

ARE CONSUMPTION TAXES BETTER THAN LABOR INCOME TAXES?  
THEORETICAL AND QUANTITATIVE IMPLICATIONS OF THE CHOICE OF  
TAX BASE

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*To Grace.*

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Kris Shaw

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# ABSTRACT

## ARE CONSUMPTION TAXES BETTER THAN LABOR INCOME TAXES? THEORETICAL AND QUANTITATIVE IMPLICATIONS OF THE CHOICE OF TAX BASE

Kristin D. Shaw

Petra Todd

In many standard models, taxes on labor income and taxes on consumption are outcome-equivalent. However, this is not the case when taxes are non-linear and households differ with respect to wages and earnings. In this dissertation, I evaluate how consumption-based and earnings-based tax systems differ in the presence of wage heterogeneity and progressive rate schedules. To understand the macroeconomic implications of the choice of tax base, I study two versions of a dynamic consumption-savings model, one analytically and the other numerically. I begin with a tractable two-period framework and show that the theoretical advantages of consumption taxation are twofold. First, it eliminates an intertemporal distortion on labor supply. Second, consumption is more strongly correlated with lifetime resources, which matters for the distributional impact of the tax system. To assess the quantitative implications, I construct a standard overlapping generations model with incomplete markets and elastic labor supply. After calibrating the model to the U.S. economy, I replace a progressive labor income tax with an equally progressive consumption tax, taking into account post-reform transition dynamics. This reform produces moderate gains in physical capital (1.9%), output (1.3%), consumption (1.5%) and welfare (0.9%). Most of the benefits stem from improvements in labor efficiency that follow from the

mitigation of distortions on work decisions. Because baseline progressivity is sub-optimal for both tax bases, I also perform a best-on-best comparison by numerically characterizing the welfare-maximizing tax code under both regimes. The quantitative conclusions from this exercise are broadly unchanged from the simple reform. A progressive consumption tax is most easily implemented by adopting a cash-flow consumption tax, as described by Kaldor (1955) among others. Since the administration of a cash-flow tax is more complicated than that of a pure labor income tax, my quantitative results provide novel guidance for policy-makers discerning between the two tax bases.

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## CHAPTER 1 : Introduction

When the people are weary of any one sort of Tax, presently some Projector propounds another, and gets himself audience, by affirming he can propound a way how all the publick charge may be born without the way that is.

---

William Petty, *A Treatise of Taxes and Contributions* (1662)

### 1.1. Statement of the Research Question

Tax system design has two core problems. One concerns the rate of taxation: should rates vary between individuals or across time? And if so, how? These are critical questions and many fruitful efforts have been made to answer them. An even more fundamental question concerns the choice of tax base. *What* should be taxed? After all, fiscal instruments must be selected before they can be calibrated.

This dissertation focuses on the choice between the taxation of labor income and the taxation of consumption. Specifically, I ask whether there are utilitarian grounds to prefer one base over the other.

Several papers in the public finance literature have asked the same question and concluded that consumption taxation is better than labor income taxation (Auerbach et al., 1983; Coleman, 2000; Correia, 2010; Motta and Rossi, 2019). But consumption taxes only deliver efficiency gains in these models because they substitute for missing fiscal instruments. In particular, consumption taxes are used to mimic a levy on initial assets, an inelastic resource that can be taxed without distortion. If tax planners could also use appropriate capital taxes, the differences between the two tax bases would disappear. Because the conclusions of these analyses depend crucially on the

exclusion of standard fiscal instruments, one is justified in asking: are consumption taxes really better than labor income taxes?

A more instructive point of departure is Erosa and Gervais (2002). Using a standard life-cycle growth model, they prove that when governments have access to four fiscal policies—namely debt plus proportional taxes on consumption, labor income and capital income—one of them is redundant. In other words, “it is possible to eliminate either consumption taxes or labor income taxes from a given fiscal policy without affecting the allocation being implemented...This observation applies whether taxes are allowed to be conditioned on age or not.”<sup>1</sup>

Consequently, the tax base question is meaningful only in settings that deviate in some way from Erosa and Gervais (2002).<sup>2</sup> Their model features homogenous agents and linear taxes, raising the question of how things might change in environments with heterogeneous agents and non-linear taxes. As Conesa and Krueger (2006) and others have emphasized, progressive taxation plays a potentially beneficial role in such settings by redistributing resources from the rich and lucky to the poor and unlucky. The optimal choice of tax base likely turns on whether one system achieves that objective more efficiently than the other. The aim of this dissertation is to determine how consumption-based and earnings-based tax systems differ in the presence of wage heterogeneity and progressive rate schedules.

## 1.2. Summary of Methods and Findings

To understand the macroeconomic implications of the choice of tax base, I study two versions of a dynamic consumption-savings model, one analytically and the other

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<sup>1</sup>Andres Erosa and Martin Gervais, 2002, “Optimal Taxation in Life-Cycle Economies”, *American Economic Review* 90(1), p. 347.

<sup>2</sup>The aforementioned studies deviate by excluding certain fiscal policies from consideration.

numerically. The model economies are populated by finitely-lived agents who differ with respect to wages and make endogenous labor supply and savings decisions. In both versions, the tax planner’s problem is formulated as a Ramsey-style optimal taxation problem in which the government selects a tax-and-transfer scheme from a given parametric class. The functional form I adopt for the tax code is taken from Benabou (2000) and Heathcote et al. (2017), among others.

The Ramsey tradition of tax design, which optimizes tax policy over an exogenously specified set of fiscal instruments, stands in contrast with the Mirrlees approach, which restricts neither the tax base nor the shape of the rate schedule. Mirrleesian tax design proceeds by formulating an appropriate social planner’s problem, characterizing the constrained-efficient allocation, and then reverse-engineering a tax code to implement it. The inevitable distortions are not imposed from without; they arise endogenously from the trade-off between insurance and incentives. The disadvantage of the Mirrlees approach is practical. The tax systems it recommends are usually quite complicated and generally depend on the entire history of labor earnings (Kocherlakota, 2005).

Although the ad hoc restrictions of Ramsey tax design are theoretically unfounded, they are simple enough to embed into richer models and more easily translated into applied policy advice. It has also been shown in some cases that the Mirrlees solution offers only small welfare gains over a simple Ramsey-style tax code (Heathcote and Tsujiyama, 2020). For these reasons, the Ramsey approach still dominates quantitative public finance, with progress made by exploring increasingly sophisticated tax instruments in increasingly sophisticated environments.<sup>3</sup> Some papers are directly inspired by insights drawn from the Mirrleesian literature. One example is Kitao (2010), who lets the capital tax rate vary with labor income in accordance with the standard

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<sup>3</sup>Two areas of active research include wealth taxes (e.g. Guvenen et al., 2019; Kaymak and Poschke, 2020) and universal transfers (e.g. Luduvic, 2019; Daruich and Fernández, 2020).

Mirrleesian result that capital taxation and labor supply are negatively correlated.

My analysis begins in Chapter 2 with a tractable two-period framework that abstracts from physical capital. Agents draw heterogeneous wage profiles and transfer resources across time using a risk-free bond. I use this model to illustrate the key qualitative differences between the candidate tax structures. The theoretical advantages of consumption taxation are twofold and arise from the fact that wages and earnings fluctuate over time whereas consumption is endogenously smoothed through borrowing and lending. As a result, lifetime resources are more strongly correlated with consumption than with earnings. If the ultimate target of redistribution is lifetime resources, as some writers argue, then consumption becomes an attractive choice of tax base for period-by-period tax systems.<sup>4</sup>

Along similar lines, progressive taxation generates an intertemporal distortion whenever it is linked to a volatile choice variable. To grasp the intuition, consider an agent whose wages change (deterministically) over time. This agent optimally chooses a higher level of work effort in the higher-wage period. This intertemporal effect is dampened, however, if earnings are subject to a progressive labor income tax. Because marginal tax rates increase with earnings, the agent's incentive to tilt hours in the direction of the high-wage period is reduced. Consequently, she flattens her life-cycle labor supply profile and generates lower lifetime earnings. By selecting a relatively smoother base, namely consumption, tax authorities can minimize or even eliminate this type of distortion.

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<sup>4</sup>See, e.g., Mirrlees et al. (2011): "The redistributive impact of a tax system is often judged by looking at how much tax individuals pay relative to their income over a relatively short time period—rarely more than a year. But people's incomes tend to change over their lives, which means that this approach can be a poor guide to how progressive the tax system is relative to a person's lifetime income...Ideally, we should judge the distributional impact of the tax system over a lifetime rather than at a point in time." pp. 23-24.

These two differences, which I call the *redistribution channel* and the *efficiency channel*, are not enough to definitively favor consumption taxes over labor income taxes. Changes in the tax base trigger changes in average tax rates to maintain government budget balance. Because these tax rate adjustments have different impacts on agents of different abilities, a simple conversion of the tax system from an earnings base to a consumption base may not improve welfare. I present a sufficient condition on the underlying wage process that guarantees welfare-superiority of progressive consumption taxation in this environment.

In Chapter 3, I turn my attention to the feasibility and administration of a non-linear consumption tax. The most common consumption taxes in the world today are the retail sales tax (in the U.S.) and the value-added tax (most everywhere else). But these indirect forms are blunt tools and ill-suited for building progressive tax systems. Alternatively, a direct tax on household expenditures can be levied according to any arbitrary rate schedule. The administration of a direct scheme was considered infeasibly difficult for a long time, despite academic support dating back to at least Hobbes (1651). It was not until the middle of the twentieth century that economists recognized the cash-flow tax as a suitable implementation, thanks largely to the work of Irving Fisher (1937) and Nicholas Kaldor (1955). The logic of the cash-flow tax is easily grasped once one observes that household consumption can be derived by subtracting the sum of contributions to savings accounts and other non-consumption tax outflows from the sum of earnings and other realized monetary inflows. This residual approach to calculating consumption dramatically reduces record-keeping requirements and compliance costs, relative to the direct summation of all consumption transactions. Nor is it entirely unfamiliar, as this is precisely the way the existing U.S. tax code treats tax-deferred retirement accounts.

That said, the cash-flow consumption tax is certainly more complicated than a labor income tax. There are also non-trivial concerns around the treatment of durable goods and certain tax evasion schemes (Seidl, 1990). On administrative grounds alone, then, an earnings base must be preferred to an expenditure base.<sup>5</sup> Only if the relative merits identified in Chapter 2 are *quantitatively* significant can a persuasive case for consumption taxation be made.

Chapter 4 address this quantitative question. Agents in this economy face idiosyncratic labor market shocks in addition to *ex ante* differences in ability. Yet they still have access to just a single financial instrument—the one-period risk-free bond—which they trade for self-insurance purposes as in Huggett (1993) or Aiyagari (1994). The government finances its expenditures using three sources of revenue: flat taxes on consumption and capital income and a non-linear household tax that is initially assessed on earnings. Additional model ingredients include retirement, mortality risk, accidental bequests and a strict borrowing constraint.

After calibrating the model to the U.S. economy, I perform a series of tax reform experiments. To begin, I assess the macroeconomic effects of converting the non-linear household tax from a labor income base to a consumption base, holding progressivity constant. By applying this simple reform only to future generations, I avoid the wind-fall gains and losses that often complicate welfare assessments along the transition. This reform leads to non-trivial long-run gains in physical capital (1.9%), output (1.3%) and consumption (1.5%). Most of the benefits stem from improvements in labor efficiency that follow from the mitigation of distortions on work decisions. Using a standard utilitarian welfare criterion, I compute a consumption-equivalent steady-state welfare gain of 0.9%. Because of how I structure the tax experiment, transitional

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<sup>5</sup>Political concerns have also plagued cash-flow tax proposals. See Bank (2003) for details.



generations experience similar welfare gains to long-run generations. Pre-reform cohorts are subject only to general equilibrium price effects and are largely unaffected. This justifies the use of steady-state comparisons to evaluate the impact of the tax reform.

Because baseline progressivity is almost certainly sub-optimal for both tax bases, I then perform a best-on-best comparison by numerically characterizing the welfare-maximizing tax code under both regimes, with all tax experiments proceeding along the same lines as the simple reform. Although the utilitarian gap narrows somewhat, the optimal consumption tax still holds a long-run welfare advantage of 0.7% when comparing optima. The main quantitative result, and chief contribution of this paper, still stands: adopting a progressive consumption tax generates moderate welfare gains relative to a progressive labor income tax.

In a closely related paper, Conesa et al. (2020) quantify the replacement of both labor and capital income taxes with a dual-rate indirect consumption tax system. In their model, infinitely-lived agents allocate expenditures between two different consumer goods, each of which is subject to its own flat-rate tax. If expenditure shares for these two goods vary with total expenditure, then a rate-differentiated system can generate some degree of progressivity. However, they find that such schemes reduce welfare both in the new steady state and along the transition.

I perform a similar exercise by extending my quantitative model to include basic and non-basic consumer goods. Using a calibrated version of the extended model, I compare two distinct tax reforms: the simple cash-flow reform from before, and a dual-rate indirect tax reform as in Conesa et al. (2020). I find that the cash-flow tax generates positive welfare gains but the dual-rate system generates substantial welfare losses. By levying different taxes on different goods, the dual-rate system deviates

from the principle of uniform commodity taxation (Deaton, 1979), distorts relative prices, and erodes any advantage of systemic progressivity. These results suggest that policy-makers seeking to enact a progressive consumption-based tax system should adopt the cash-flow structure over the rate-differentiated structure.

### 1.3. Relationship to the Literature

To the best of my knowledge, this study is the first to quantify the implications of *non-linear* cash-flow taxation in a model of heterogenous agents and incomplete markets. But many papers have quantified the shift from income taxes to *linear* consumption taxes, including Summers (1981), Auerbach et al. (1983), Altig et al. (2001), Nishiyama and Smetters (2005), Lehmus (2011) and Kitao (2011). This literature offer three important methodological lessons for the present study. First, the analyst must carefully consider the induced transition, especially the path of government debt. An increased reliance on consumption taxation in a life-cycle setting tends to increase household demand for assets. But it also increases the government supply of debt, which largely crowds out the accumulation of physical capital. If this is not properly accounted for, the results will grossly overestimate the long-run welfare gains of reform.

