U^l) - \lambda f^l \frac{r}{1+r} - \mu \phi_h'(a_U^l) = 0 \tag{A.2h}$$

Tackle the allocation for the household with high productivity. First, divide the first-order conditions for y^h by the one for c_1^h to solve for the income wedge.

$$\begin{aligned}
\frac{(\tilde{f}^h + \mu) v'\left(\frac{y^h}{\theta_h}\right)\frac{1}{\theta_h}}{(\tilde{f}^h + \mu) u'(c_1^h)} &= \frac{\lambda f^h}{\lambda f^h} \\
\frac{v'\left(\frac{y^h}{\theta_h}\right)\frac{1}{\theta_h}}{u'(c_1^h)} &= 1 \\
\implies t_y^h &= 0
\end{aligned} \tag{A.3}$$

Second, subtract the first-order condition for a_U^h from the one for c_1^h, then divide by the one for c_2^h to solve for the wealth wedge.

$$\begin{aligned}
\frac{(\tilde{f}^h + \mu)(u'(c_1^h) - \phi_h'(a_U^h))}{(\tilde{f}^h + \mu)\beta_h u'(c_2^h)} &= \frac{\lambda f^h \left(1 - \frac{r}{1+r}\right)}{\lambda f^h \frac{1}{1+r}} \\
\frac{u'(c_1^h) - \phi_h'(a_U^h)}{\beta_h u'(c_2^h)} &= 1 \\
\implies t_w^h &= 0
\end{aligned} \tag{A.4}$$

Third, divide the first order condition for c_1^h by the one for a_U^h to solve for the capital income wedge.

$$\begin{aligned}
\frac{(\tilde{f}^h + \mu) u'(c_1^h)}{(\tilde{f}^h + \mu)\phi_h'(a_U^h)} &= \frac{\lambda f^h}{\lambda f^h \frac{r}{1+r}} \\
\frac{u'(c_1^h)}{\phi_h'(a_U^h)} &= \frac{1+r}{r} \\
\frac{1}{r}\frac{\phi_h'(a_U^h)}{u'(c_1^h) - \phi_h'(a_U^h)} &= 1 \\
\implies t_k^h &= 0
\end{aligned} \tag{A.5}$$

Now, tackle the allocation for the household with low productivity. To do so, take the first order condition for c_1^l and rearrange using the definition of the marginal social welfare weight g^l.

$$
\begin{aligned}
\tilde{f}^l u_1'^l - \lambda f^l - \mu u_1'^l &= 0 \\
\frac{u_1'^l}{\lambda}\frac{\tilde{f}^l}{f^l} - 1 - \frac{\mu u_1'^l}{\lambda f^l} &= 0 \\
\implies g^l &= \frac{\tilde{f}^l}{\tilde{f}^l - \mu}
\end{aligned}
\tag{A.6}
$$

First, divide the first-order conditions for y^l by the one for c_1^l to solve for the income wedge.

$$
\begin{aligned}
\frac{(\tilde{f}^l - \mu)v'\left(\frac{y^l}{\theta_l}\right)\frac{1}{\theta_l} + \mu\left(v'\left(\frac{y^l}{\theta_l}\right)\frac{1}{\theta_l} - v'\left(\frac{y^l}{\theta_h}\right)\frac{1}{\theta_h}\right)}{(\tilde{f}^l - \mu)u'(c_1^l)} &= \frac{\lambda f^l}{\lambda f^l} \\
\frac{\mu}{\tilde{f}^l - \mu}\frac{\left(v'\left(\frac{y^l}{\theta_l}\right)\frac{1}{\theta_l} - v'\left(\frac{y^l}{\theta_h}\right)\frac{1}{\theta_h}\right)}{u'(c_1^l)} &= 1 - \frac{v'\left(\frac{y^l}{\theta_l}\right)\frac{1}{\theta_l}}{u'(c_1^l)} \\
\implies t_y^l = (g^l - 1)\frac{\left(v'\left(\frac{y^l}{\theta_l}\right)\frac{1}{\theta_l} - v'\left(\frac{y^l}{\theta_h}\right)\frac{1}{\theta_h}\right)}{u'(c_1^l)}
\end{aligned}
\tag{A.7}
$$

Second, subtract the first-order condition for a_U^l from the one for c_1^l, then divide by the one for c_2^l to solve for the wealth wedge.

$$
\begin{aligned}
\frac{(\tilde{f}^l - \mu)(u'(c_1^l) - \phi_l'(a_U^l)) + \mu(\phi_h'(a_U^l) - \phi_l'(a_U^l))}{(\tilde{f}^l - \mu)\beta_l u'(c_2^l) - \mu(\beta_h - \beta_l)u'(c_2^l)} &= \frac{\lambda f^l\left(1 - \frac{r}{1+r}\right)}{\lambda f^l \frac{1}{1+r}} \\
(u'(c_1^l) - \phi_l'(a_U^l)) = \beta_l u'(c_2^l) - \frac{\mu}{\tilde{f}^l - \mu}&\left[(\beta_h - \beta_l)u'(c_2^l) + (\phi_h'(a_U^l) - \phi_l'(a_U^l))\right] \\
\frac{(u'(c_1^l) - \phi_l'(a_U^l))}{\beta_l u'(c_2^l)} &= 1 - \frac{\mu}{\tilde{f}^l - \mu}\left(\frac{\beta_h - \beta_l}{\beta_l} + \frac{\phi_h'(a_U^l) - \phi_l'(a_U^l)}{\beta_l u'(c_2^l)}\right) \\
\frac{\mu}{\tilde{f}^l - \mu}\left(\frac{\beta_h - \beta_l}{\beta_l} + \frac{\phi_h'(a_U^l) - \phi_l'(a_U^l)}{\beta_l u'(c_2^l)}\right) &= 1 - \frac{(u'(c_1^l) - \phi_l'(a_U^l))}{\beta_l u'(c_2^l)} \\
\implies t_w^l = (g^l - 1)&\left(\frac{\beta_h - \beta_l}{\beta_l} + \frac{\phi_h'(a_U^l) - \phi_l'(a_U^l)}{\beta_l u'(c_2^l)}\right)
\end{aligned}
\tag{A.8}
$$

Third, divide the first-order condition for c_1^l by the one for a_U^l to solve for the capital income wedge.

$$\frac{(\tilde{f}^l-\mu)\phi_l'(a_U^l)-\mu(\phi_h'(a_U^l)-\phi_l'(a_U^l))}{(\tilde{f}^l-\mu)u'(c_1^l)}=\frac{\lambda f^l\frac{r}{1+r}}{\lambda f^l}$$
$$(1+r)\left[(\tilde{f}^l-\mu)\phi_l'(a_U^l)-\mu(\phi_h'(a_U^l)-\phi_l'(a_U^l))\right]=r(\tilde{f}^l-\mu)u'(c_1^l)$$
$$(\tilde{f}^l-\mu)\phi_l'(a_U^l)-(1+r)\mu(\phi_h'(a_U^l)-\phi_l'(a_U^l))=r(\tilde{f}^l-\mu)(u'(c_1^l)-\phi_l'(a_U^l))$$
$$\frac{1}{r}\frac{(\tilde{f}^l-\mu)\phi_l'(a_U^l)}{(\tilde{f}^l-\mu)(u'(c_1^l)-\phi_l'(a_U^l))}=1+\frac{1+r}{r}\frac{\mu(\phi_h'(a_U^l)-\phi_l'(a_U^l))}{(\tilde{f}^l-\mu)(u'(c_1^l)-\phi_l'(a_U^l))}$$
$$-\frac{\mu}{\tilde{f}^l-\mu}\frac{1+r}{r}\frac{\phi_h'(a_U^l)-\phi_l'(a_U^l)}{u'(c_1^l)-\phi_l'(a_U^l)}=1-\frac{1}{r}\frac{\phi_l'(a_U^l)}{u'(c_1^l)-\phi_l'(a_U^l)}$$
$$\implies t_k^l=-(g^l-1)\frac{1+r}{r}\frac{\phi_h'(a_U^l)-\phi_l'(a_U^l)}{u'(c_1^l)-\phi_l'(a_U^l)} \tag{A.9}$$

A.2 Lifecycle Pattern of Assets

The simplified version of the household utility maximization problem, as presented in Section 1.3, assumes that households receive a fixed labor income annually throughout their working life. Moreover, each year, they allocate the same amount and proportion of their income towards the return asset and the utility asset. Considering that their savings in asset i yield a gross after-tax return of $\overline{R}_i$, the amount of asset i owned by a household at the end of year t during their working life is given by

$$a_{i,t}=\overline{R}_i a_{i,t-1}+\delta_i a_{i,T_w}, \qquad t\in[1,T_w] \tag{A.10}$$

where a_{i,T_w} is the amount of savings in asset i at the time of retirement. δ_i measures how much the consumption during working life needs to decrease to increase a_{i,T_w} by one unit.