Second, the papers cited above study the wholesale replacement of an income tax system with a flat consumption tax. Consequently, their numerical results largely reflect the elimination of taxes on capital income. To properly evaluate the relative merits of consumption taxation over against labor income taxation, it is essential that saving incentives not be directly modified in any of the policy experiments.

Third, it is vital that the analyst carefully consider the treatment of existing wealth. A newly imposed consumption tax mimics a lump-sum tax on pre-existing wealth

while a labor income tax produces the opposite effect. To insulate the numerical results from bias of this sort, the reform must be designed to minimize windfall gains and losses. The implicit capital levy effect appears prominently in Coleman (2000) and Correia (2010) as well.

Several recent contributions have explored the implications of consumption taxation for non-standard economic environments. Motta and Rossi (2019) evaluate the power of consumption taxes to substitute for missing taxes on monopoly rents. Nakajima and Takahashi (2020) study the effectiveness of consumption taxation jointly with a lump-sum transfer program in a model of indivisible labor. Two recent papers investigate the macroeconomic effects of greater reliance on consumption taxes in the presence of multiple consumer goods. Conesa et al. (2020) numerically characterize the optimal dual-rate consumption tax for an environment with two distinct non-durable commodities. Li (2020) introduces a durable into a standard incomplete markets model, and finds that a shift to consumption taxes is welfare-decreasing since it effectively tightens the borrowing constraint on young and poor households.

My study is closely linked to research that posits lifetime income as the ultimate objective of redistributive fiscal policy and therefore focuses on tax structures that mimic, as much as possible, a direct tax on lifetime resources. One way of achieving this goal is the cumulative assessment method famously championed by William Vickrey (1939, 1947, 1969, 1992). Although he was mainly motivated by considerations of horizontal equity<sup>6</sup> it has been shown that tax-smoothing of this sort is optimal in settings where the disutility of work is isoelastic and wages, while heterogeneous, grow at the same rate for all workers (Werning, 2007; Diamond, 2006). Quantitative

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<sup>6</sup>Vickrey (1939, p. 379): “It has long been considered one of the principal defects of the graduated individual income tax that fluctuating incomes are, on the whole, subjected to much heavier tax burdens than incomes of comparable average magnitude which are relatively steady from year to year.”

assessments of a hypothetical lifetime taxation system include Huggett and Parra (2010) for the U.S. and Haan et al. (2019) for Germany. A tax on annual expenditures like the one studied here approximates a tax on lifetime earnings, at least to the extent that households smooth consumption over time through borrowing and saving.<sup>7</sup>

I also contribute to ongoing research on the optimal degree of tax progressivity. In several recent contributions to this literature the welfare-maximizing tax schedule is found to be steeply-sloped (İmrohoroğlu et al., 2018; Brüggemann, 2021; Kindermann and Krueger, 2021). In contrast, Boar and Midrigan (2020) consider a wider range of possible tax codes and find that a flat income tax combined with a large lump-sum transfer is close to optimal. The cash-flow tax I study in this paper represents a middle ground. It mitigates the distortion on labor supply in a similar fashion to the flat tax but still allows for flexibility in setting the overall progressivity of the system. The value of that additional flexibility will determine the ultimate usefulness of the cash-flow tax as a fiscal policy.

A final strand of literature that merits discussion is the sizable body of research on tax-favoured saving plans like IRAs and 401(k)s. Many empirical studies have documented the impact of these programs on household savings behaviour. A central concern is whether contributions to retirement accounts constitute ‘new saving’ (as found by Poterba et al., 1995) or merely substitution from pre-existing accounts (as found by Attanasio and DeLeire, 2002). The same question has been investigated in quantitative frameworks by İmrohoroğlu et al. (1998), Love (2006) and Fehr et al. (2008), with similarly conflicting results. Because tax-favoured retirement accounts

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<sup>7</sup>The link between annual consumption and lifetime earnings in the context of tax design has been noted by McCaffery (2005) and Mirrlees et al. (2011), but given little formal attention in the literature.

shield assets from ongoing taxation on realized returns, but cash-flow taxation does not (at least not in the form I study), my analysis deviates from these other studies by abstracting from changes in saving incentives. Instead, I focus attention on how tax-smoothing impacts redistribution and intertemporal labor supply.

## CHAPTER 2 : The Qualitative Case for Consumption Taxation

The best taxes are those which are levy'd upon consumptions.

---

David Hume, *Political Discourses* (1752)

The case for consumption taxation has a rich intellectual history, dating back to at least Hobbes and comprising contributions from many notable academics and policy-makers. The literature is dominated by two standard arguments, one ethical—consumption taxation is *fair*—and the other economic—consumption taxation is *efficient*. In this chapter, I briefly outline the standard formulations of these arguments, hopefully lending some context to the consistent popularity of consumption taxation among reformers.

I also explain why the standard arguments fail to demonstrate the alleged superiority of consumption taxation. The rhetorical failure stems from the misattribution to consumption taxes of certain equity or efficiency effects that are more properly linked to the presence or absence of other tax provisions. For instance, it is not uncommon to find that arguments couched in terms of consumption taxes are in fact arguments for zero capital income taxes. But these are different fiscal instruments, and it does not follow that tax systems must be consumption-based even if one stipulates that the ideal tax rate for capital income is zero. Neither is it uncommon to find results that favor consumption taxes only because they mimic exogenously excluded levies on existing wealth. The ubiquity of these confusions means that much of the literature is orthogonal to the particular merits (or demerits) of consumption taxation, at least vis-à-vis labor income taxation.

To properly assess the question at hand, we must therefore take care to formulate

the tax design problem so that the results do not hinge on the exclusion of certain fiscal instruments from the policy choice set. I perform an analysis of this sort within the framework of a simple overlapping generations model. Unlike Erosa and Gervais (2002), households in my model vary with respect to wages and earnings. I show how this difference, along with non-linear taxation, breaks the equivalency between consumption taxation and labor income taxation. In so doing, I provide an economic rationale for consumption taxation that does not suffer from the weaknesses of the standard arguments.

## 2.1. Fairness

The classical theorists were chiefly concerned with notions of tax fairness. It is only with the advent of modern economic theory in the 20th century that attention turned primarily to positive arguments. Even still, a concern for fairness continues to motivate many contemporary discussions of taxation, within both academia and the political arena. The relevant literature highlights three principal concepts of fairness.

### *2.1.1. Fairness as Justice*

One version of the fairness argument posits consumption as the only equitable basis for assessment because consumption measures a person's withdrawal from society's pool of resources whereas income measures his contribution. From this standpoint, income taxes are unfair precisely because they penalize work, wealth-creation and thrift. Importantly, this is not an economic argument about incentives and elasticities. It is not wrong to penalize work, wealth-creation and thrift (just) because they are economic goods; it is (also) wrong because they are *moral* goods. In the words of this perspective's seminal advocate:

The Equality of Imposition consisteth rather in the Equality of that which

is consumed, than of the riches of the persons that consume the same. For what reason is there, that he which laboureth much, and sparing the fruits of his labour, consumeth little, should be more charged, then he that liveth idly, getteth little, and spendeth all he gets; seeing the one hath no more protection from the Common-wealth than the other? But when the Impositions are layed upon the those things which men consume, every man payeth Equally for what he useth: Nor is the Common-wealth defrauded by the luxurious waste of private men.<sup>1</sup>

The principle of rewarding (or at least not punishing) pro-social behaviour, thereby promoting virtuous relationships between members of society, has been re-formulated by many subsequent thinkers, including economists, legislators and legal scholars. The logic is easily grasped and appealing in its moral simplicity: tax profligacy, not prudence. Because the Hobbesian norm aligns well with moral intuitions about cooperation and fairness, it is not surprising that many consumption tax advocates instinctively endorse it.<sup>2</sup>

The force of the ‘common pool’ argument is diminished, however, by the inexorable bind of the taxpayer’s budget constraint. Taxpayers cycle through the roles of ‘spender’ and ‘saver’ throughout their lives, and status as one or the other is as much a product of age, need and random fluctuations in circumstances as it is of underlying characteristics of taste and temperment. Whatever is earned is eventually spent, and he who augments the Common-wealth today returns tomorrow to deplete it.

Thus, even if one affirms the “Natural Justice that every man should pay according

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<sup>1</sup>Thomas Hobbes, *Leviathan* (1651), Pt. I, Ch. 30, para. 181.

<sup>2</sup>For copious examples, see Appendix A.1.



to what he actually enjoyeth”<sup>3</sup>, it is not obvious why the principle applies to arbitrary subintervals of time, rather than the entire lifespan. From a lifetime perspective, it makes little difference whether one selects consumption or earnings as the taxable stream, as these are (to a first approximation) equal in present value. Whatever difference remains is mostly due to patterns of inheritance, and these can be accounted for with appropriate taxes on estates and bequests. Because the distinction between earner and spender is fuzzy, the Hobbesian concept of fairness bears less on the question at hand than first supposed.

### *2.1.2. Fairness as Neutrality*

John Stuart Mill endorsed consumption taxation on somewhat different grounds. While his concern lay also with the differential treatment of savers and spenders, he did not frame the issue in moralistic terms, as a set of judgments about the relative moral value of different activities. Rather, he was concerned that the tax system be impartial between taxpayers with different intertemporal preferences. For Mill, it was unfair that a person be taxed twice on the same part of his resources, once when it was earned and invested, and again when it yielded a financial return. Because a future sum consisting of principal and accumulated interest is equal in present-value terms to the principal alone, the non-exclusion of savings introduces an unjustified bias against savers, no different than if a heavier sales tax were arbitrarily imposed on one kind of widget but not on others. Mill was especially mindful of non-wealthy taxpayers who had no means to provide for retirement or for dependents except by saving out of current earnings. As such, “no income tax is really just from which savings are not exempted.”<sup>4</sup>

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<sup>3</sup>William Petty, *A Treatise of Taxes and Contributions*, (London: N. Brooke, 1662), p. 75.

<sup>4</sup>John Stuart Mill, *Principles of Political Economy* (1848), Book V, Ch. 11, section 4.

The problem of ‘double taxation’ galvanizes many political arguments in favor of consumption taxes. But intertemporal neutrality doesn’t necessitate a consumption-based tax system. Mill’s concerns could be allayed just as easily with an earnings-based tax system. The pivotal choice is the inclusion or exclusion of capital income. As such, the Millian concept of fairness does little to elucidate the choice between consumption and labor income, which is the topic at hand. Questions about the proper role of capital income taxation fall outside the scope of this study.

### *2.1.3. Fairness as Ability-to-Pay*

In *The Wealth of Nations*, moral philosopher Adam Smith set out four maxims of a sound tax system, the first of which requires that taxes be levied according to a person’s ability to pay. That is, each taxpayer’s contribution ought to be a function of the resources “which they respectively enjoy under the protection of the state.”<sup>5</sup> But what measurable quantity best encapsulates a person’s ability to pay, income or consumption?

One approach lets revealed preference settle the matter. In his proposal for an expenditure tax in the United Kingdom, Kaldor (1955, p. 47) writes:

Accruals from the various sources cannot be reduced to a common unit of spending power on any objective criteria. But each individual performs this operation for himself when, in the light of all his present circumstances and future prospects, he decides on the scale of his personal living expenses. Thus a tax based on actual spending rates each individual’s

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<sup>5</sup>Smith’s other three maxims are: (2) “The tax which each individual is bound to pay ought to be certain, and not arbitrary”; (3) “Every tax ought to be levied at the time, or in the manner, in which it is most likely to be convenient for the contributor to pay it”; and (4) “Every tax ought to be so contrived as both to take out and to keep out of the pockets of the people as little as possible over and above what it brings into the public treasury.” See *The Wealth of Nations* (1776), Bk. V, Ch. ii.

spending capacity according to the yardstick which he applies to himself.

According to Kaldor, the normative case for consumption taxation does not depend on moral judgments about net contributions to collective prosperity (as in Hobbes) or the putative inequity of double taxation (as in Mill). It is enough that consumption taxation discerns each person's taxable capacity from the decisions she freely makes for herself. Put another way, the tax system should judge a person's *ability* to pay for *public* goods and services by her demonstrated *willingness* to pay for *personal* goods and services. In this Kaldor echoes one of Hobbes's contemporaries, Sir William Petty (1662, p. 71), who argued that a "man is actually and truly rich according to what he eateth, drinketh, weareth, or any other way really and actually enjoyeth; others are but potentially or imaginatively rich."

Not all agree. Some maintain that income, as a proxy for potential consumption, is indeed the correct measure of ability to pay (Goode, 1980). If two individuals, *A* and *B*, have \$100 each, and *A* spends only half while *B* spends it all, is it really correct to say that *A* is less *able* to pay taxes? Others hold that consumption mismeasures ability to pay by ignoring valuable non-consumption attributes of wealth such as security, status and power (Aaron and Galper, 1985). Still others defer to "the person in the street" who, apparently, endorses income as the best indicator of taxable capacity (Pechman, 1990, p. 6). Ultimately, the answer to the ability-to-pay question depends on what one thinks is most indicative of a taxpayer's economic status: what she could do, or what she does do.

## 2.2. Efficiency

Beginning in the early twentieth century, the study of public finance pivoted away from abstract notions of fairness and toward concrete notions of economic efficiency

(e.g. Ramsey, 1927). This paradigm shift furnished consumption tax advocates with new arguments, particularly the claim that consumption taxes generate fewer aggregate distortions than income taxes. This line of reasoning has two strands, one explicit and the other implicit. The explicit argument takes Mill's concern for neutrality between savers and spenders and re-casts it as a formal argument about capital formation and intertemporal choice. The implicit argument relies on the ability of consumption taxes to mimic missing fiscal instruments. I discuss both arguments in turn.

### *2.2.1. Savings Neutrality*

The neutrality argument is straightforward and familiar: by exempting savings from the tax base, a consumption-based tax system eliminates intertemporal distortions on saving and investment, thereby encouraging capital accumulation and stimulating long-run economic growth. Numerous consumption-tax proponents have advanced this argument in support of their proposals (e.g., Seidman, 1989; McCaffery, 2002; Frank, 2005; Bankman and Weisbach, 2006; Carroll and Viard, 2012), often appealing to classic results in the public finance literature (e.g., Atkinson and Stiglitz, 1976; Judd, 1985; Chamley, 1986).

And the reformers may be correct on this point.<sup>6</sup> But this is not so much an argument for *consumption* taxes as it is an argument against *capital* taxes. Indeed, it is perfectly feasible for a tax system to consist of a tax on capital income in addition to a tax on earnings or consumption. Whether the former is a bad idea or not is an important question (Atkeson et al., 1999; Conesa et al., 2009; Fehr and Kindermann, 2015), but not pertinent to the choice between a labor income base and a consumption base.<sup>7</sup>

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<sup>6</sup>They may also be incorrect. See Straub and Werning (2020) for a critical re-evaluation of the Judd-Chamley result.

<sup>7</sup>The literature's conflation of consumption taxation with zero capital income taxation is ubiq-

The standard efficiency argument, then, has little to say about consumption taxation *qua* consumption taxation, particularly in comparison with and as an alternative to labor income taxation. Perhaps because of this, the distinction between the two is often dismissed and sometimes ignored altogether. Instead, they are cast as economically equivalent approaches for achieving savings neutrality. Some tax reformers that couch their arguments in consumption-tax terms end up proposing a straight labor income tax instead, arguing that since the two systems differ only in the timing of tax payments the administratively simpler wage tax is superior (e.g. Hall and Rabushka, 2007).

But are all other things really equal? With homogeneous households, complete markets and linear taxes, perhaps (recall Erosa and Gervais, 2002). The question remains open, however, for settings with heterogeneous agents, uninsurable risk or non-linear taxation.

Consider the unique contribution made by Krusell et al. (1996). They augment the neoclassical growth model with household heterogeneity and a political process for endogenously determining linear tax rates on consumption and/or income. Because the decisive median voter is a low-wealth type by assumption, equilibrium tax rates are higher whenever the scope for redistribution is broadest, namely when taxation is consumption-based. As a result, steady-state output is lower in a consumption tax regime compared with a labor income tax regime.

Another area where the distinction between consumption taxation and labor income taxation has been duly recognized is the treatment of supernormal returns on investment. As noted by Mirrlees et al. (2011), an earnings tax leaves excess returns (and losses) untouched while a consumption tax effectively makes the government a

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uitious. See Appendix A.2.

silent partner in its taxpayers' investments, enjoying a share of both windfall gains and windfall losses. There is some debate in the literature as to whether investment risk alone breaks the equivalence between labor income taxation and consumption taxation, with some arguing yes (Ahsan, 1989; Ahsan and Tsigaris, 1998) and others no (Zodrow, 1995).

Supernormal returns do not arise in the models studied here. Political mechanisms play no role either. Instead of investment risk or political interests, it is the presence of non-linear taxation and idiosyncratic labor market risk that generates differences in outcomes between the two systems. I study the choice between non-linear labor taxes and non-linear consumption taxes independently of the decision to tax capital or not, paying special attention to any effects on the intertemporal substitution of labor effort.

### *2.2.2. Implicit Capital Levy*

The standard practice in the literature is to model tax reforms as unanticipated once-and-for-all changes to the tax code. In these experiments, consumption taxes hold a significant advantage over labor income taxes because they target not just future streams of earnings but also the existing stock of wealth, which is inelastically supplied and can therefore be taxed without distortion. It is natural, therefore, for consumption taxes to outperform labor income taxes in standard optimal taxation problems, a point emphasized by Auerbach et al. (1983), whose quantitative results suggest that the implicit capital levy accounts for the entire difference between consumption taxes and wage taxes.

The implicit capital levy is also the key to understanding Coleman (2000), Correia (2010), and Motta and Rossi (2019), three papers that examine the tax base question

analytically as well as numerically. While consumption taxes dominate labor income taxes in each of these studies, the theoretical results depend critically on the use of new consumption taxes to indirectly target existing wealth. In the case of Motta and Rossi (2019), consumption taxes also serve as an indirect means of taxing monopolistic rents.

But as with the savings neutrality argument, the implicit capital levy argument is not really about consumption taxes *per se*. In the cited examples, consumption taxes are favored because and only because they mimic missing fiscal instruments in a way that labor income taxes cannot. If the labor tax alternative were augmented with an *explicit* capital levy (and, in the case of Motta and Rossi (2019), also a tax on profits), then then the relative benefit of consumption taxes as indirect levies on wealth and rents would disappear, restoring equivalency between the two tax bases. To properly assess the relative merits of consumption taxes and labor income taxes, it is necessary to formulate the tax design problem in such a way that the results are not affected by incompleteness in the set of admissible fiscal policies.

### 2.3. The Qualitative Model

In this section, I construct a theoretical model in which the standard arguments do not apply. Agents are homogenous in preferences and neither leave nor receive bequests, so there is no scope for claims about fairness. The economy is capital-free and competitive, so there are no capital taxes for consumption taxes to mimic. Instead, tax-base equivalency breaks down because agents are heterogeneous in wages and taxes are non-linear.

### 2.3.1. Basic Environment

**Households** The economy is populated by agents who live for  $J$  periods (and hence by  $J$  overlapping generations) and who are endowed with one unit of time at every age. A continuum of new agents is born in each period, each of whom draws an idiosyncratic productivity profile  $w = (w_1, w_2, \dots, w_J)$  from some distribution  $F$ . Each generation is identical to the next, meaning that the cross-section of productivities is time-invariant. Because all uncertainty is resolved at the moment of economic birth, each household acts with full knowledge of its future.

Labor is the sole input into a linear production technology. An agent with productivity  $w$  who works  $h$  hours generates output  $y = wh$ . Under the assumption of competitive labor markets, an agent's productivity  $w$  can be taken as her wage rate (hence the notation).

At each age  $j$ , the agent chooses hours  $h_j$  and consumption  $c_j$ . Households can freely save and borrow subject to a lifetime budget constraint. For simplicity, I set the discount rate and the interest rate equal to zero. I relax this assumption in Section 2.5.

Preferences over streams of consumption and leisure are assumed to be time-separable, with a period utility function given by:

$$u(c, h) = \log c - \phi \frac{h^{1+\gamma}}{1+\gamma} \tag{2.1}$$

The parameter  $\phi > 0$  represents disutility of work effort while the parameter  $\gamma > 0$  governs the elasticity of labor supply. In particular, the static Frisch elasticity is  $\frac{1}{\gamma}$ .



The household's maximization problem is therefore:

$$(H) \quad U(w; \hat{T}) = \max_{\{c_j, h_j\}} \sum_{j=1}^J \left( \log c_j - \phi \frac{h_j^{1+\gamma}}{1+\gamma} \right)$$

$$\text{s.t.} \quad \sum_{j=1}^J (w_j h_j - c_j - \hat{T}(c_j, w_j h_j)) \geq 0$$

where  $\hat{T}(\cdot)$  denotes the household's tax liabilities, which can depend on both consumption and labor earnings. Since this is a capital-free economy, there is no capital income and therefore no capital income taxes. Though not essential to the results, the absence of physical capital in the model helps focus attention on consumption taxation as an alternative to *labor* income taxation specifically, independently of how the return to savings is treated.

**Government** The government implements a tax-and-transfer scheme to accomplish two goals: (1) finance exogenous per capita expenditures  $g$ ; and (2) redistribute resources between households. The government's motivation is utilitarian: it seeks to maximize average lifetime utility. Although there are overlapping generations, the stationarity of the environment means that each generation is effectively self-contained.

The tax-and-transfer scheme under consideration takes the following form<sup>8</sup>:

$$z' = \lambda z^{1-\tau} \quad \lambda \geq 0 \quad \tau \leq 1$$

where  $z$  and  $z'$  are the pre- and post-tax quantities of whatever financial category comprises the tax base, and  $\lambda$  and  $\tau$  are fiscal parameters. Taxes are then defined

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<sup>8</sup>This functional form is well-established in the public finance literature. Its use dates back to at least Feldstein (1969) and was popularized by Benabou (2000). For recent examples of its use in models with heterogeneous agents, see Guner et al. (2016), Heathcote et al. (2017) and Wu (2021).

as:

$$T(z) = z - \lambda z^{1-\tau} \tag{2.2}$$

The parameter  $\tau$  governs the *progressivity* of the tax. A negative value renders the tax system regressive, while  $\tau = 0$  implies a proportional tax with flat rate  $1 - \lambda$ . I direct my attention, however, toward progressive systems. A tax regime is deemed progressive whenever  $\tau > 0$ . In this case, marginal tax rates increase with  $z$ , a fact that follows from the convexity of the tax function.<sup>9</sup> The tax code becomes confiscatory as  $\tau \rightarrow 1$ : all agents are left with exactly  $\lambda$  regardless of their measured tax base.

The parameter  $\lambda$  scales the tax function and determines the cut-off between those who pay taxes and those who do not. The break-even point is  $z_0 = \lambda^{1/\tau}$ . All agents with  $z < z_0$  receive a positive net transfer.

While the tax function has two parameters, the government can only choose  $\tau$  freely. It must set  $\lambda$  to satisfy a balanced budget constraint:

$$\mathbb{E}[z] = \mathbb{E}[z'] + g \quad \Rightarrow \quad \lambda = \frac{\mathbb{E}[z]}{\mathbb{E}[z^{1-\tau}]} - \frac{g}{\mathbb{E}[z^{1-\tau}]}$$

The Ramsey problem facing the government is thus to choose  $\tau$  so that the resulting allocation maximizes a social welfare function derived from the household's value function. Given the government's utilitarian motive, we can write this problem as

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<sup>9</sup>The tax function's first two derivatives are  $T'(z) = 1 - \lambda(1-\tau)z^{-\tau}$  and  $T''(z) = \lambda\tau(1-\tau)z^{-(1+\tau)}$ . Notice that the second derivative is strictly positive for  $\tau \in (0, 1)$ .

follows:

$$(R) \quad \begin{aligned} & \max_{\tau} \int U(w; \tau, \lambda) dF(w) \\ & \text{s.t.} \quad \lambda = \frac{\mathbb{E}[z]}{\mathbb{E}[z^{1-\tau}]} - \frac{g}{\mathbb{E}[z^{1-\tau}]} \end{aligned}$$

I consider two possibilities for the tax base. First, labor income, so that  $z$  and  $z'$  are properly thought of as pre-tax earnings and post-tax earnings. Second, consumption, so that  $z$  and  $z'$  are properly thought of as gross expenditure and consumption.

Before moving on to the analysis, I will describe in fuller detail two special cases of the model, namely the one- and two-period versions, since this is all we need to address the qualitative differences between the two candidate tax bases.

### 2.3.2. One Period Version

Consider first the case where  $J = 1$ . There is no reason to distinguish between consumption taxation and labor income taxation in this case since it is trivially true that expenditures and earnings are equal. But it will prove useful in what follows to develop some notation. The static version of the household's problem is:

$$\begin{aligned} U^1(w; \tau, \lambda) &= \max_{c, h} \log c - \phi \frac{h^{1+\gamma}}{1+\gamma} \\ & \text{s.t.} \quad c = \lambda(wh)^{(1-\tau)} \end{aligned}$$

Substituting for consumption, we can rewrite this as:

$$U^1(w; \tau, \lambda) = \max_h \log \lambda + (1 - \tau) \log w + (1 - \tau) \log h - \phi \frac{h^{1+\gamma}}{1 + \gamma}$$

Let  $\bar{h}$  denote the solution to this maximization problem. After taking first-order conditions, we easily obtain an expression for the the optimal static labor supply:

$$\bar{h} = [(1 - \tau)\phi^{-1}]^{\frac{1}{1+\gamma}}$$

Notice that hours are independent of wages. This should not surprise as it is well known that the income and substitution effects arising from variation in wages exactly offset when utility is logarithmic. By substituting the solution back into the objective function we obtain the associated value function:

$$U^1(w; \tau, \lambda) = \log \lambda + (1 - \tau) \log w + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \quad (2.3)$$

It follows that the Ramsey problem in the static environment can be written as:

$$(R1) \quad \begin{aligned} \max_{\tau, \lambda} \quad & \log \lambda + (1 - \tau) \mathbb{E}[\log w] + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \\ \text{s.t.} \quad & \mathbb{E}[w] \bar{h} - \lambda \mathbb{E}[w^{1-\tau}] \bar{h}^{1-\tau} - g = 0 \end{aligned}$$

### 2.3.3. Two Period Version

Now consider the case where  $J = 2$ . Earnings and expenditures are generally not equal period-by-period in this case, which, as we will see, has important implications for the government's choice of tax base.

To begin with, suppose that households are subject to both consumption and labor taxes, each belonging to the parametric class (2.2). Let  $\lambda_c$  and  $\tau_c$  denote the consumption tax parameters and  $\lambda_l$  and  $\tau_l$  denote the labor tax parameters. The household's

problem is then written as:

$$\begin{aligned}
U^2(w; \tau_c, \lambda_c, \tau_l, \lambda_l) = & \max_{x_1, x_2, h_1, h_2} \log c_1 + \log c_2 - \phi \frac{h_1^{1+\gamma}}{1+\gamma} - \phi \frac{h_2^{1+\gamma}}{1+\gamma} \\
\text{s.t. } & x_1 + x_2 = \lambda_l (w_1 h_1)^{1-\tau_l} + \lambda_l (w_2 h_2)^{1-\tau_l} \\
& c_j = \lambda_c x_j^{1-\tau_c} \quad j = 1, 2
\end{aligned}$$

Here,  $x_j$  denotes *expenditure* in period  $j$ , which is equal to consumption grossed up to include applicable taxes. Since there is a one-to-one relationship between expenditure and consumption, the problem can be formulated using either  $x$  or  $c$  as a choice variable.