Using backward induction for Equation (A.10) for each year from year 1 up to year t, and leveraging the initial condition $a_{i,0}=0$, we derive

$$a_{i,t}=\delta_i a_{i,T_w}\cdot\sum_{0=1}^{t-1}(\overline{R}_i)^k \tag{A.11}$$

Setting $t=T_w$ allows us to calculate δ_i.

$$-\frac{\partial c_1}{\partial a_{i,T_w}}=\delta_i=\frac{1}{\sum_{t=0}^{T_w-1}(\overline{R}_i)^t} \tag{A.12}$$

Once the value of δ_i is determined given on $\overline{R}_i$, we can calculate the amount of asset i a household will own at the time of their retirement using Equation (A.10). During working life, the ratio of asset i holdings at period t to the retirement amount is given by

$$\frac{a_{i,t}}{a_{i,T_w}} = \frac{\sum_{k=0}^{t-1}(\overline{R}_i)^k}{\sum_{t=0}^{T_w-1}(\overline{R}_i)^t} \tag{A.13}$$

After their retirement, households start to withdraw from their savings to fund their retirement consumption. However, their remaining savings at the end of each year continue to yield a financial return. The amount of asset i owned by a household at the end of year t during their working life is given by

$$a_{i,t} = \overline{R}_i a_{i,t-1} - \sigma_i a_{i,T_w}, \qquad t \in [T_w + 1, T_w + T_r] \tag{A.14}$$

σ_i measures how much the increase in consumption during retirement when a_{i,T_w} increases by one unit.

Once again, using backward induction, this time for Equation (A.14) for each year from year T_w for t years up to year $t + T_w$ yields

$$a_{i,t+T_w} = a_{i,T_w}(\overline{R}_i)^t - \sigma_i a_{i,T_w} \sum_{k=1}^{t-1}(\overline{R}_i)^k \tag{A.15}$$

Setting $t = T_r$ and leveraging the asset depletion condition $a_{i,T_w+T_r} = 0$ allows us to calculate σ_i.

$$\frac{\partial c_2}{\partial a_{i,T_w}} = \sigma_i = \frac{(\overline{R}_i)^{T_r}}{\sum_{k=0}^{T_r-1}(\overline{R}_i)^k} \tag{A.16}$$

During retirement, the ratio of asset i holdings at year $t + T_w$ to the retirement amount is given by

$$\frac{a_{i,t+T_w}}{a_{i,T_w}} = \frac{\sum_{k=t}^{T_r-1}(\overline{R}_i)^k}{\sum_{k=0}^{T_r-1}(\overline{R}_i)^k} \tag{A.17}$$

Figure A.1 summarizes the life cycle pattern of both the return asset and the utility asset, employing Equations (A.11) and (A.15).

Additionally, we can also calculate the implied inter-period between working life and retirement.

$$-\frac{\partial c_2}{\partial c_1} = \frac{\sigma_i}{\delta_i} = (\overline{R}_i)^{T_r} \cdot \frac{\sum_{t=0}^{T_w-1}(\overline{R}_i)^t}{\sum_{t=0}^{T_r-1}(\overline{R}_i)^t} \tag{A.18}$$

The ratio $\frac{\sigma_i}{\delta_i}$ measures the increase in retirement consumption when households reduce their working life consumption by one unit and allocate those savings to asset i. The inter-period gross interest rate for the return asset is calibrated to be 26.78, while that for the utility asset is 10.42. It's important to note that these gross return rates reflect financial yields over an extended period and also consider the fact that retirement is shorter than

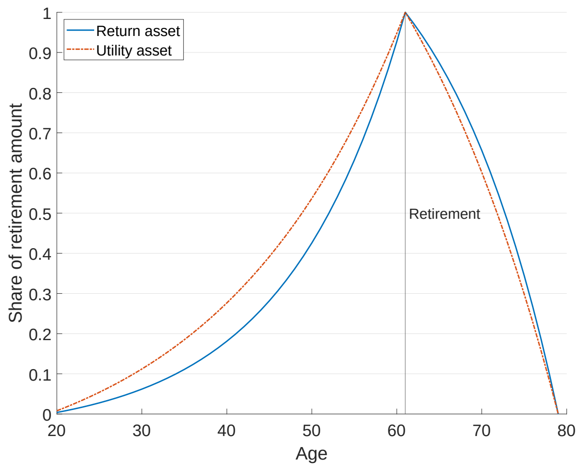


Figure A.1: Lifecycle Pattern of Assets

Notes: The figure illustrates the life cycle pattern of the return and utility assets as a ratio of their value at households' retirement. The blue line shows the evolution of the return asset, and the red line shows the evolution of the utility asset. For this figure, the calibrated values of tax and interest rates are utilized. The annual interest of the return asset is 9.31% and the annual interest of the utility asset 5.35%. The capital income tax rate is given by 20%, whereas the wealth tax rate is 0%.

working life. Therefore, even without any annual returns, a household can increase their retirement consumption by $\frac{T_w}{T_r} > 1$ units by reducing their working life consumption by one unit.

A.2.1 Lifetime Discount Rate of the Utility Asset

The lifetime utility of wealth can be expressed as the discounted sum of the annual utility of wealth at the end of each period.

$$\phi_i^{LT} = \sum_{t=1}^{T_w} \beta_i^t \phi_i\left(a_{U,t}\right) + \sum_{t=T_w+1}^{T_w+T_r-1} \beta_i^t \phi\left(a_{U,t}\right) \tag{A.19}$$

The utility of wealth is assumed to exhibit CRRA property, given by

$$\phi_i(a_{U,t}) = \xi_i \frac{a_{U,t}^{1-\mu} - 1}{1-\mu}$$

Using this functional form assumption, we can calculate the utility of wealth for any fraction k of the utility asset at retirement.

$$\begin{aligned}
\phi_i(k \cdot a_{U,T_w}) &= \xi_i \frac{(k \cdot a_{U,T_w})^{1-\mu} - 1}{1-\mu} \\
&= k^{1-\mu} \cdot \xi_i \frac{a_{U,T_w}^{1-\mu} - 1}{1-\mu} + \frac{k^{1-\mu} - 1}{1-\mu} \\
&= k^{1-\mu} \cdot \phi_i(a_{U,T_w}) + \phi(k) \qquad \text{(A.20)}
\end{aligned}$$

Setting $k = \frac{a_{U,t}}{a_{U,T_w}}$ allows us to calculate the utility of wealth at any given period in terms of the utility of wealth at retirement.

$$\phi(a_{U,t}) = \left(\frac{a_{U,t}}{a_{U,T_w}}\right)^{1-\mu} \phi(a_U) + \phi\left(\frac{a_{U,t}}{a_{U,T_w}}\right)$$

Then, the lifetime utility of wealth reads as

$$\begin{aligned}
\phi_i^{LT} = & \underbrace{\left(\sum_{t=1}^{T_w} \beta_i^t \left(\frac{a_{U,t}}{a_{U,T_w}}\right)^{1-\mu} + \sum_{t=T_w+1}^{T_w+T_r-1} \beta_i^t \left(\frac{a_{U,t}}{a_{U,T_w}}\right)^{1-\mu}\right)}_{\equiv \beta_i^{\phi}} \cdot \phi_i\left(a_{U,T_w}\right) + \\
& \underbrace{\left(\sum_{t=1}^{T_w} \beta_i^t \phi_i \left(\frac{a_{U,t}}{a_{U,T_w}}\right)^{1-\mu} + \sum_{t=T_w+1}^{T_w+T_r-1} \beta_i^t \phi_i \left(\frac{a_{U,t}}{a_{U,T_w}}\right)^{1-\mu}\right)}_{\equiv \phi_i^C} \qquad \text{(A.21)}
\end{aligned}$$

Equation (A.13) provides information about the ratio $\frac{a_{U,t}}{a_{U,T_w}}$ for working life, while Equation (A.17) does the same for retirement.

A.3 Individual Optimization Algorithm

Consider the following constrained utility maximization problem

$$\begin{aligned}
\max_{c_1, c_2, y, a_U, a_R} \quad & U(c_1, c_2, y, a_U, a_R) \\
\text{s. t.} \quad & c_1 = y - a_U - a_R \qquad \text{(A.22)} \\
& c_2 = a_U + a_R R
\end{aligned}$$

where c_1 and c_2 represent the first and the second period consumption, y represents the labor income, a_U represents the utility asset, and a_R represents the return asset.