Letting  $\mu$  denote the Lagrange multiplier on the budget constraint, the first-order conditions are given by:

$$\begin{aligned}
x_j : \quad 0 &= (1 - \tau_c) x_j^{-1} - \mu \\
h_j : \quad 0 &= -\phi h_j^\gamma + \mu \lambda_l (1 - \tau_l) w_j^{1-\tau_l} h_j^{-\tau_l}
\end{aligned}$$

It follows immediately that the household's optimal consumption path is (unsurprisingly) constant:  $c_1 = c_2 = c$ . The intertemporal ratio of hours is:

$$\frac{h_1}{h_2} = \left( \frac{w_1}{w_2} \right)^{\left( \frac{1-\tau_l}{\gamma+\tau_l} \right)} \quad (2.4)$$

Observe that the allocation of labor effort across time depends on the wage ratio and the elasticity parameter  $\gamma$  (naturally), but also the labor tax parameter  $\tau_l$ . The consumption tax parameter  $\tau_c$ , by contrast, is absent. This marks the first important difference between the two tax regimes.

Some further algebra yields expressions for optimal hours;

$$h_j^* = \left[ 2(1 - \tau_l)(1 - \tau_c)\phi^{-1} \left( 1 + \left( \frac{w_{-j}}{w_j} \right)^{(1-\tau_l)\left(\frac{1+\gamma}{\gamma+\tau_l}\right)} \right)^{-1} \right]^{\frac{1}{1+\gamma}} \quad j = 1, 2 \quad (2.5)$$

for the household's value function under a pure labor income tax;

$$U^L(w; \lambda_l, \tau_l) = 2 \log \lambda_l + 2 \log \left( \frac{(w_1 h_1^*)^{1-\tau_l} + (w_2 h_2^*)^{1-\tau_l}}{2} \right) - \phi \frac{h_1^{*(1+\gamma)}}{1+\gamma} - \phi \frac{h_2^{*(1+\gamma)}}{1+\gamma} \quad (2.6)$$

and for the household's value function under a pure consumption tax:

$$U^C(w; \lambda_c, \tau_c) = 2 \log \lambda_c + 2 \log \left( \left[ \frac{w_1 h_1^* + w_2 h_2^*}{2} \right]^{1-\tau_c} \right) - \phi \frac{h_1^{*(1+\gamma)}}{1+\gamma} - \phi \frac{h_2^{*(1+\gamma)}}{1+\gamma} \quad (2.7)$$

Recall that in the static version of the model, the government's set of fiscal instruments was effectively limited to a single policy parameter, namely  $\tau$ . In the multi-period model, the government is also free to choose the tax base. Thus, we have two competing Ramsey problems, one that implements a labor income tax and another than implements a consumption tax. The next subsection explores the relative merits of these two approaches.

## 2.4. Labor Tax v. Consumption Tax

The fundamental tax design problem in models with heterogeneous agents is that certain relevant information (typically the household's underlying skills, as here) is known only to the agents themselves. Since the government is unable to condition the tax code directly on these hidden exogenous characteristics, it must resort to taxes levied on observable endogenous characteristics. So, for example, instead of taxing

*potential* earnings, the government must settle for taxing *actual* earnings.

The question, then, is this: which observable endogenous quantity should we tax, earnings or consumption? Is there any reason for the tax designer to prefer one base over the other? In the life-cycle model of Erosa and Gervais (2002), the answer is no. If an allocation can be implemented using a labor income tax, then it can also be implemented using a consumption tax, a result that obtains whether or not the tax code is conditioned on age.

But we get a different answer here. Indeed, the main theoretical implication of this thesis is that there are economic grounds for preferring the consumption base. Two features of the model drive this result. First, underlying productivity varies over the life cycle, resulting in household earnings that fluctuate from period to period. Second, taxation is allowed to be *progressive*, so households face time-varying marginal tax rates whenever they are subject to graduated tax rates on labor income. Since marginal tax rates adversely affect work incentives, this means that an agent's labor supply is most distorted when she is most productive, and least distorted when she is least productive. By flattening the rewards from work across time, a progressive labor income tax generates a double distortion. Not only is the overall level of effort distorted, but also the allocation of effort over the life cycle.

Fundamentally, the problem with the progressive labor tax is that it applies a graduated rate schedule to a fluctuating tax base. To avoid the resulting intertemporal distortion, the tax designer must either abandon progressivity or find an alternative tax base, one that does not fluctuate from period to period. Fortunately, there is such an alternative, one that is smoothed endogenously by the households themselves: consumption.

And so we arrive at the first reason to favour consumption taxes. By breaking the link between when income is earned and when tax is assessed, a consumption-based tax reduces the distorting effects of progressive taxation, leading to more efficient work decisions and higher lifetime output. This effect is not present in Erosa and Gervais (2002) because their model admits only linear taxes. These insights are formalized in the following two lemmas.<sup>10</sup>

**Lemma 1.** *Progressive taxation (that is,  $\tau > 0$ ) distorts the level of lifetime labor effort whether it is levied on labor income or consumption. In fact, the severity of the distortion is equal. But a progressive tax on earnings also distorts the allocation of effort across time. Thus, a progressive labor tax imposes a greater distortion than a progressive consumption tax.*

**Proof.** Let  $v$  denote the lifetime disutility of labor effort. It is given by:

$$\begin{aligned} v &= \phi \frac{h_1^{*(1+\gamma)}}{1+\gamma} + \phi \frac{h_2^{*(1+\gamma)}}{1+\gamma} \\ &= \frac{2(1-\tau_l)(1-\tau_c)}{1+\gamma} \left[ \left( 1 + \left( \frac{w_2}{w_1} \right)^{(1-\tau_l)\left(\frac{1+\gamma}{\gamma+\tau_l}\right)} \right)^{-1} + \left( 1 + \left( \frac{w_1}{w_2} \right)^{(1-\tau_l)\left(\frac{1+\gamma}{\gamma+\tau_l}\right)} \right)^{-1} \right] \\ &= \frac{2(1-\tau_l)(1-\tau_c)}{1+\gamma} \end{aligned}$$

where I use (2.5) and the fact that  $\frac{1}{1+\frac{a}{b}} + \frac{1}{1+\frac{b}{a}} = 1$ . Note that  $\tau_l$  and  $\tau_c$  are interchangeable in this expression. Thus, both tax types have the same impact on lifetime labor effort. However, only the consumption tax leaves the optimal ratio of hours across time undistorted, a fact that follows directly from (2.4). ■

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<sup>10</sup>Note that an analogous argument can be made *against* the consumption base. Specifically, if consumption fluctuates from period to period (say, because there are shocks to marginal utility) then a progressive consumption tax would distort the intertemporal allocation of consumption spending. But this problem does not arise in the current environment because the optimal consumption path in the model is flat (by construction). Consequently, marginal rates do not fluctuate in equilibrium when taxes are levied on expenditure.



**Lemma 2.** *Consider household outcomes under two different tax regimes: a pure labor tax and a pure consumption tax. Suppose both regimes are similarly progressive, i.e., set  $\tau_c = \tau_l$ . Without loss, let  $w_1 > w_2$ . Then:*

1.  $h_1^C > h_1^L > h_2^L > h_2^C$
2.  $h_1^C + h_2^C < h_1^L + h_2^L$
3.  $y^c = w_1 h_1^C + w_2 h_2^C > w_1 h_1^L + w_2 h_2^L = y^L$

*That is, the household works fewer lifetime hours under the consumption tax, but allocates more of them to the high-wage period, leading to higher lifetime output. If wages are constant, change all inequalities to equalities.*

**Proof.** Parts 1 and 2 are corollaries of Lemma 1. Since momentary disutility of labor is convex in hours ( $\gamma > 0$ ) and the hours ratio is steeper under the consumption tax, then the stated pattern of hours is the only way for lifetime disutility of labor effort to be equal under the two regimes. Part 3 says that despite lifetime hours being lower under the consumption tax, lifetime output is higher, thanks, of course, to the superior allocation of effort. The proof for this is relegated to the appendix. ■

The rationale for favouring consumption taxes over labor taxes strengthens when we remember why we desire progressivity in the first place. Recall the two potentially beneficial functions of progressive taxation. First, to help equalize the distribution of resources between different classes of households (*ex ante* redistribution). Second, to help insure against idiosyncratic household risk in the absence of complete markets (*ex post* insurance). Both these functions are best served by adopting consumption

as the tax base.<sup>11</sup>

To see why, it is helpful to think of the tax system as a mechanism in which taxpayers send signals to the government, who in turn assigns tax liabilities based on those signals. For the mechanism to implement an effective *ex ante* redistribution program or an effective *ex post* insurance program, it is essential that these signals be informative about the unobserved characteristics of the taxpayers. Consider the case of a household that generates low annual earnings. What kind of household is this? Is it a poor household in a typical year? Or a rich household in an atypical year? If the latter, are its low earnings anticipated or unanticipated? If unanticipated, is the shock transitory or persistent? It is difficult to answer these questions with just a single data point. *Current* earnings are not very informative; what we need is information about *lifetime* earnings. Indeed, one important lesson from the theoretical literature on dynamic optimal taxation is that constrained-efficient tax codes generally depend on an agent's entire history of labor earnings (see Kocherlakota, 2005).

But such schemes are usually inadmissible in Ramsey-style tax problems, where the planner is constrained not just to a parametric class of tax schedules, but also by the implicit requirement that these schedules be functions of current variables only. Of course, it could be argued that this latter restriction is a feature, not a bug. Actual tax codes often do depend only on current variables. In this sense at least, the Ramsey approach reflects the tax planner's problem more closely than the Mirrleesian approach.

Faced with this temporal restriction, the tax planner must determine which *current* tax base embodies more information about a household's *lifetime* tax base. With

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<sup>11</sup>Because there are no unanticipated productivity shocks in the current framework, only the *ex ante* redistribution motive technically applies here. But the discussion and reasoning is relevant to both concerns, and certainly both apply to the quantitative model described in Sections 4.1.

that in mind, let  $y$  denote lifetime earnings and observe that:

$$y = \sum y_j = \sum c_j$$

Because consumption decisions follow a simple smoothing rule, a single observation reveals the entire consumption path, and is therefore *perfectly* informative about lifetime resources. Consequently, assigning tax liabilities according to periodic consumption is equivalent to assigning tax liabilities according to lifetime resources. The same cannot be said about earnings. In general, we cannot infer  $y_2$  from  $y_1$  or  $y_1$  from  $y_2$ , at least not exactly. Current earnings are only *partially* informative about lifetime resources. These insights are formalized in the following sequence of results.<sup>12</sup>

**Lemma 3.** *The consumption-based dynamic Ramsey problem is isomorphic to the static Ramsey problem.*

**Proof.** From (2.7), the value function for the household under a progressive consumption tax is:

$$U^C(w; \lambda, \tau) = 2 \log \lambda + 2 \log \left( \left[ \frac{w_1 h_1^* + w_2 h_2^*}{2} \right]^{1-\tau} \right) - \phi \frac{h_1^{*(1+\gamma)}}{1+\gamma} - \phi \frac{h_2^{*(1+\gamma)}}{1+\gamma}$$

After some algebra, we obtain:

$$\begin{aligned} U^C(w; \lambda, \tau) &= 2 \left\{ \log \lambda + (1 - \tau) \log(w^C) + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ &= 2 \cdot U^1(w^C; \tau, \lambda) \end{aligned}$$

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<sup>12</sup>If unanticipated productivity shocks are introduced, consumption is no longer perfectly informative about lifetime resources, merely *more* informative. The basic intuition remains.

where  $w^C$  is the agent's "pseudo-static" wage:

$$w^C = \left[ w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1}{\gamma}} \right] \left[ 1 + \left( \frac{w_2}{w_1} \right)^{\frac{1+\gamma}{\gamma}} \right]^{\frac{-1}{1+\gamma}} 2^{\left( \frac{-\gamma}{1+\gamma} \right)}$$

The "pseudo-static" wage is the constant wage that is welfare-equivalent to the agent's actual wage profile. In other words, the agent is indifferent between her actual wage profile  $(w_1, w_2)$  and the alternative wage profile  $(w^C, w^C)$ . Notice that when  $w_1 = w_2 = \tilde{w}$ , the pseudo-static wage collapses to  $w^C = (\tilde{w} + \tilde{w})(1 + 1)^{\left( \frac{-1}{1+\gamma} \right)} 2^{\left( \frac{-\gamma}{1+\gamma} \right)} = \tilde{w}$ . In contrast, when  $w_1 \neq w_2$ , then  $w^C > \frac{w_1 + w_2}{2}$ .

The government's Ramsey problem is:

$$\begin{aligned} \text{(RC)} \quad & \max_{\tau, \lambda} \quad 2 \left\{ \log \lambda + (1 - \tau) \mathbb{E}[\log w^C] + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ & \text{s.t.} \quad 2 \left\{ \mathbb{E}[w^C] \bar{h} - \lambda \mathbb{E}[(w^C)^{1-\tau}] \bar{h}^{1-\tau} - g \right\} = 0 \end{aligned}$$

This problem is identical to R1 except that  $w$  is replaced by  $w^C$ . ■

**Lemma 4.** *The earnings-based dynamic Ramsey problem is not isomorphic to the static Ramsey problem.*

**Proof.** From (2.6), the value function for the household under a progressive labor tax is:

$$U^L(w; \lambda, \tau) = 2 \log \lambda + 2 \log \left( \frac{(w_1 h_1^*)^{1-\tau} + (w_2 h_2^*)^{1-\tau}}{2} \right) - \phi \frac{h_1^{*(1+\gamma)}}{1 + \gamma} - \phi \frac{h_2^{*(1+\gamma)}}{1 + \gamma}$$

After some algebra, we obtain:

$$U^L = 2 \left\{ \log \lambda + (1 - \tau) \log (\Omega(w, \tau) w^L) + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \right\}$$

where  $w^L$  is the agent's "pseudo-static" wage:

$$w^L = \left[ w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\gamma+\tau}} \right] \left[ 1 + \left( \frac{w_2}{w_1} \right)^{\frac{(1-\tau)(1+\gamma)}{(\tau+\gamma)}} \right]^{\frac{-1}{1+\gamma}} 2^{\left( \frac{-\gamma}{1+\gamma} \right)}$$

and  $\Omega$  is defined as follows:

$$\Omega(w, \tau) = \left[ \left( \frac{1}{2^\tau} \right) \left( w_1^{1-\tau} + \left[ w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\gamma+\tau}} \right]^{1-\tau} \right) \left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\gamma+\tau}} \right)^{-(1-\tau)} \right]^{\frac{1}{1-\tau}}$$

The function  $\Omega$  has the following form:

$$\Omega^p = 2^{p-1} (a^p + b^p) (a + b)^{-p} = \left( \frac{a^p + b^p}{2} \right) \left( \frac{a + b}{2} \right)^{-p} \leq \left( \frac{a + b}{2} \right)^p \left( \frac{a + b}{2} \right)^{-p} = 1$$

where the inequality follows from Jensen's inequality. Thus,  $\Omega$  is less than unity for all wage paths, holding strictly whenever wages are not constant.

The government's Ramsey problem is

(RL)

$$\begin{aligned} \max_{\tau, \lambda} & \quad 2 \left\{ \log \lambda + (1 - \tau) \mathbb{E} \log (\Omega w^L) + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ \text{s.t.} & \quad 2 \left\{ \mathbb{E}[\square w^L] \bar{h} - \lambda \mathbb{E}[(\Omega w^L)^{1-\tau}] \bar{h}^{1-\tau} - g \right\} = 0 \end{aligned}$$

This problem is not identical to the static analogue. It looks very much like R1 but with  $w$  replaced by  $\Omega w^L$ , except that the  $\Omega$  is missing in one spot (the red rectangle).

■

**Proposition 1.** *A period-by-period tax can replicate a progressive tax on lifetime earnings if it is based on current consumption but not if it is based on current earnings.*

**Proof.** This follows directly from Lemmas 3 and 4. ■

The analysis so far has yielded two reasons for preferring a consumption base over a labor income base. First, consumption taxes do not distort intertemporal work decisions. Households work fewer lifetime hours, but allocate their efforts more efficiently so that lifetime output is higher. Second, a consumption tax allows the government to assign tax liabilities according to lifetime resources. As a result, the government’s redistributive aims can be pursued in a more targeted fashion. On both fronts—incentives and redistribution—the case for a progressive consumption tax appears strong.

Strong, but incomplete. While a tax on consumption is indeed equivalent to a tax on lifetime earnings, a tax on lifetime earnings is not equivalent to a tax on the *path* of earnings. There is information in the parts that is lost in the whole.<sup>13</sup> If a labor income tax manages to exploit that information in some way, then that must be balanced against the aforementioned advantages of consumption taxation.

Lemma 5 shows that under a certain restriction on the distribution of wage profiles  $F$ , it can be shown that switching from an earnings base to a consumption base is welfare-improving.

**Lemma 5.** *Let Assumption 1 be satisfied (see below). Then a consumption tax with progressivity  $\tau$  is strictly superior to a labor income tax with progressivity  $\tau$ , for all  $\tau > 0$ .*

*Proof.* Consider again the tax planner’s problem under a consumption tax (RC) and a labor income tax (RL). Using the government budget constraint to eliminate  $\lambda$

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<sup>13</sup>Recall again the lesson from Kocherlakota (2005) and related literature that optimal taxes in a given period usually depend on the household’s labor income in that period *and* all previous periods. There are circumstances in which a cumulative lifetime tax is sufficient (Werning, 2007), but these are not general.

(leaving just one free tax parameter, viz.,  $\tau$ ), we can express social welfare as a function of tax progressivity. Respectively for the two tax bases:

$$\begin{aligned}
V^C(\tau) &= 2 \left\{ \log \left( \frac{\mathbb{E}[w_C] \bar{h} - g}{\mathbb{E}[(w_C)^{1-\tau}] \bar{h}^{1-\tau}} \right) + (1 - \tau) \mathbb{E}[\log w_C] \right. \\
&\quad \left. + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\
V^L(\tau) &= 2 \left\{ \log \left( \frac{\mathbb{E}[w_L] \bar{h} - g}{\mathbb{E}[(\Omega w_L)^{1-\tau}] \bar{h}^{1-\tau}} \right) + (1 - \tau) \mathbb{E} \log (\Omega w_L) \right. \\
&\quad \left. + \left( \frac{1 - \tau}{1 + \gamma} \right) [\log(1 - \tau) - \log \phi - 1] \right\}
\end{aligned}$$

Let  $\Delta(\tau)$  denote the (halved) difference in social welfare between the two tax regimes given a common choice of  $\tau$ . Eliminating common terms, we obtain:

$$\begin{aligned}
\Delta(\tau) &= \left\{ \log(\mathbb{E}[w_C] \bar{h} - g) - \log(\mathbb{E}[(w_C)^{1-\tau}]) + \mathbb{E}[\log w_C^{1-\tau}] \right\} \\
&\quad - \left\{ \log(\mathbb{E}[w_L] \bar{h} - g) - \log(\mathbb{E}[(\Omega w_L)^{1-\tau}]) + \mathbb{E}[\log(\Omega w_L)^{1-\tau}] \right\}
\end{aligned}$$

Since  $\log(\cdot)$  is an increasing concave function, and  $E[w_C] > E[w_L]$ , we have:

$$\begin{aligned}
\Delta(\tau) &> \left\{ \log \mathbb{E}[w_C] - \log \mathbb{E}[w_C^{1-\tau}] + \mathbb{E} \log(w_C^{1-\tau}) \right\} - \left\{ \log \mathbb{E}[w_L] - \log \mathbb{E}[(\Omega w_L)^{1-\tau}] \right. \\
&\quad \left. + \mathbb{E} \log(\Omega w_L)^{1-\tau} \right\} \\
&= \left\{ \log \mathbb{E}[w_C] - \log \mathbb{E}[w_L] \right\} + \left\{ \mathbb{E} \log(w_C^{1-\tau}) - \log \mathbb{E}[w_C^{1-\tau}] \right\} \\
&\quad - \left\{ \mathbb{E} \log(\Omega w_L)^{1-\tau} - \log \mathbb{E}[(\Omega w_L)^{1-\tau}] \right\} \\
&> \left\{ \mathbb{E} \log(w_C^{1-\tau}) - \log \mathbb{E}[w_C^{1-\tau}] \right\} - \left\{ \mathbb{E} \log(\Omega w_L)^{1-\tau} - \log \mathbb{E}[(\Omega w_L)^{1-\tau}] \right\}
\end{aligned}$$

Jensen's inequality and the strict concavity of the log-function imply that both bracketed differences are negative. To go further, recall that  $w_C \geq w_L \geq \Omega w_L$  for all  $w$ ,

holding with equality if and only if the wage path is constant. Thus, for any wage path, we can write  $\hat{w} = w_C^{1-\tau}$  and  $(\Omega w_L)^{1-\tau} = \kappa \hat{w}$ , where  $0 < \kappa \leq 1$ . Adopting this simplified notation:

$$\begin{aligned}
\Delta(\tau) &> \{\mathbb{E} \log \hat{w} - \log \mathbb{E} \hat{w}\} - \{\mathbb{E} \log(\kappa \hat{w}) - \log \mathbb{E}[\kappa \hat{w}]\} \\
&= \{\mathbb{E} \log \hat{w} - \log \mathbb{E} \hat{w}\} - \{\mathbb{E} \log \kappa + \mathbb{E} \log \hat{w} - \log(\mathbb{E}[\kappa] \mathbb{E}[\hat{w}] + Cov(\kappa, \hat{w}))\} \\
&\quad \pm \log \mathbb{E} \hat{w} \\
&= \log(\mathbb{E}[\kappa] \mathbb{E}[\hat{w}] + Cov(\kappa, \hat{w})) - \mathbb{E} \log(\kappa) - \log \mathbb{E}[\hat{w}]
\end{aligned}$$

If  $Cov(\kappa, w_C) \geq 0$  then:

$$\Delta(\tau) \geq \log(\mathbb{E}[\kappa] \mathbb{E}[\hat{w}]) - \mathbb{E} \log \kappa - \log \mathbb{E} \hat{w} = \log \mathbb{E}[\kappa] - \mathbb{E} \log(\kappa) > 0$$

where the final inequality follows from Jensen's inequality. Under these conditions, a consumption tax with parameter  $\tau$  is superior to a labor income tax with the same parameter. In fact, there must exist some  $\delta > 0$  so that the result goes through as long as  $Cov(\kappa, w_C) > -\delta$ .  $\square$

**Proposition 2.** *Let Assumption 1 be satisfied (see below). Then an optimal progressive consumption tax is welfare-superior to an optimal progressive labor income tax.*

*Proof.* Let  $\tau_L^*$  denote the optimal progressivity of a labor income tax. It follows directly from Lemma 5 that social welfare would be higher under a consumption tax with progressivity  $\tau_L^*$ . *A fortiori*, an optimized consumption tax must be better than an optimized labor income tax.  $\square$

The proof for Lemma 5 relies upon the following assumption.



**Assumption 1.**  $Cov(\kappa, w_C) \geq 0$ , where  $\kappa$  and  $w_C$  are defined as above.

What does it mean for  $Cov(\kappa, w_C)$  to be non-negative? Note that  $w_C$  reflects undistorted lifetime earnings capacity while  $\kappa \in (0, 1]$  reflects the combined penalty imposed on households with uneven wage profiles when earnings are subject to progressive taxation. The covariance is positive when higher pseudo-static wages are associated with *lower* penalties. Thus, Assumption 1 means that low-wage profiles must not be especially flat compared with high-wage profiles.

To see why this matters, imagine that there are two classes of households. Low-type households earn the same low wage in both periods. High-type households earn high but variable wages. In this world, low-wage profiles are flat wage profiles, implying that  $Cov(\kappa, \hat{w})$  is negative. Assumption 1 is not satisfied.

What happens when the government switches the tax base from labor income to consumption, *keeping tax parameters fixed*? The impact on low types is nil. Since their wages are constant over time, they neither borrow nor save and consume what they earn in each period. Consequently, they are unaffected by the change in the statutory tax base. In contrast, high-type households benefit from improved incentives and insurance, leading to higher pre- and post-tax lifetime earnings. But because tax liabilities tend to fall when the tax base is smoothed—as it is for high types in this example—it is possible if not likely that government revenues will fall. The only way to re-balance the budget without changing  $\tau$  is to lower  $\lambda$ . And this makes the low types strictly worse off, which is especially bad from a social welfare perspective.

The problem here is that the tax penalty imposed on agents with fluctuating productivity changes the *effective* progressivity of the tax. In particular, when uneven wage profiles tend to be high wage profiles, there are two ways to amplify the redistributive

function of the tax code: (1) increase  $\tau$ ; and (2) tax earnings instead of consumption. In principle, the government could maintain budget balance by adjusting  $\tau$  instead of  $\lambda$ , or by adopting a more flexible tax function. But these strategies, however sensible in practice, would make the problem altogether intractable and preclude any possibility of establishing a result like Lemma 5. Assumption 1, then, should be thought of as a *sufficient* condition to obtain a *stronger-than-needed* result. It bears little if at all on the essential intuition underlying the appeal of progressive consumption taxation.

## 2.5. What if Consumption Is Not Constant?

It is no accident that optimal consumption paths in the model are constant; this was by design. A critical reader may wonder if any of the results rely upon this abstraction. In this section, I generalize the model to allow for upward- and downward-sloping consumption paths and show how the tax planner can accommodate for age-varying expenditure patterns when designing a progressive consumption tax.

### 2.5.1. The Household's Modified Problem

Let  $\beta$  denote the household's discount factor. In the benchmark model I imposed  $\beta = 1$ , leading to constant consumption streams; I now relax this assumption and admit any  $\beta > 0$ . The household is subject to consumption taxation and its maximization problem is:

$$\begin{aligned}
 U^\beta(w) = \max_{x_1, x_2, h_1, h_2} & \quad \log c_1 + \beta \log c_2 - \phi \frac{h_1^{1+\gamma}}{1+\gamma} - \beta \phi \frac{h_2^{1+\gamma}}{1+\gamma} \\
 \text{(H}\beta\text{)} \quad \text{s.j.} & \quad x_1 + x_2 = w_1 h_1 + w_2 h_2 \\
 & \quad c_j = \lambda x_j^{1-\tau} \quad j = 1, 2
 \end{aligned}$$

The solution to the household's problem is characterized by the following Euler equations for hours, expenditure and consumption.

$$h_2 = \left[ \left( \frac{1}{\beta} \right) \left( \frac{w_2}{w_1} \right) \right]^{\frac{1}{\gamma}} h_1 \quad x_2 = \beta x_1 \quad c_2 = \beta^{1-\tau} c_1 \quad (2.8)$$

Unlike before, expenditure and consumption now generally follow non-constant paths. Notice that the consumption stream  $\{c_1, c_2\}$  is distorted by progressive taxation whenever  $\beta \neq 1$ , that is, whenever non-constant consumption is optimal. From (2.8), we have:

$$c_2 = \beta^{1-\tau} c_1 \implies \frac{1}{c_1} \neq \frac{\beta}{c_2} \iff u_{c_1} \neq \beta u_{c_2}$$

This wedge in the household's Euler equation is analogous to the one imposed on labor supply decisions by progressive labor income taxation (see Lemma 1). The underlying problem is the same, viz., the application of a progressive rate schedule to a fluctuating base.

There are fiscal tools, however, that will allow the tax planner to correct the intertemporal distortion of consumption. I focus attention on two remedies: (1) age-dependent taxation; and (2) endogenous tax smoothing. I show that both policies restore the planner's ability to replicate a tax on lifetime resources.

### *Age Dependence*

The idea of conditioning taxes on age is not new. Several papers have touted the merits of age-dependent income taxation, with Weinzierl (2011) being a leading example. The key lesson from this literature is that age dependence allows the tax code to accommodate for how the distribution of skills and wages changes over the life cycle.

For example, if the famous “no distortion at the top” result applies, then it should apply separately at each age. But this would be impossible to implement if taxpayers of all ages were subject to the same rate schedule.

A similar principle applies to consumption taxation. If consumption increases over the life cycle (as it would if  $\beta > 1$ ), then a highly-endowed young agent and a modestly-endowed old agent might incur the same expenditures. We might wish to treat them differently for redistributive purposes, but would be unable to do so if constrained by an age-independent system.