This problem is constructed without taxes to keep the expressions simpler; however, the following arguments can be also made for a maximization problem including income and capital taxes as long as there is no cross-dependency between any two taxes.

The Lagrange function of this optimization problem is given by

$$\mathcal{L} = U(c_1, c_2, y, a_U, a_R) - \lambda_1(y - c_1 - a_U - a_R) - \lambda_2(a_U + a_R - c_2). \tag{A.23}$$

First-order conditions for five choice variables and two Lagrange coefficients are given by

$$c_1 : \quad U'_{c_1} + \lambda_1 = 0 \tag{A.24a}$$
$$c_2 : \quad U'_{c_2} + \lambda_2 = 0 \tag{A.24b}$$
$$y : \quad U'_y - \lambda_1 = 0 \tag{A.24c}$$
$$a_U : \quad U'_{a_U} + \lambda_1 - \lambda_2 = 0 \tag{A.24d}$$
$$a_R : \quad U'_{a_R} + \lambda_1 - \lambda_2 R = 0 \tag{A.24e}$$
$$\lambda_1 : \quad y = c_1 + a_U + a_R \tag{A.24f}$$
$$\lambda_2 : \quad a_U + a_R R = c_2. \tag{A.24g}$$

where $U'_k = \frac{\partial U}{\partial k}$ is the partial derivative of lifetime utility with respect to k.

A set of choice variables and Lagrange coefficients that satisfy the seven first-order conditions above yields the utility-maximizing and feasible individual choice.

Combining Equations (A.24a) and (A.24c) gives us the optimality condition that governs the choice between the first-period consumption and the labor income.

$$U'_y = -U'_{c_1} \tag{A.25}$$

On the other hand, combining Equations (A.24a), (A.24b), and (A.24e), and making use of the fact that a_R does not affect individual utility ($U'_{a_R} = 0$), we can deduce the optimality condition that governs the choice between the first and the second-period consumption.

$$U'_{c_2} = U'_{c_1} \frac{1}{R} \tag{A.26}$$

Similarly, combining Equations (A.24a), (A.24d), and (A.24e) yields the following condition.

$$U'_{a_U} = U'_{c_1} \frac{R-1}{R} \tag{A.27}$$

If we assume the utility function is weakly separable, that is, the partial derivative of a choice variable does not depend on other choice variables, then we can rewrite Equations (A.25), (A.26), and (A.27) to obtain a closed-form solution of the labor income, the second-period consumption, and the utility asset in terms of the first-period consumption.

$$y = {U'_y}^{-1}(-U'_{c_1}) \equiv \tilde{y}(c_1) \tag{A.28}$$

$$c_2 = {U'_{c_2}}^{-1}\left(U'_{c_1}\frac{1}{R}\right) \equiv \tilde{c_2}(c_1) \tag{A.29}$$

$$a_U = {U'_{a_U}}^{-1}\left(U'_{c_1}\frac{R-1}{R}\right) \equiv \tilde{a_U}(c_1) \tag{A.30}$$

The pairs on each of these closed-form solutions are consistent with the respective optimality conditions. However, they are not necessarily feasible. For example, any pair (c_1, c_2) that satisfies $c_2 = \tilde{c_2}(c_1)$ is consistent with the optimality condition between c_1 and c_2. But, no claim can be made on the *feasibility* of those pairs.

To ensure that the individual choices are feasible, we can obtain another expression for c_2 using the budget constraints. First, consider Equation (A.24f) and use the closed form solutions we found in Equations (A.28) and (A.30).

$$\begin{aligned} \tilde{y}(c_1) &= c_1 + \tilde{a_U}(c_1) + a_R \\ \implies a_R &= \tilde{y}(c_1) - c_1 - \tilde{a_U}(c_1) \equiv \hat{a_R}(c_1) \end{aligned} \tag{A.31}$$

Then, plug in Equations (A.30) and (A.31) into Equation (A.24g).

$$\tilde{a_U}(c_1) + \hat{a_R}(c_1) = c_2 \equiv \hat{c_2}(c_1) \tag{A.32}$$

Equation (A.32) gives us a set of pairs (c_1, c_2) that are consistent with the optimality conditions between c_1 and y; as well as c_1 and a_U. The fact that we used the budget constraints to obtain $\hat{c_2}(c_1)$ ensures that the choice of c_2 is feasible given the optimal choices of y and a_U.

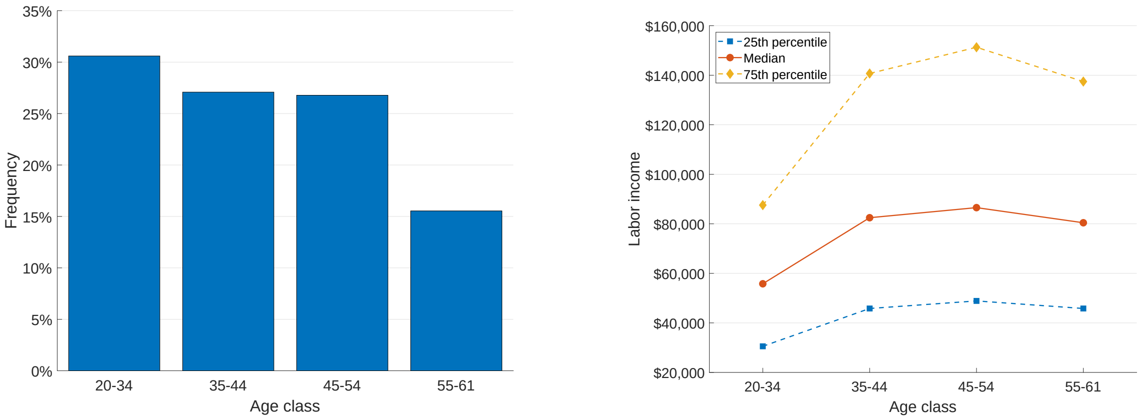
On the one hand, we have a closed-form expression of c_2 that is consistent with *the optimality condition* between c_1 and c_2 from Equation (A.29). On the other hand, we have another expression that is consistent with the optimality conditions of y and a_U, and also *feasible* according to the budget constraints from Equation (A.32). If there exists a c_1^* such that

$$\tilde{c_2}(c_1^*) = \hat{c_2}(c_1^*), \tag{A.33}$$

then the choice set $(c_1^*, \tilde{c_2}(c_1^*), \tilde{y}(c_1^*), \tilde{a_U}(c_1^*), \tilde{a_R}(c_1^*))$ solves the constrained utility maximization problem given in Equation (A.22).

A.4 Additional Figures

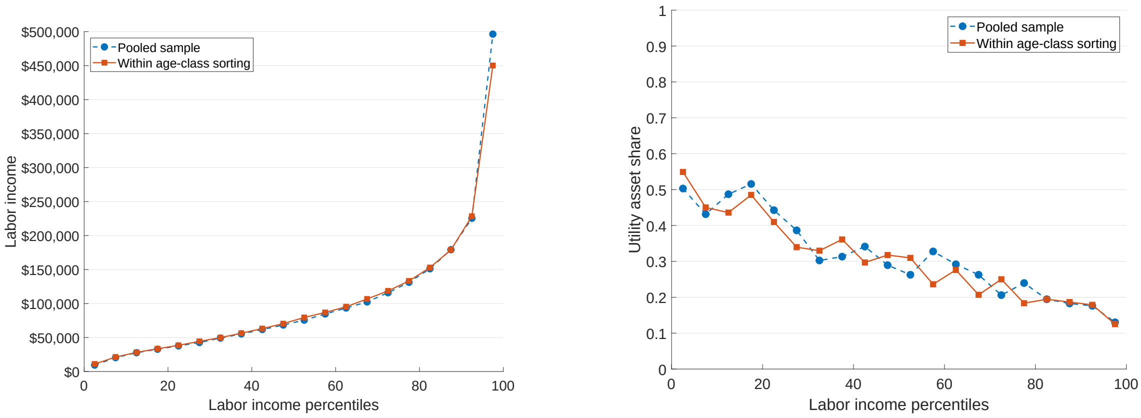
A.4.1 Within Age-Class Calibration Method



(a) Survey Weights (b) Labor Income Within Classes

Figure A.2: Age-Class Grouping

Notes: The left figure depicts the survey weights of each age class as a ratio of the total survey weights of the whole sample. The right figure illustrates the income distribution with each age class. The blue dashed line shows the 25th percentile, the red line shows the median, and the yellow dashed line shows the 75th percentile of the within-age-class labor income distribution.

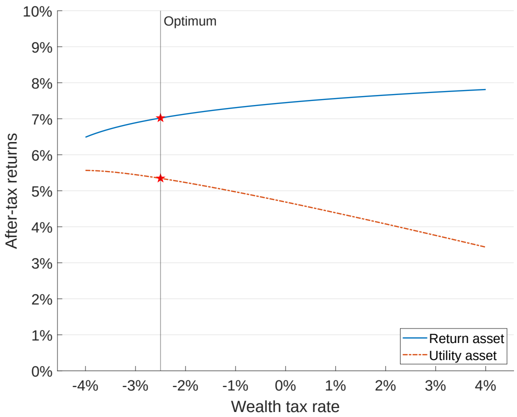


(a) Labor Income (b) Portfolio Share

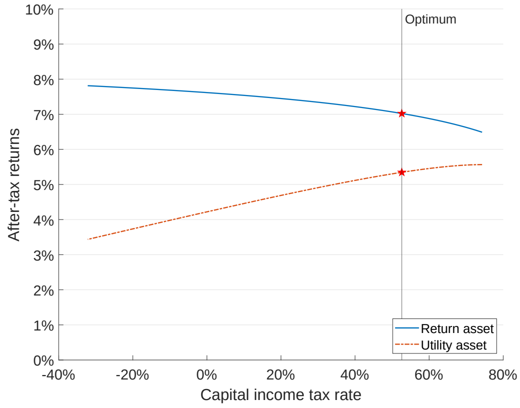
Figure A.3: Comparison of Two Methods

Notes: The figure compares the calibration results using the within-age-class sorting method and the pooled sample. The left panel depicts the calibrated labor income and the right panel depicts the calibrated utility asset share along the labor income distribution. In both panels, the blue dashed line shows the result when using the pooled sample and the red line shows the result when using the within-age-class sorting method

A.4.2 After-Tax Return of Assets



(a) Respecting Wealth Tax Rate



(b) Respecting Capital Income Tax Rate

Figure A.4: Change in After-Tax Returns

Notes: Both figures illustrate the change in after-tax returns of both the return asset and the utility asset. The left panel pertains to variations in the wealth tax rate, while the right panel pertains to variations in the capital income tax rate. In both figures, the other capital tax rate is adjusted to maintain revenue neutrality. The before-tax return of the return asset is calibrated at 9.31%, while that of the utility asset is at 5.86%. The red stars denote the after-tax returns following the optimal reform. Specifically, the optimal after-tax return of the return asset is 7.02%, and that of the utility asset is 5.35%.

A.4.3 Decomposition of Utility Change into Mechanical and Behavioral Effects

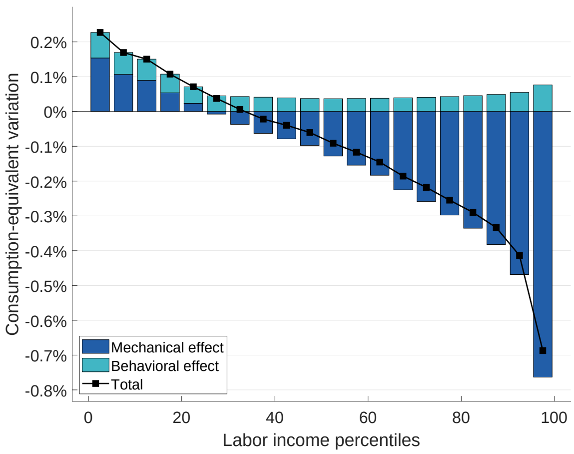


Figure A.5: Mechanical and Behavioral Changes

Notes: The figure illustrates the decomposed change in household lifetime utility after the optimal reform with respect to the baseline. The decomposition captures the mechanical effect, which is defined by the change in utility keeping households' behavior fixed, and the behavioral effect, which is defined by the change in utility due to behavioral responses. The y-axis represents the proportional consumption transfer to each household such that their lifetime utility is equal to that in the economy after the optimal reform. The black line represents the net change in households' lifetime utility.

Appendix B

Appendix to Chapter 2

B.1 Optimal State-Dependent Saving Tax Rates

Recall the optimization problem given in Equation (2.7). The Lagrangian function of this problem is given by

$$\mathcal{L} = u(c_1) + \sum_{i=h,l} p_i u(c_{2i}) + \lambda \left((p_l \tau_l + p_h \tau_h)a - G \right)$$

where λ measures the shadow price of relaxing the budget constraint by a unit exogenously. The first-order conditions are

$$\tau_l : -p_l u'_{2l} a + \lambda \left((p_l \tau_l + p_h \tau_h) \frac{\partial a}{\partial \tau_l} + p_l a \right) = 0 \tag{B.1}$$

$$\tau_h : -p_h u'_{2h} a + \lambda \left((p_l \tau_l + p_h \tau_h) \frac{\partial a}{\partial \tau_h} + p_h a \right) = 0 \tag{B.2}$$

Rearrange the first-order condition with respect to the low-state tax rate.

$$p_l \left(-\frac{u'_{2l}}{\lambda} + 1 \right) a - (p_l \tau_l + p_h \tau_h) \varepsilon_{a,1-\tau_l} \frac{a}{1-\tau_l} = 0$$

$$\frac{p_l \tau_l + p_h \tau_h}{p_l (1-\tau_l)} = \frac{1 - \frac{u'_{2l}}{\lambda}}{\varepsilon_{a,1-\tau_l}}$$

$$\implies \frac{\tau_l}{1-\tau_l} = \frac{1}{\varepsilon_{a,1-\tau_l}} \cdot \left(1 - \frac{u'(c_{2l})}{\lambda} \right) \cdot \frac{p_l}{p_l + p_h \frac{\tau_h}{\tau_l}} \tag{B.3}$$

Similarly, the first-order condition with respect to the high-state tax rate can be rearranged to obtain

$$\frac{\tau_h}{1-\tau_h} = \frac{1}{\varepsilon_{a,1-\tau_h}} \cdot \left(1 - \frac{u'(c_{2h})}{\lambda} \right) \cdot \frac{p_h}{p_l \frac{\tau_l}{\tau_h} + p_h} \tag{B.4}$$

Combining the two optimality conditions shows how the government should set these two tax rates concerning one another.

$$\frac{\frac{p_l\tau_l+p_h\tau_h}{p_l(1-\tau_l)}}{\frac{p_l\tau_l+p_h\tau_h}{p_h(1-\tau_h)}} = \frac{\varepsilon_{a,1-\tau_h}}{\varepsilon_{a,1-\tau_l}} \frac{1-\frac{u'_{2l}}{\lambda}}{1-\frac{u'_{2h}}{\lambda}}$$

$$\implies \frac{1-\frac{u'_{2h}}{\lambda}}{1-\frac{u'_{2l}}{\lambda}} = \frac{\varepsilon_{a,1-\tau_h}}{\varepsilon_{a,1-\tau_l}} \frac{p_l(1-\tau_l)}{p_h(1-\tau_h)} \tag{B.5}$$

B.2 Proof of Corollary 2.2

To demonstrate the corollary, begin with the first-order conditions provided in Equations (B.1) and (B.2). Scale the condition concerning the low-state tax rate by −1 and the condition concerning the high-state tax rate by $\frac{p_l}{p_h}$ and then combine the two conditions. This scaling ensures that the resulting tax reform does not alter the immediate tax revenue. Assuming that $\tau_l = \tau_h = \tau$, the total change in the Lagrangian becomes

$$\begin{aligned} -\frac{\partial\mathcal{L}}{\partial\tau_l} + \frac{\partial\mathcal{L}}{\partial\tau_h}\frac{p_l}{p_h} &= p_l a u'(c_{2l}) - p_h a u'(c_{2h})\frac{p_l}{p_h} + \lambda\left(-\tau\frac{\partial a}{\partial\tau_l} + \tau\frac{\partial a}{\partial\tau_l}\frac{p_l}{p_h} - p_l a + p_h a\frac{p_l}{p_h}\right) \\ &= p_l a(u'(c_{2l}) - u'(c_{2h})) + \lambda\tau\left(-\frac{\partial a}{\partial\tau_l} + \frac{\partial a}{\partial\tau_l}\frac{p_l}{p_h}\right) \end{aligned}$$

Using the definition of the saving elasticity,

$$-\frac{\partial\mathcal{L}}{\partial\tau_l} + \frac{\partial\mathcal{L}}{\partial\tau_h}\frac{p_l}{p_h} = p_l a(u'(c_{2l}) - u'(c_{2h})) + \lambda\frac{\tau}{1-\tau}\left(\varepsilon_{a,1-\tau_l}a - \varepsilon_{a,1-\tau_h}a\frac{p_l}{p_h}\right) \tag{B.6}$$

The first term in this addition is positive, if marginal utility is diminishing. Assuming the condition in Equation (2.6) holds, the second term is also positive. Consequently, the tax reform outlined in the corollary results in an improvement in the government's objective.