Fortunately, it is relatively straightforward to introduce age-dependent average tax rates in this setting. Let  $\tau$  be universal but allow  $\lambda$  to vary with age. In particular, consider:

$$\begin{aligned}\lambda_1 &= \lambda \\ \lambda_2 &= \beta^\tau \lambda\end{aligned}\tag{2.9}$$

The following proposition describes how adjusting the tax parameters in this way eliminates the intertemporal distortion.

**Proposition 3.** *When consumption paths are non-constant, an age-dependent period-by-period consumption tax can:*

1. *Eliminate the intertemporal distortion on consumption; and*
2. *Replicate a progressive tax on lifetime earnings.*

*Proof.* The proof is similar to earlier ones. I relegate it to the appendix. □

### 2.5.2. Hybrid Taxation

The tax-base question is meaningful in dynamic settings only because of the implicit restriction to period-by-period taxation. If households were taxed once, at death, then the question would be moot—constrained optimal behaviour ensures that lifetime consumption equals lifetime earnings.<sup>14</sup> In the absence of direct lifetime taxation, the consumption base is preferred because it fluctuates less from year to year. By taxing agents according to a relatively smooth base, the tax planner can still design a system that is progressive with respect to lifetime resources.

But when consumption is less than perfectly flat (as when  $\beta \neq 1$ ), tax liabilities vary from year to year and the tax system begins to diverge from its lifetime ideal. One way to fix this problem is to let taxes depend on age, as documented in the previous subsection. Alternatively, the government can let households smooth their tax liabilities directly. This can be accomplished fairly easily by giving households access to both qualified and non-qualified tax treatments. Under this regime, households decide for themselves how much of their net saving to deduct (and, similarly, how much of their net borrowing to include). The tax system would be neither earnings-based nor consumption-based, but rather a *hybrid* of the two.

The household's problem under the hybrid system is written as:

$$\begin{aligned}
 U^2(w) = \max_{x_1, x_2, h_1, h_2, s} & \quad \log c_1 + \beta \log c_2 - \phi \frac{h_1^{1+\gamma}}{1+\gamma} - \beta \phi \frac{h_2^{1+\gamma}}{1+\gamma} \\
 \text{(Hh)} \quad \text{s.j.} & \quad x_1 + x_2 = w_1 h_1 + w_2 h_2 \\
 & \quad c_1 = \lambda x_1^{1-\tau} - s \\
 & \quad c_2 = \lambda x_2^{1-\tau} + s
 \end{aligned}$$

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<sup>14</sup>Notwithstanding bequests given and received, which are absent in this model.

Here, the choice variable  $x$  is re-interpreted as the household's taxable income, that is, earnings less net saving into *qualified* accounts. The new choice variable  $s$  denotes net saving into *non-qualified* accounts. The key difference between this model and the benchmark model is that the household's tax smoothing is not constrained by its chosen consumption pattern. The intertemporal budget constraint ensures that all earnings are declared taxable at some point, but the household is free to use non-qualified saving and borrowing to shift consumption across time without triggering any consequences for its tax return.

The following proposition describes how hybrid taxation produces the same benefits as age-dependence.

**Proposition 4.** *When consumption paths are non-constant, a period-by-period hybrid tax can:*

1. *Eliminate the intertemporal distortion on consumption; and*
2. *Replicate a progressive tax on lifetime earnings.*

*Proof.* I relegate the proof to the appendix. □

### 2.5.3. Age Dependence v. Hybrid Taxation

While both solutions correct for year-to-year changes in household consumption, hybrid taxation holds two advantages over age dependence. The first is practical. The status quo is already a hybrid system. By using a mixture of instruments, a taxpayer can smooth her tax liabilities over time, at least in part. Reforming the tax system along the lines of the hybrid tax model is therefore a matter of refinement, not overhaul. Age dependence, on the other hand, is largely absent from the actual tax code. Introducing age-conditioned rate schedules into the tax system is likely to prove very

difficult, both administratively and politically.

The second advantage lies in hybrid taxation's potential to address problems outside the scope of this simple model. Age dependence only works if consumption varies in a predictable age-related fashion, as it does here. It would not work if consumption varied for idiosyncratic reasons. Suppose, for example, that households are subject to preference shocks: the marginal utility of consumption is especially high in some periods and especially low in others, leading to year-to-year variation in consumption. An age-dependent tax system cannot smooth these sorts of fluctuations. It accounts only for trends, not deviations.

Now consider a household's likely behaviour under hybrid taxation. In periods of especially low expenditures, the household makes unregistered savings. In so doing they forgo the savings deduction and inflate the current tax base. But since their marginal tax rate is relatively low in such periods the increase is muted. Then, in periods of unusually high expenditures, the household can finance its spending needs by drawing down its unregistered savings. This pattern of saving and dis-saving allows the household to 'pre-pay' future tax liabilities when it can exploit more favourable tax rates.

Unanticipated shocks are not the only reason why household expenditures vary from year to year. Spending also fluctuates if households make lumpy purchases of large consumer durables, most notably owner-occupied housing. Imagine, for instance, if households had to include downpayments in their tax base in the year of purchase. This would result in large and unfair spikes in taxes owed. But the problem only arises if all financial assets are treated as qualified accounts. If the household could instead save for its downpayment through non-qualified accounts, it could avoid any concurrent tax consequences when making a purchase.

It is true that the dual-treatment option pushes the system away from a pure consumption tax base. But taxing consumption was never the end, only a means. The goal is to build a period-by-period tax system that can redistribute resources with minimal distortion. Any measure that enables households to smooth tax liabilities over time aids in that regard. I discuss some of the issues in more detail in the next chapter, which covers the practical administration of a progressive consumption tax.



## CHAPTER 3 : On the Feasibility of Progressive Consumption

### Taxation

But what I should lay down as a perfectly unexceptionable and just principle of income tax, if it were capable of being practically realised, would be to exempt all savings... I am laying this down merely as the theory of a perfectly just income tax. I am quite aware that it cannot be fully carried out.

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John Stuart Mill, *Report from the Select Committee* (1861)

It is strange that those who recognize that “spendings” are the only fair and logical base for taxable income often fail to realize how practical and simple is its application.

---

Irving Fisher and Herbert Fisher, *Constructive Income Taxation* (1942)

The previous chapter laid out the case for basing progressive tax structures on consumption instead of labor income. In this chapter, I discuss the administration and operation of such a scheme.

### 3.1. Indirect Consumption Taxation: The RST and the VAT

The most familiar forms of consumption taxation are the retail sales tax (RST) and the value-added tax (VAT). These are general consumption taxes that apply to a broad range of goods and services. Most jurisdictions also levy taxes on specific good and services through the use of import duties, excise taxes (e.g. gasoline, cigarettes), and taxes on specific services (e.g. financial services, hotel accommodations). All of these taxes are indirect, in that they are levied against transactions, products, or

events, rather than persons. In this section I briefly discuss the RST and the VAT.

### *3.1.1. Retail Sales Tax*

The retail sales tax is the simplest version of a general consumption tax. It is imposed only on the sale of final goods and services and is remitted to the government by sellers. No tax is charged if the purchaser intends to resell the item or use it as a business input. To distinguish between end-users and intermediate-users, businesses and other non-consumers are typically required to present a “resale certificate” or equivalent evidence when buying an item that would normally be subject to tax. In the absence of such evidence, the retailer collects the tax by default.

While no RST has ever been adopted federally, subnational legislators are more enthusiastic about its merits, so much so that sales taxes are in force almost everywhere in the country. Including a population-weighted average of local taxes, the combined statutory rate ranges from 0% in four hold-out states (Delaware, Montana, New Hampshire and Oregon), to 9.5% in a trio of southern states (Arkansas, Louisiana and Tennessee). The population-weighted average across all states is 7.4%. The RST is far less popular internationally. Of the 37 countries in the OECD, only the U.S. employs an RST as its principal form of consumption tax.

The RST has (at least) two major drawbacks. First, because only final goods and services are subject to taxation, it becomes necessary to discriminate between purchasers. This necessitates the creation of a costly administrative apparatus to enable exemptions and track transactions. Because exemption coverage in the US is less than complete in practice, the RST inadvertently leads to substantial taxation of business inputs and goods for resale (OECD, 2020), in violation of standard proscriptions against the taxation of intermediate goods (Diamond and Mirrlees, 1971).

Second, and relatedly, final-stage collection creates opportunities for tax evasion since the system necessarily relies on honest and thorough record-keeping by retailers, many of whom are small businesses. This problem is particularly acute for services, which are inherently intangible and therefore less easily monitored. Because the incentive to avoid and evade increases with the rate of taxation, the feasible scale of the RST is arguably limited (Murray, 1997; Gale, 2005).

### *3.1.2. Value Added Tax*

An alternative form of general consumption tax is the value-added tax. Its central and distinguishing feature is the multi-stage process by which it is collected. Instead of a single levy at the final point-of-sale, the VAT is applied at every point along the supply chain. Each trader in the chain—whether manufacturer, wholesaler or retailer—participates by paying tax on its purchases and collecting tax on its sales. Because a business is allowed to deduct the tax charged on its inputs, the tax effectively applies only to the economic value added at each stage of production or distribution, hence the name. Suppose, for example, that the VAT is 20%, and a business purchases \$1000 of inputs, paying an additional \$200 in tax. Suppose further that it sells its outputs for \$1500, collecting an additional \$300 in tax. When the business files its return with the tax authority, it remits a net tax of \$100, exactly in line with the \$500 of value-added that it produced.

There are two main mechanisms for operating the staged collection process. The invoice-credit method relies on invoices passed between traders at each transaction. These invoices are used by purchasers to submit claims for credit against taxes paid on inputs. The subtraction method calculates assessments according to entity-based measures of taxable sales and purchases. Almost all VATs are administered using the

invoice-credit method.<sup>1</sup>

The VAT solves both drawbacks of the RST mentioned above. Because it applies to all sales, there is no need to make legal distinctions between intermediate goods and final goods. This eliminates the need for exemption certificates and mitigates the risk of unintended taxation of intermediate goods. Moreover, the credit-invoice method doubles as a built-in enforcement mechanism, thereby eliminating a major avenue for avoidance and evasion. By linking one trader's credit to another's obligation, the system is designed for relatively easy cross-checking. And because claims for tax credits require appropriate documentation, both parties are incentivized to properly report transactions to the relevant authority.

For these reasons, the VAT has proven quite popular internationally. First implemented by France in 1954, a VAT of some kind has been adopted by every OECD country except the U.S., accounting for more than one-fifth of all tax revenue in these economies. The unweighted average tax rate across the OECD is close to 20%, substantially higher than the average sales tax rate in the U.S. At least 170 countries have adopted a VAT worldwide, up from 50 countries three decades ago. Besides its administrative advantages over the RST, the global appeal of the VAT is linked to its neutral treatment of imports, an important feature in an era of steady trade liberalization. The adoption of the VAT across the European Union, for instance, is directly tied to the development of its internal market.<sup>2</sup>

It should be noted that the widespread adoption of the VAT has not diminished the

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<sup>1</sup>See Schenk et al. (2015) for a detailed discussion of tax liability calculations.

<sup>2</sup>The 1957 Treaty of Rome established the European Economic Community, the predecessor of the EU, and led to the mandatory adoption of the VAT. Article 99 of that treaty states: "The Commission shall consider in what way the laws of the various Member States concerning turnover taxes, excise duties and other forms of indirect taxation, including compensatory measures applying to exchanges between Member States, can be harmonised in the interest of the Common Market."

importance of income taxes. Tax authorities have typically used the VAT to replace turnover taxes, excise taxes and other taxes on specific goods and services, not taxes on income or property. (See Figure 15 in the appendix.)

### *3.1.3. Indirect Consumption Taxes and Progressivity*

The case for consumption taxation presented in Chapter 2 presumed a progressive tax system. It is natural to ask, then, whether these familiar forms are appropriate fiscal instruments. As indirect taxes, both the single-rate RST and the single-rate VAT are proportional by construction. They take no account of an individual taxpayer's personal circumstances or ability to pay. Moreover, if the marginal propensity to consume is higher for poor households, than general consumption taxes are regressive with respect to income. This perceived regressivity is one of the chief complaints about taxes of this sort (Caspersen and Metcalf, 1994).

One way to bypass the proportionality problem is to set different rates for different categories of goods and services, with exemptions or zero-ratings for necessities<sup>3</sup> and very high rates for luxuries. To the extent that consumption patterns vary with socio-economic status, a system of differentiated tax rates could bring about the desired degree of progressivity. Most state sales taxes and European VATs have adopted this approach to some degree in their implementations.

But rate differentiation dissatisfies for several reasons. For one thing, it violates the principle of uniform commodity taxation. Atkinson and Stiglitz (1976) showed that indirect taxes are superfluous whenever tastes for commodities are homogeneous, utility is separable in consumption and leisure, and the government has access to flexibly non-linear taxation of earnings.<sup>4</sup> Under these conditions, rate differentiation

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<sup>3</sup>The difference between zero-ratings and exemptions is discussed in Schenk et al. (2015, ch. 9).

<sup>4</sup>For a clear exposition and simple proof of this result, see Laroque (2005). For variations on

only serves to distort household consumption decisions. The Atkinson-Stiglitz result leaves open the possibility that such taxes could play a useful role when tastes are heterogeneous. But even then, tastes would have to covary with unobserved ability in predictable ways, and there there is no *prima facie* reason to suspect this is the case. And even if it were the case, there is still the problem of pinning down the correct rates for different categories, almost certainly an impossible task given the sheer number of different goods and services. Finally, a highly-differentiated RST or VAT would be subject to constant political pressure as producers and consumers of different kinds of goods lobby for systemic adjustments in their favor.

In his text on public finance, Arthur Pigou raised these and many other objections to rate-differentiation, including concerns about the difficulty of targeting certain kinds of services enjoyed by the rich (e.g. foreign travel) and the ease of raising revenue from the most basic items (e.g. food staples). He writes:

The construction of a *progressive* expenditure tax would present other and more formidable difficulties; for it would be necessary to impose upon each commodity, not a single rate, but a number of different rates adjusted to the incomes of the various purchasers. Such an arrangement would be absolutely unworkable... It is idle, therefore, to look in practice for a system of commodity taxes that shall be better than proportionate.<sup>5</sup>

Consumption tax designers have, for the most part, failed to heed Pigou's advice. Most modern general consumption tax systems are riddled with exemptions, reduced rates, and other base-narrowing interventions. In the UK, for example, raw and unprocessed nuts are zero-rated. A fruit and nut mix is zero-rated too, but only if

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this theme, see also Atkinson (1977) and Deaton (1979).