To illustrate the last statement of the corollary, consider the limit as $\lambda \to \infty$. In this scenario, the first term becomes insignificant, reflecting the government's disregard for the insurance motive. However, the positivity of the second term ensures that tax revenue increases following the tax reform.

B.3 Marginal Excess Burden of Elementary Joint Tax Reforms

The marginal excess burden of elementary joint tax reforms depends on three separate effects of the reform on tax revenue. Consider the additional tax revenue raised from individuals whose income and wealth are higher than the threshold values that characterize the joint tax reform. The additional revenue collected from these individuals is given by

$$\begin{aligned} \Delta R^M(y,a) &= \int_y^\infty \int_a^\infty \Delta T f(y',a') da' dy' \\ &= \Delta T \cdot \overline{F}(y,a) \end{aligned} \tag{B.7}$$

where ΔT represents the increase in an individual's tax liability and $\overline{F}(y,a)$ represents the exceedance function of the joint income and wealth distribution.

Two distortions on labor supply and wealth accumulation decrease tax revenue. They are given by

$$\Delta R_Y^E(y,a) = \int_a^\infty -\varepsilon_{y,1-T_Y'} \frac{y'}{1-\tau_Y(y',a)} \tau_Y(y',a) \frac{\Delta T}{\Delta y} \Delta y f(y,a') da' \tag{B.8}$$

$$\Delta R_A^R(y,a) = \int_y^\infty -\varepsilon_{a,1-T_A'} \frac{a'}{1-\tau_A(y,a')} \tau_A(y,a') \frac{\Delta T}{\Delta a} \Delta a f(y',a) dy' \tag{B.9}$$

If the initial tax schedule consists of two univariate tax functions, the marginal tax rate of income does not depend on wealth, and vice versa.

$$\tau_Y(y) = \tau_Y(y,a') \quad \forall a' \tag{B.10}$$

$$\tau_A(a) = \tau_A(y',a) \quad \forall y' \tag{B.11}$$

We can simplify the total effect of two distortions on tax revenue using the identities above

$$\Delta R_Y^E(y,a) = -\Delta T \cdot y \cdot \varepsilon_{y,1-T_Y'} \cdot \frac{\tau_Y(y)}{1-\tau_Y(y)} \cdot f(y|a' > a) \tag{B.12}$$

$$\Delta R_A^R(y,a) = -\Delta T \cdot a \cdot \varepsilon_{a,1-T_A'} \cdot \frac{\tau_A(a)}{1-\tau_A(a)} \cdot f(a|y' > y) \tag{B.13}$$

where $f_Y(y|a' > a)$ and $f_A(a|y' > y)$ conditional probability distribution functions of income and wealth. According to Equation (2.13), the marginal excess burden of elementary joint reforms is given by

$$\begin{aligned} MEB_{\text{joint}}(y,a) = y \cdot \varepsilon_{y,1-T_Y'} \cdot \frac{\tau_Y(y)}{1-\tau_Y(y)} \cdot \frac{f(y|a' > a)}{\overline{F}(y,a)} \\ + a \cdot \varepsilon_{a,1-T_A'} \cdot \frac{\tau_A(a)}{1-\tau_A(a)} \cdot \frac{f(a|y' > y)}{\overline{F}(y,a)} \end{aligned} \tag{B.14}$$

We can show that the exceedance function of the joint distribution is identical to the exceedance functions of conditional income and wealth distributions. Using the definition of marginal distributions yields the result.

$$
\begin{aligned}
\overline{F}(y,a) &= \int_y^\infty \int_a^\infty f(y',a')da'dy' \\
&= \int_y^\infty f_Y(y'|a' > a)dy' \\
&= 1 - F_Y(y|a' > a)
\end{aligned} \tag{B.15}
$$

Similarly,

$$
\begin{aligned}
\overline{F}(y,a) &= \int_a^\infty \int_y^\infty f(y',a')dy'da' \\
&= \int_a^\infty f_A(a'|y' > y)da' \\
&= 1 - F_A(a|y' > y)
\end{aligned} \tag{B.16}
$$

B.4 Additional Figures and Tables

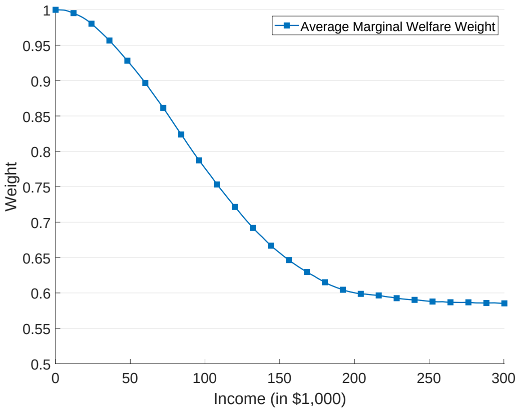
B.4.1 Mean Income and Wealth Across the Joint Distribution

			Wealth groups		
			Bottom 50%	Mid 40%	Top 10%
Income groups	Bottom 50%	I	30,700	39,000	39,800
		W	41,400	400,000	3,563,300
	Mid 40%	I	99,500	112,500	129,700
		W	75,100	489,000	3,086,300
	Top 10%	I	280,400	295,900	592,300
		W	105,000	716,600	8,146,300

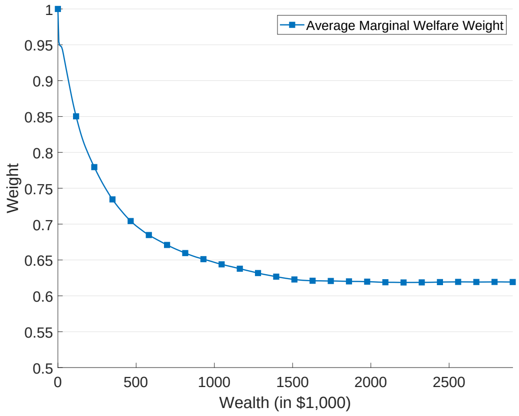
Table B.1: Mean Income and Wealth Across the Joint Distribution

Notes: The table summarizes the mean income and wealth values along the joint distribution of income and wealth. The income distribution is divided into three bins. The bottom 50% represents households up to the 50th percentile, the mid 40% represents households between the 50th and 90th percentile. The top 10% represents households above the 90th percentile of the income distribution. The same division is also applied to the wealth distribution. The first number above in each cell, denoted by I, represents the average income in U.S. dollars in the respective joint bin. The second number below, denoted by W, represents the average wealth in U.S. dollars in the same bin.

B.4.2 Calibrated Welfare Weights



(a) Across Income Distribution



(b) Across Wealth Distribution

Figure B.1: Calibrated Average Marginal Social Welfare Weights

Notes: The figure illustrates the calibrated average marginal social welfare weights obtained through the inverse-optimum approach. The left panel corresponds to the income distribution, while the right panel corresponds to the wealth distribution. These calibrated weights indicate the welfare gain when individuals above a certain income or wealth threshold receive an additional unit of consumption.

Appendix C

Appendix to Chapter 3

C.1 Details on Calibration

C.1.1 Data

For the calibration of the country-specific income distributions, we utilize data on labor income restricted to individuals in the working age (18-65) with positive income from the 2018 European Union Statistics on Income and Living Conditions (EU-SILC). Gross labor income is calculated as the sum of employment and self-employment income. Annual incomes are reported for the previous year of the survey leading to 2017 as the reference year of all country-specific income distributions. See Atkinson, Guio and Marliere (2017) for details.

C.1.2 Kernel Density Estimation

We employ a standard kernel density estimation based on a normal kernel function to smooth the country-specific income distributions obtained from the EU-SILC. For all countries, we use an evenly spaced income grid with 1000 nodes that are spaced between €2,500 and €2,000,000. We use a large bandwidth of €30,000 as the number of observations is rather small in EU-SILC data. Lockwood (2020) and Choné and Laroque (2010) note that a large bandwidth is useful for obtaining smooth income distributions. Figure C.1 shows the country-specific income distributions.

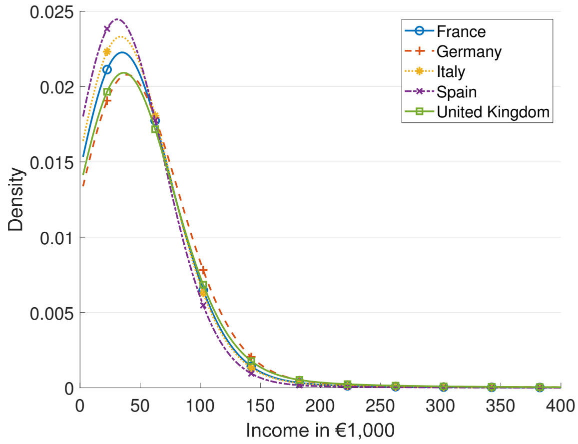
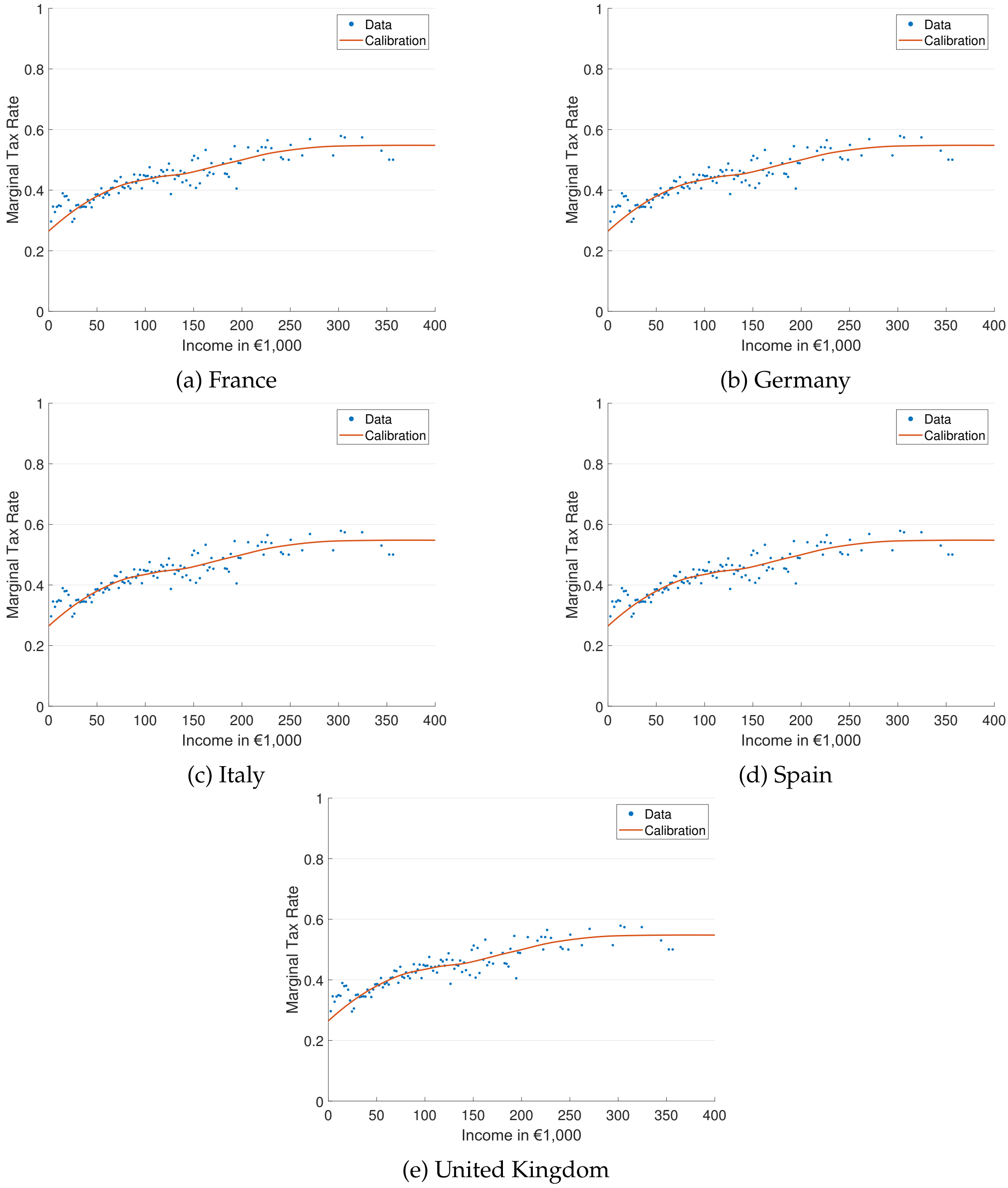


Figure C.1: Country-Specific Income Distributions

Notes: The probability density functions (pdf) are based on a standard kernel density estimation and add a Pareto distribution for incomes above €150,000, where the Pareto parameter decreases linearly between €150,000 and €250,000. All income-distributions involve a fixed mass of individuals with an income of zero. The underlying income data originate from the 2018 EU-SILC.

C.1.3 Current Tax-Transfer System



(a) France (b) Germany (c) Italy (d) Spain (e) United Kingdom

Figure C.2: Simulated Average and Smoothed Marginal Tax Rates with EUROMOD

Notes: The blue dots illustrate the simulated marginal tax rates with EUROMOD. The red line illustrates the current schedule of marginal tax rates calibrated by a second-order local weighted regression (LOESS) with a constant extrapolation based on a EUROMOD simulation of effective marginal tax rates.

C.1.4 Fiscal Pressure

We use government spending data and forecasts from the OECD (2019) and the International Monetary Fund (2021) to simulate the fiscal pressure faced by governments due to the COVID-19 pandemic.

Figure C.3 shows the net government lending or borrowing from 2016 until 2026. The grey area marks the pandemic time period. It is clear that all governments have had already and are expected to have significantly higher budget deficits during the pandemic period compared to before.

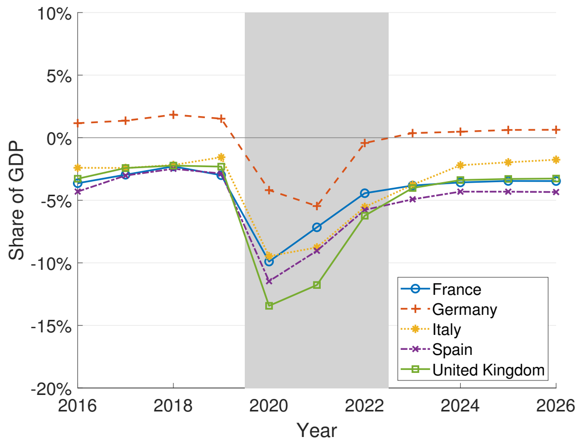
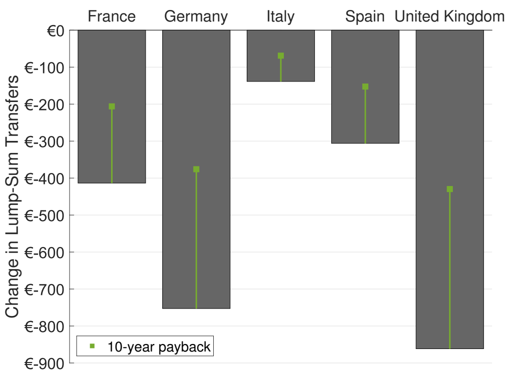


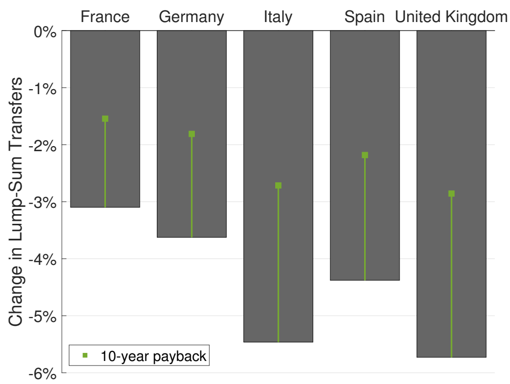
Figure C.3: Net Government Lending/Borrowing

Notes: For years until 2020, we use the actual data from the OECD's Government at a Glance. For years from 2021, we use the forecast data from the IMF World Economic Outlook. The grey area denotes the pandemic time period.