<sup>5</sup>Arthur C. Pigou, *A Study in Public Finance*, p. 123.

the nuts comprise less than a quarter of the whole by weight. Roasted, coated or salted nuts are subject to the standard rate. Unless, of course, they are unshelled, in which case a zero-rating applies. Similar examples abound in every jurisdiction that employs a RST or VAT. And yet evidence suggests that these administrative nightmares do not reduce the regressivity of the tax as intended (de la Feria and Walpole, 2020).

### 3.2. Direct Consumption Taxation: The Cash-Flow Tax

Because it is difficult to deviate very far from linearity with either an RST or a VAT, they are unlikely instruments for establishing a progressive consumption tax. Alternatively, a *direct* tax on spending—that is, one whose application is personal rather than transactional—could be levied at graduated rates in any arbitrary way. In that case, higher-spending households could be made to contribute proportionately greater amounts to the public treasury, with the degree of progressivity controlled by the statutory rate schedule. Early advocates for this kind of tax include many prominent economists of the 19th and early 20th centuries, including John Stuart Mill, Alfred Marshall and Arthur Pigou. Their enthusiasm was muted, however, by concerns of measurement and feasibility. It was considered both unrealistic and unreasonable to expect taxpayers to keep sufficiently complete records so as to accurately monitor spending from year to year. Testifying before the Colwyn Committee on National Debt and Taxation in 1924, John Maynard Keynes characterized a system of this sort as “theoretically sound” but “practically impossible”. In his seminal book-length treatment of the topic, Nicholas Kaldor (1955) summarizes the general attitude amongst economists of that era as follows:

Full exploration of the problem was delayed by the persistent conviction

that studying the merits of such a tax was largely an academic exercise—for it was taken for granted that the administrative difficulties involved in assessing people on their spending were too great for this “ideal” system of taxation to be put into practice.<sup>6</sup>

Fortunately, the solution to this problem is easily grasped once one observes that only two pieces of information are needed to calculate a household’s consumption expenditures: (1) the sum of earnings, incomes, transfers and other receipts; and (2) the sum of net contributions to savings and investment. After subtracting the second sum from the first, what remains must equal consumption. The direct consumption tax operates, therefore, very much like the existing income tax, except that taxpayers are allowed a deduction for net savings into “qualified” accounts. Instead of recording thousands of individual transactions, only a small number of data points are needed, many if not most of which are already collected by the existing administrative apparatus. After all, this type of treatment is already granted to pension plans and retirement accounts like the IRA and the 401(k). The conceit of the direct consumption tax is to do away with these special tax-advantaged programs and their limits, restrictions and penalties, and instead treat all savings in this manner.<sup>7</sup>

The idea of using the household’s budget constraint to recover consumption for the purposes of personal taxation is closely associated with Irving Fisher. He and his brother, Herbert Fisher, authored an influential text on the subject of income taxation in which they write the following:

We propose, then, to reckon taxable spendings, not by adding together the separate items spent for food, clothing, rent, amusements, etc., but by

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<sup>6</sup>Nicholas Kaldor, *An Expenditure Tax* (London: Unwin University Books, 1955), p. 11.

<sup>7</sup>For detailed descriptions of the operation of a cash-flow tax, see Kaldor (1955), Andrews (1974), United States Treasury (1977) and Graetz (1979).



adding together the *gross receipts from all sources* and then deducting all items of outgo *other* than “spendings.” The chief deductions under this proposal are: investments, taxes paid during the taxable year, and proper exemptions for the taxpayer and his dependents. . . The application of this simple procedure to the tax problem is the only novelty in the present proposal. Moreover, the data needed for this calculation are considerably more trustworthy than those used in our present income taxes, which often depend on debatable estimates.<sup>8</sup>

The Fisher brothers called their tax plan a “spendings tax”, but the idea has acquired many other names over the years as other academics and thinkers have championed its cause, including “expenditure tax” (Kaldor, 1955), “consumption-type personal income tax” (Andrews, 1974), “savings-exempt income tax” (Domenici, 1994), “consumed income tax” (Goldberg, 2013), and *Verbrauchseinkommensteuer* (Schumpeter). My preferred label is “cash-flow consumption tax”, the name used in *Blueprints for Basic Tax Reform* (1977) and one that highlights its key features. First, that it is indeed a consumption tax and not an income tax, despite a practical application that deviates from the existing tax system mostly by degree and not in kind. As such it should be considered alongside the RST and the VAT as an alternative to a labor income tax. And second, its use of cash-flow accounting principles to indirectly measure a taxpaying unit’s consumption expenditures. In what follows “cash-flow consumption tax” or, more briefly, “cash-flow tax” will be my standard choice of nomenclature, but all these names should be considered synonymous.

The key difference between the indirect consumption taxes and the cash-flow tax is that the latter can be applied at *graduated* rates. Thus, if a policy-maker desires

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<sup>8</sup>Irving Fisher and Herbert Fisher, *Constructive Income Taxation* (New York: Harper and Brothers, 1942), p. 6.

flexibility in setting the progressivity of the tax system, she is well-advised to favor the latter form. And since this dissertation concerns settings where taxes are allowed to be non-linear, it is the cash-flow form that I have in mind throughout.

### 3.3. The Legislative History of the Cash-Flow Consumption Tax

The history of the modern federal income tax begins with the ratification of the Sixteenth Amendment to the United States Constitution in 1913. While income taxes had been collected sporadically throughout the previous century (most notably during the Civil War and its aftermath), the federal government had theretofore relied on tariffs and excise taxes to finance its limited activities. In any case, there were constitutional obstacles to the adoption of an income tax at the national level.<sup>9</sup> The Sixteenth Amendment cleared these obstacles, paving the way for the government to establish a federal income tax, a power it exercised later that same year with the passage of the Revenue Act of 1913. These acts greatly enhanced the U.S. Treasury's capacity to raise revenue, but also introduced a new hobby-horse for policy-makers and scholars to ride: fundamental tax reform.

Over the past century, several attempts have been made to reform the federal income tax code along the lines of a cash-flow consumption tax. The earliest occurred in 1921 when Republican Congressman Ogden Mills proposed a progressive "spendings tax" as a partial replacement for the existing income tax. Treasury Secretary Henry Morgenthau advanced a similar plan in 1942 in the wake of the country's entry into the Second World War. Both the 1921 and 1942 proposals died in committee, unable

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<sup>9</sup>After dozens of misfires, Congress successfully passed a federal income tax bill in 1894, but the Supreme Court of the United States struck it down less than a year later in *Pollock v. Farmers' Loan & Trust Company*, 157 U.S. 429 (1895). In the Court's opinion, the income tax violated the constitutional requirement that all direct taxes be apportioned among the states according to population.

to secure a sufficiently broad coalition of support.

Renewed interest in fundamental tax reform during the 1970s precipitated a thorough investigation by the U.S. Treasury Department into the merits and feasibility of progressive consumption taxation. After initial reports from the Advisory Commission on Intergovernmental Relations (1974) and the Office of Tax Analysis (1977), the case for a cash-flow tax was laid out more rigorously in *Blueprints for Basic Tax Reform*, with economist David Bradford as lead author.<sup>10</sup> The first version of the document was published in 1977, with a revised edition appearing seven years later in advance of the Tax Reform Act of 1986. The Reagan administration ultimately rejected personal cash-flow taxation, choosing instead to streamline the existing tax system by drastically reducing marginal rates and by eliminating many deductions, exemptions and loopholes. That said, several consumption-tax elements were passed into law during this era. Most significantly, the introduction and refinement of the IRA and the 401(k) between 1974 and 1986 transformed the tax code into the hybrid system we recognize today.

The 1986 reforms were not resilient, however, and fundamental tax reform was back at the top of the political agenda within a decade. In April 1995, a bipartisan trio of Senators co-sponsored a bill proposing a progressive cash-flow consumption tax, which they called the Unlimited Savings Allowance (USA) Tax (Domenici et al., 1995). But as in 1921 and 1942, their proposal never reached the floor of the House or Senate for a vote.

As documented by Bank (2003), each iteration of the expenditure tax proposal failed

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<sup>10</sup>Around the same time, a similarly sweeping review of tax policy was undertaken in the United Kingdom by the Institute of Fiscal Studies under the chairmanship of James Meade. Their report, published as *The Structure and Reform of Direct Taxation*, strongly advised a transition toward a progressive cash-flow consumption tax.

for the same reason: an inability to convince either side of the political spectrum that a cash-flow tax represented a worthy compromise of its political aims. Recall that the essential components of the progressive consumption tax are (1) a graduated rate structure; and (2) the exemption of net savings from the tax base. Opponents on the right applaud the latter but object to the former; they prefer an indirect consumption tax or a flat tax on earnings.<sup>11</sup> Opponents on the left applaud the former but object to the latter; they take exception to wealthy but frugal households avoiding their ‘fair share’ of the tax burden.<sup>12</sup> With both sides unwilling to sacrifice its ideological commitments, the cash-flow tax has not yet gained enough political traction despite bipartisan support among moderates.<sup>13</sup>

Serious proposals for a cash-flow consumption tax have been advanced in other countries as well, including Australia, Denmark, Sweden and the United Kingdom. None was adopted, except for small-scale experiments in India and Sri Lanka in the 1950s that overtaxed those countries’ administrative capacities and were quickly abandoned.

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<sup>11</sup>During during the tax reform craze of the mid-1990s (that is, contemporaneously to the USA Tax proposal), there were at least four separate congressional resolutions for a VAT, three for a Hall-Rabushka style flat tax, and one for a national RST. See Schenk (1996) for a review.

<sup>12</sup>During the 1921 congressional committee hearings, Representative William Stevenson asked: “I wonder how [Mills] would think a man like the late Russell Sage was bearing his part of governmental expenses when he was drawing his millions and living on \$60 a month or thereabouts, and all of that exempt?” (as quoted in Bank, 2003) A like-minded person today might find an equivalent exemplar in famously frugal Warren Buffett.

<sup>13</sup>It is interesting to consider Bank’s diagnosis of the actual political failures of cash-flow consumption taxation in the United States alongside James Meade’s concerned musings in the preface to *The Structure and Reform of Direct Taxation* (1978, p. xvi):

A possible political reaction to this would, I suppose, be for the “left” to reject it because it gave an opportunity for private capitalist enterprise (as well as for state enterprise and labour-managed enterprise) to invest more and to expand employment opportunities, and for the “right” to reject it because it would hit the rich who were living on inherited property. My hope is that the opposite would happen—that the “left” would welcome the egalitarian overtones and the “right” the opening up of opportunities and incentives for all forms of enterprise. Indeed, if we are to find a reasonable base of political consensus in our mixed economy, I can see no better fiscal contribution to this end than a tax structure of this kind.

### 3.4. Practical Issues

The fundamental idea of cash-flow taxation is to indirectly measure household spending by adding all cash inflows and subtracting all non-consumption cash outflows. In practice, of course, things are less straightforward. Where ambiguities arise, the design of the tax should be guided by its ultimate aim: producing an accurate measure of the taxpayers consumption flow. Lawrence Seidman (1997, p. 72) puts the principle this way:

The key question is not whether an item is ‘income’, but whether it is a cash inflow that must be included in order to yield an accurate computation of consumption. Similarly, the issue is not whether a particular cash inflow item is ‘taxable’. What is taxable is consumption. The term cash inflow should replace ‘income’ on the household tax return.

In this section, I discuss some of the practical issues that relate to the administration of a cash-flow consumption tax. To motivate this discussion, it is helpful to express more formally the extent of the data requirements by writing down a typical household budget constraint:

$$c_t + \Delta d_t = y_t + T_t + Rk_t - k_{t+1} \tag{3.1}$$

where  $c$  denotes non-durable consumption,  $\Delta d$  denotes net purchases of consumer durables,  $y$  denotes labor earnings,  $T$  denotes transfers,  $k$  denotes assets, and  $R$  denotes the gross rate of return.

### 3.4.1. *Measuring Wealth*

One potential problem is immediately apparent from examining the right-hand side of (3.1). In order to calculate consumption through the budget constraint, it seems necessary that we measure wealth. And then we have simply traded one measurement problem (observing thousands of individual consumption transactions) for another (observing and accurately measuring all forms of household wealth).

But this is not a serious problem as it is not necessary to observe  $k_t$ , only  $Rk_t - k_{t+1}$ . The variable we need to track is saving, not wealth. Or more precisely, net saving. Indeed, the cash-flow tax does not even require that we observe all inflows and outflows, only their net difference. A taxpayer might make many deposits into and withdrawals from a qualified savings account through the course of a single tax period, but the only information the tax authority requires is their final sum. In fact, since the observation of  $Rk_t - k_{t+1}$  requires no knowledge of its constituent parts at all, a sensible administrative principle is that only non-zero net cash flows need be reported.

One implication of this principle is that unrealized capital gains (and losses) can be safely ignored for the purpose of cash-flow taxation. While a capital gain does constitute an income flow, it does not constitute a cash flow. Only when the asset is sold and the gains realized must the taxpayer claim it on his tax return. In that case, the taxpayer reports the whole proceed of the sale, not just the realized gain. (Recall that the initial purchase price would have been deducted in the year the taxpayer acquired the asset.) The only case in which it may prove unnecessary to report the sale is if the proceeds are used to purchase another asset. In that case the net saving is zero, and no tax slip need be produced if all transactions occur within the same

account. Thus, if revenue from the sale of an asset generates \$1000, the addition to the taxpayers base is \$1000 regardless of how much constitutes a gain (or loss). If some or all of the \$1000 is used to finance the purchase of a new asset then an offsetting deduction can be claimed and the net impact on the tax assessment is reduced accordingly. Otherwise, the proceeds are counted as consumption expenditures.

The treatment of interest, dividends, pension benefits and other financial incomes is similarly straightforward. Claim all distributions to the taxpayer. Ignore any amount retained within a qualified account or other financial vehicle.