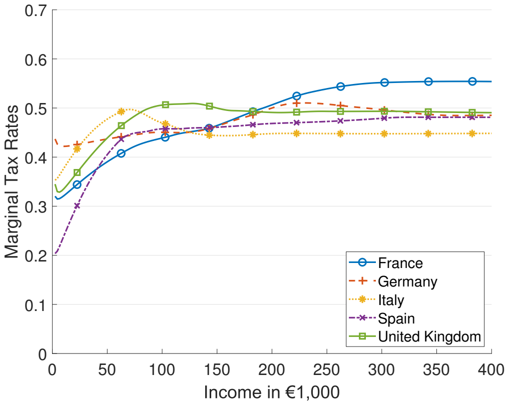
C.2 Different Repayment Scenarios



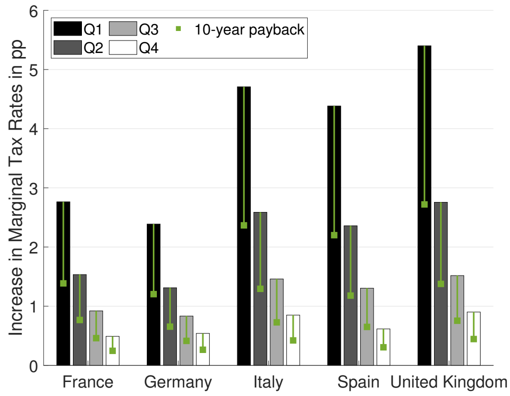
(a) Absolute Decrease in Lump-Sum Transfers



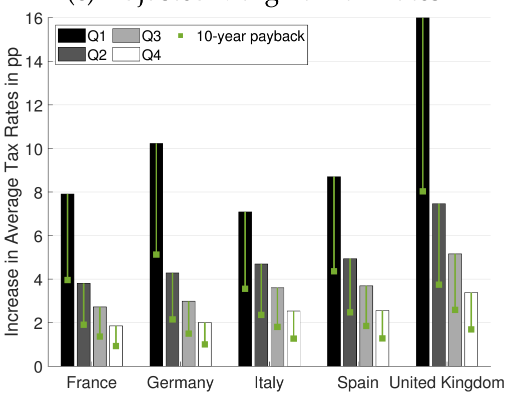
(b) Relative Decrease in Lump-Sum Transfers



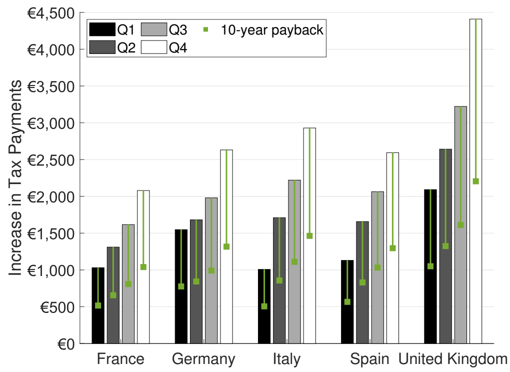
(c) Adjusted Marginal Tax Rates



(d) Increase in Marginal Tax Rates



(e) Increase in Average Tax Rates



(f) Increase in Absolute Tax Payments

Figure C.4: Change in Tax Rates and Tax Payments for Different Measures of Fiscal Pressure

Notes: The figure compares the average change in lump-sum transfers, marginal tax rates, average tax rates and absolute tax payments due to fiscal pressure from the baseline simulation to another measure of fiscal pressure. The bars correspond to the baseline simulation where governments are required to pay back the additional stock of debt in five years. The green squares correspond to a scenario where governments are required to pay back the additional stock in ten years.

C.3 Wealth Distribution Shocks

	All	Bottom 20%	20-40%	40-60%	60-80%	80-90%	90-100%
Euro Area	229.1	75.6	113.4	178.3	238.7	343.7	736.1
Belgium	366.2	121.7	254.8	399.5	410.4	522.3	773
Germany	232.8	54.1	138.9	160.3	237.3	351.7	798.1
Estonia	111.9	39	59.2	73.7	130.8	136.7	377.7
Ireland	365.5	176.4	210.6	273.9	380.3	632.2	944.2
Greece	93.9	39.9	58.4	96.5	101.9	140.2	206.3
Spain	257.8	95.7	142.1	179.9	267.4	347.7	862.7
France	242	79.7	113.7	172.7	246.6	354.2	840.8
Croatia	106.6	109.8	64	69.8	98.7	118.6	264.6
Italy	214.3	79.3	105	165.3	247.5	327.6	621.6
Cyprus	499.7	137.4	243.3	304.7	481.1	676.9	1998.4
Latvia	43	11.4	28.5	27.5	47.1	58	144.1
Lithuania	84.3	62.8	57.9	83.1	95	102.1	145.3
Luxembourg	897.9	305.8	530.1	626.2	924.4	1438.2	2784.9
Hungary	73	32.1	43.9	61.4	71.7	93.6	218.7
Malta	400.7	211.4	316.7	265.3	427.7	462.5	1117.7
Netherlands	186	75.6	98.6	138.8	178.6	314.9	563
Austria	250.3	67.5	113	178.8	260.8	332.1	932.3
Poland	95.5	42.2	60.1	85.7	102.6	138.5	236.3
Portugal	162.3	63.6	79.2	103.8	151.6	194.5	632.4
Slovenia	144.3	77.2	96.3	128.4	147	202	344.4
Slovakia	103.5	48.3	76.7	83.4	107.8	156.6	247
Finland	206.6	63	111.3	170.9	214.5	281.8	665.2

Table C.1: Net Wealth Means Across the Income Distribution

Notes: The table is taken from the Statistical Tables of the 2017 Household Finance and Consumption Survey from the European Central Bank (2020) (Table A4).

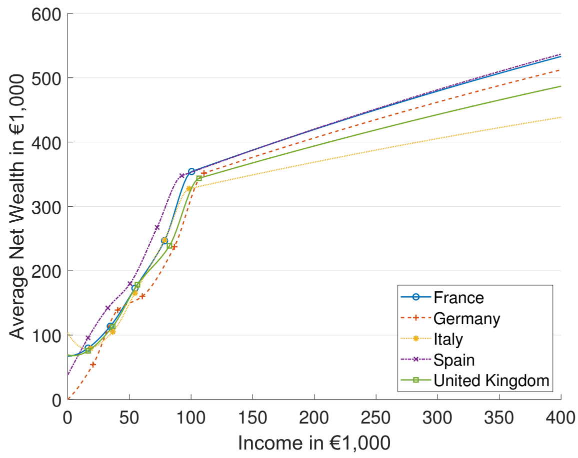


Figure C.5: Average Net Wealth across the Income Distribution

Notes: The six markers illustrate the average net wealth for six points of the income distribution taken from the Table A4 from the Statistical Tables of the 2017 Household Finance and Consumption Survey. The curves fit these values based on a shape-preserving piece-wise cubic interpolation. In Germany, the average net wealth of the lowest income is set to zero. For the UK we use the average of the Euro area countries as the UK is not included in the Household Finance and Consumption Survey.

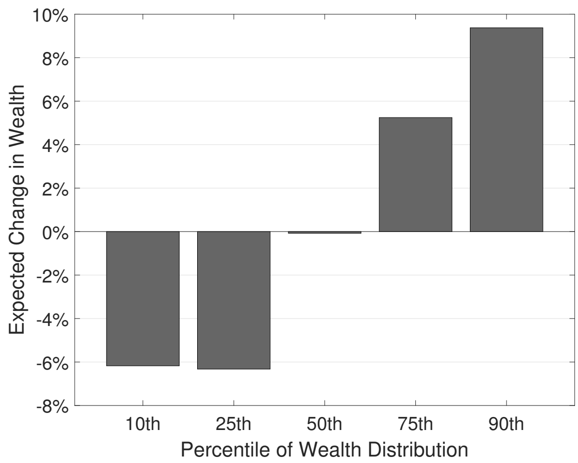
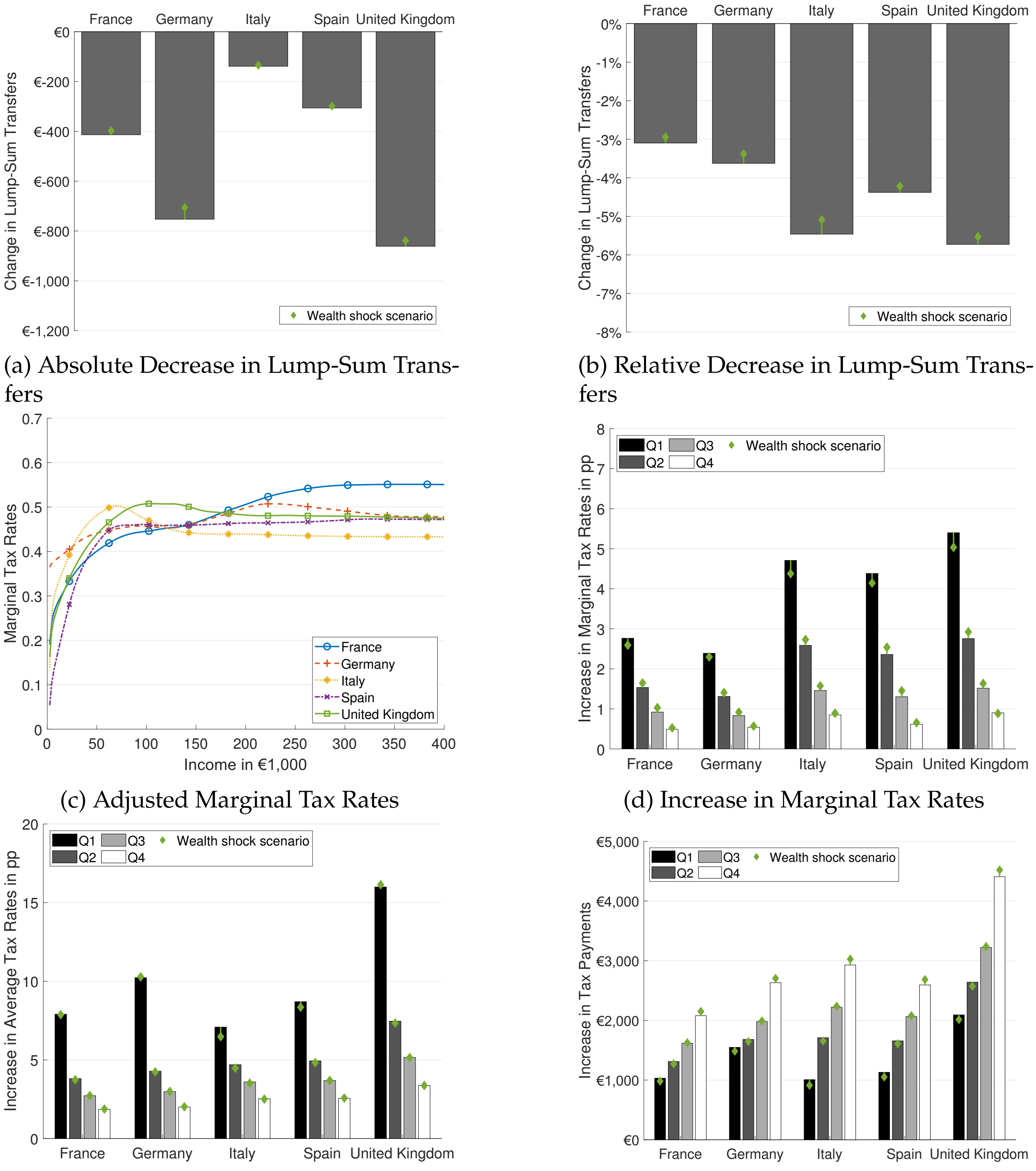


Figure C.6: Expected Percentage Change in Wealth

Notes: The shown values are taken from Figure 4 in Angelopoulos et al. (2021).



(a) Absolute Decrease in Lump-Sum Transfers

(b) Relative Decrease in Lump-Sum Transfers

(c) Adjusted Marginal Tax Rates

(d) Increase in Marginal Tax Rates

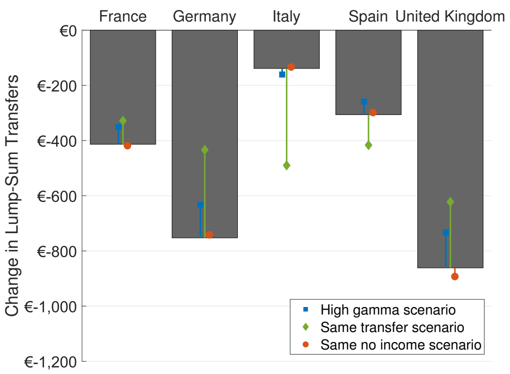
(e) Increase in Average Tax Rates

(f) Increase in Absolute Tax Payments

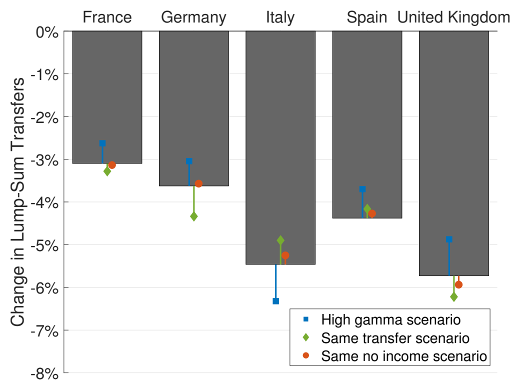
Figure C.7: Change in Tax Rates and Tax Payments with Wealth Shocks

Notes: The figure compares the change in lump-sum transfers, marginal tax rates, average tax rates and absolute tax payments due to fiscal pressure from our simulations without income income effects to another scenario where individuals are affected by the wealth shock due to COVID-19. The bars correspond to the simulations without wealth the shock. The green squares correspond to a scenario, where individuals are affected by the wealth shock and required to restore their old wealth level by saving or dissaving. There are no income effects in both scenarios.

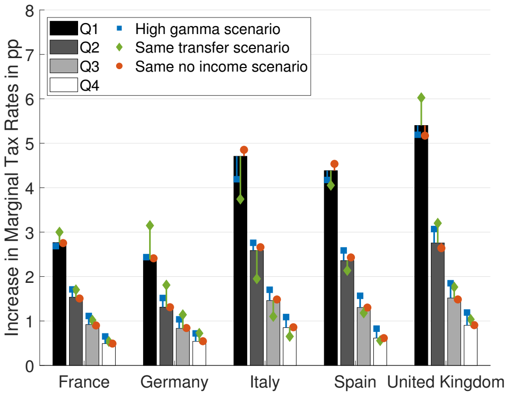
C.4 Further Robustness



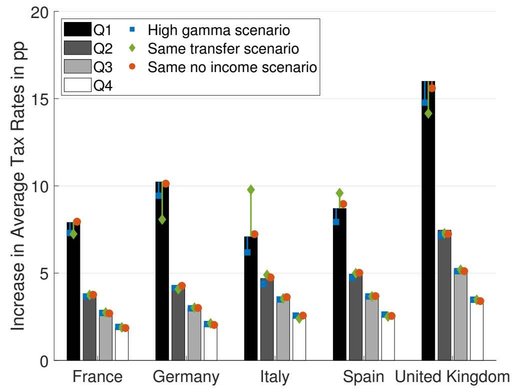
(a) Absolute Decrease in Lump-Sum Transfers



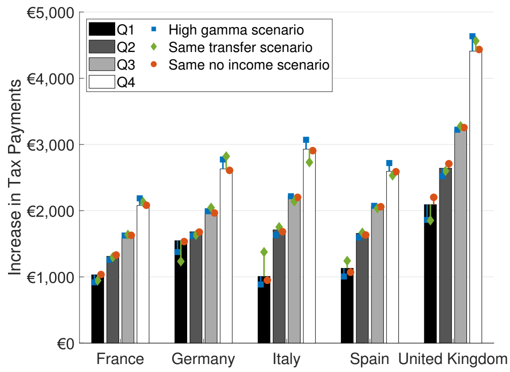
(b) Relative Decrease in Lump-Sum Transfers



(c) Increase in Marginal Tax Rates



(d) Increase in Average Tax Rates



(e) Increase in Absolute Tax Payments

Figure C.8: Change in Tax Rates and Tax Payments for Different Scenarios

Notes: The figure compares the average change in lump-sum transfers, marginal tax rates, average tax rates and absolute tax payments due to fiscal pressure from the baseline simulation to different measures of fiscal pressures. The bars correspond to the baseline simulation. The blue squares correspond to a scenario where individuals are more risk averse, the green diamonds correspond to a scenario where all countries have the same level of transfers initially and the red circles correspond to a scenario where all countries have the same share of individuals with zero income.

Eidesstattliche Versicherung

Ich versichere hiermit eidesstattlich, dass ich die vorliegende Arbeit selbständig und ohne fremde Hilfe verfasst habe. Die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sowie mir gegebene Anregungen sind als solche kenntlich gemacht. Die Arbeit wurde bisher keiner anderen Prüfugsbehörde vorgelegt und auch noch nicht veröffentlicht. Sofern ein Teil der Arbeit aus bereits veröffentlichten Papers besteht, habe ich dies ausdrücklich angegeben.

München, 14. März 2024

Mehmet Ayaz