As a rule, the cash-flow tax makes no distinctions between different types of inflows and outflows. In contrast, income tax systems typically make many distinctions between different types of capital income, generating a host of problems and distortions. These problems include the measurement of real capital gains in the presence of inflation, the incentive for unrealized capital gain accrual (lock-in effect), and the bias toward debt financing over equity financing that is embedded in the corporate income tax structure. It is a mistake, however, to conclude that the mere adoption of personal cash-flow taxation solves these problems. The cash-flow tax is, after all, a consumption tax, not an alternative to or substitute for capital income taxes. Capital income amounts are included in the cash-flow tax base only insofar as they reflect accretions to the household's current expenditure capacity. Consequently, the manner in which the cash-flow tax treats financial flows is orthogonal to the aforementioned (and other unmentioned) problems of capital income taxation. These will continue to exist as long as a capital income taxes exist.

### 3.4.2. Borrowing

Looking again at the right-hand side of (3.1), it behooves us to ask what happens if  $k_{t+1} < 0$ . That is, how does the cash-flow tax treat borrowers? The answer is simple: the same way it treats lenders. Recall that the cash-flow consumption tax grants deductions for savings (a cash outflow) but levies taxes on withdrawals (a cash inflow). The same principle applies to borrowing. Since a loan is a cash inflow, it must be added to the tax base. By the same token, repayments of principal and interest are cash outflows and therefore tax-deductible. While this aspect of cash-flow taxation is unfamiliar to the taxpaying public, it is generally conceded to be the correct way of implementing such a tax. In a 1984 report, the U.S. Treasury writes:

The principle of taxing consumption determines the treatment of loans under a consumed income tax. Since repayment of old debt is equivalent to saving, a deduction would be granted for such repayment and for payments of interest; similarly, the proceeds of borrowing would be included in taxable consumption. If the net loan proceeds were not included in the tax base, taxpayers could game the system by borrowing funded depositing them in a qualified account, and taking a deduction for the increase in their saving. Although the present value of the taxes might not be affected, since the taxpayer could not deduct the repayments and interest on the loan, omitting borrowing from the base would enable the taxpayer to postpone the liability. This would disrupt the timing of government receipts and would seem unfair.<sup>14</sup>

Notably, and in keeping with the fundamental principle of cash-flow tax design, only loans used to finance the purchase of goods and services would increase a taxpayer's

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<sup>14</sup>U.S. Treasury, *Tax Reform for Fairness, Simplicity, and Economic Growth* (1984), p. 192



current tax obligation. Loans used to finance the purchase of capital assets would result in no change in tax burden, as the deduction from the investment exactly offsets the inclusion from the loan. A related exception applies when a loan is used to finance the purchase of consumer durables, a topic to which I return in a subsequent subsection.

### *3.4.3. Insurance*

Insurance is an area where it is important to remember that the objective of the cash-flow tax is to approximate a household's consumption in the taxable period. As such, different kinds of insurance should receive different kinds of treatment. Life insurance should be treated like other forms of saving, that is, by deducting premiums and including benefits. This means that the beneficiary of a life insurance policy is liable for a large and immediate tax obligation in the year she receive a payout. But since she can also claim a deduction for any amount saved, the effective increase in her tax obligation is commiserate with her marginal propensity to consume out of wealth. Most other forms of insurance should be ignored, especially health insurance and property insurance. In these cases, the premium should be considered a consumption item, not saving.

### *3.4.4. Consumer Durables*

**Durable Consumption and Tax Smoothing.** The treatment of consumer durables is one of the trickiest practical issues a cash-flow tax designer must consider. The defining feature of a consumer durable is that it generates an ongoing flow of valued services, rather than a momentary burst of consumption. As such, their purchase is simultaneously an act of both spending and saving. This dual role in the households portfolio poses a significant administrative challenge as the tax designer must devise

a way to disentangle the immediate consumption value from the future consumption value. Otherwise the entire tax burden for the consumer durable is felt in a single tax period, which is neither consistent with the guiding principles of the cash-flow consumption tax nor desirable for reasons of equity and efficiency.

One possibility is the application of a depreciation schedule that instructs the taxpayer on how to amortize the cost of the durable good over time. But that approach imposes onerous record-keeping, complicates the assessment of a taxpayer's obligation, and requires many arbitrary decisions by a tax authority, exactly the sort of problems cash-flow taxation is meant to preclude.

Alternatively, the tax system could ignore the problem altogether. This approach is adequate for semi-durables like children's clothes and furnace filters, goods whose lifespans are shorter than the taxable period. This approach is also adequate for small and medium durables like microwaves and vacuum cleaners. Although the expenditure path for any one such item is very lumpy, a household's aggregate expenditure on this class of good is relatively stable from year to year. It is with respect to large durables like vehicles, boats and, especially, housing that cash-flow taxation presents a serious problem. If a taxpayer is unable to claim a deduction for the purchase of a large durable because such transactions are ignored by the tax system, then her tax base in the year of purchase will greatly overstate her actual consumption, creating a disproportionate immediate burden and undermining the purpose of cash-flow consumption taxation.

Amortization and exclusion, then, are both unsatisfactory responses to the problem of durables. What we need is a tax treatment that approximates the consumption flow over time without producing wild swings in an individual's tax base or generating unreasonable administrative cost. Does such a treatment exist? Yes, in two parts.

For concreteness, consider a taxpayer who purchases a car for \$20,000. She finances her purchase with \$8000 cash and a \$12,000 loan, which she repays in six annual instalments of \$2000 (suppose no interest for simplicity of exposition). Recall from a previous subsection that consumer borrowing should generally be treated like other cash flows: include the loan proceeds and deduct the loan repayments. In the case of loans secured against durables, however, the prescribed treatment is the opposite. If both the \$12,000 loan and the \$2000 repayments are excluded, then the system implicitly spreads the tax burden across time. To the extent that the repayment period matches the lifespan of the durable, this method provides a decent approximation to the imputed consumption flow. Seidman (1997, p. 79) recommends the loan-exclusion method, writing:

This treatment postpones the consumer durable tax on the amount equal to the loan. It therefore improves the accuracy of the computation of each year's flow of consumption, appropriately eases the tax in the year of purchase, and spreads it over time as the loan is repaid. Because it improves the accuracy of the measuring the household's annual consumption, I recommend that this treatment be required, not optional.

But what about the \$8000 downpayment? If the taxpayer withdraws the money from her qualified saving account, she must add the amount to her current tax base. Equivalently, if she takes the money out of current earnings, she forgoes the opportunity to deposit \$8000 into her qualified account. Either way, she triggers a large immediate tax increase that overstates the change in her current consumption. But this is only true if the qualified treatment is the only way for taxpayers to save. Imagine instead that taxpayers make deposits to two different kinds of accounts, qualified and non-qualified. Qualified accounts function along the lines of the basic cash-flow logic:

contributions are deductible and withdrawals are taxable. Non-qualified accounts function in the conventional way: they are ignored.

Thus, in anticipation of a large future outlay, our car-buying taxpayer avoids an atypically high tax bill by saving up in a non-qualified account. She forgoes the deduction as she saves, but also avoids the \$8000 taxable withdrawal when she dis-saves. In the end, her \$20,000 purchase results in a much smaller immediate tax burden. The rest of the obligation is spread out pre-purchase as she saves and post-purchase as she repays. While this method does not and cannot match the actual consumption flow, it achieves the first-order goal of minimizing large fluctuations in the tax burden from year to year.

Large outlays for lumpy non-durable consumption, e.g. weddings and vacations, can be treated in a similar fashion. In general, it is my recommendation that a cash-flow system allow taxpayers to choose for themselves how to treat their borrowing and saving activities. In the presence of a progressive rate schedule, it is in the taxpayer's self-interest to smooth her burden as much as possible. She will naturally want save and borrow in non-qualified accounts for atypical expenditure needs, and save and borrow in qualified accounts to self-insure against income shocks and prepare for retirement. There is no need to police these matters too closely, as the interests of taxpayer and tax authority are broadly aligned.

**Durable Resales.** A related issue concerns the resale of consumer durables. Suppose our taxpayer sells her car three years later at a price of \$11,000. She uses part of the proceeds to repay the outstanding \$6000 on the car loan. What, if anything, should the tax system do about this transaction? To answer this question, recall that the purchaser of a consumer durable absorbs the tax by forgoing a series of po-

tential deductions.<sup>15</sup> First, by making deposits into a non-qualified account in order to save for a downpayment. Second, by excluding loan repayments from the set of deductible cash outflows. Because these non-deductions embody the whole value of the consumer durable, any requirement to report the the resale proceeds as a cash inflow would effectively subject the taxpayer to double taxation. The tax system, then, should ignore resales. The taxpayer is free to do whatever she likes with the \$11,000, which in this scenario reflects the car's unused consumption value. She could purchase a different consumer durable or re-deposit the money into a non-qualified account and use it to finance a stream of non-durable consumption. In either case, her computed tax base remains a rough approximation of her actual consumption stream.

A more complicated scenario arises when the underlying value of the durable increases between the the date of purchase and the date of resale. In that case, the resale price reflects not just the unused consumption value *as it was measured at the time of purchase*, but also its subsequent appreciation. Ideally, the appreciation should be considered a realized capital gain and included as a taxable cash inflow, a treatment which requires a method of measuring the capital gain. It is not obvious how to do this since asset appreciation and heterogeneous usage rates are observationally equivalent. If the expected resale price of the taxpayers vehicle is \$10,000, but she sells it for \$11,000, does the difference reflect appreciation for that particular make and model, or better care and maintenance? A good rule of thumb, and one to which most commentators subscribe, is to ignore durable resales unless the resale price nominally exceeds the initial price. In that case, the difference must be reported as a realized capital gain. Combined with a reasonable lower threshold (say \$5000), this

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<sup>15</sup>Similarly, one can think about the tax on non-durable consumption as a single instance of forgoing a potential deduction.

treatment would restrict practical attention to a much narrower class of transactions, namely resales of owner-occupied housing and high-value collectibles.

For similar reasons, the tax code should address the treatment of unanticipated depreciation and loss. Suppose, for example, that our taxpayer's car is stolen. In that case she neither benefits from the proceeds of a resale nor does she exhaust the vehicle's consumption value. And yet she remains liable for the full tax burden, both because she largely pre-paid it through non-qualified saving and because she remains liable for the outstanding non-deductible repayments. Two remedies to this problem merit recommendation. First, if the durable is insured then the loss of consumption value is offset by the associated insurance payout. And as discussed in the previous subsection, property insurance is properly excluded from cash-flow taxation calculations. This remedy applies not just to vehicles but to a large number of other insurable goods. For example, theft and damage are typically covered under homeowner's or renter's insurance. Second, if the durable is uninsured or only partially insured, then the taxpayer can claim a deduction for a casualty, disaster or theft loss, as is currently permitted in the existing income tax code by filing a Form 4684.

It should be noted that the resale of consumer durables is primarily a distributional issue, not a fiscal one. Regardless of whether proceeds are partially or fully included, the government's tax base is, to a first approximation, the same. The main impact is felt in the resale price, which depends on the relative elasticities in the resale market. The administrative choices in this area should therefore be guided by concerns about how the tax burden is smoothed over the life cycle, and how the tax burden is distributed across sellers and buyers of used durables.

**Summary.** The treatment I describe in this subsection is what the tax literature typically prescribes with respect to consumer durables under cash-flow consumption taxation. This consensus view is summarized by Michael Graetz:

I recommend an identical approach for the taxation of consumer durables and the taxation of housing. No deductions should be permitted for the purchase of consumer durables and housing; yield in the form of imputed rents should be ignored; and when the sale price does not exceed the original cost, no amount need be included in the expenditure tax base upon sale. When the sale price of a house or consumer durable exceeds original cost, such excess should be added to expenditure tax receipts, when received. Loans for the purchase of consumption goods or housing should ordinarily not be included in expenditure tax receipts, and no deduction should be allowed for interest or principal payments. A dollar limitation might be using in implementing this rule.<sup>16</sup>

#### *3.4.5. Labor Income vs Capital Income*

Looking again at (3.1), note that the right-hand side includes income from both labor and capital. To the extent that income tax systems treat labour and capital differently, administrative distinctions must be made between these two sources of income. This matters especially for the tax treatment of pass-through income from a partnership or closely-held business, and also for the treatment of various corporate compensation schemes like stock options.

The cash-flow consumption tax, on the other hand, cares not a whit about these distinctions. As with dividends and capital gains, its disinterested treatment of inflows

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<sup>16</sup>Michael Graetz, "Expenditure Tax Design", 1980, p. 197.

and outflows makes the particular classification of any given flow irrelevant. Bonuses, stock redemptions, self-employment income, and distributions from partnerships or S-corporations are all added to the same ledger.

#### 3.4.6. *Gifts and Bequests*

The usual prescription for gifts and bequests is to treat them like standard cash flows. That is, require beneficiaries to claim the gift as a cash inflow and allow benefactors to deduct the gift as a cash outflow. Inclusion is favoured here because it aligns most closely with the consumption tax ideal. After all, it is the beneficiary who spends and consumes the gift, not the benefactor. Seidman (1997, p. 85) puts the logic this way:

A donor household does not consume resources when it gives a cash gift, bequest, or charitable contribution. Hence the gift, bequest, or contribution should be tax deductible, just like saving—it is a non-consumption cash outflow. If the donee (recipient) household saves it, the donee should not be taxed. When and if the donee consumes it, it should be taxed.

Since death and inheritance are easily observed (and traditionally taxable) events, this treatment poses little incremental administrative cost for bequests. It is somewhat less clear how to feasibly account for *inter vivos* gifts. It would be costly and difficult to monitor transfers of this sort between taxpayers, so the system would have to depend on voluntary declarations. As with consumer durable resales, the issue here is not primarily one of revenue, but how to properly spread the tax burden across individuals and across time. In the case of gifts between living taxpayers, a self-enforcement mechanism can help. Since it is collectively beneficial to report gifts



from a high-rate taxpayer to a low-rate taxpayer, the parties to a private transfer are typically incentivized to comply. When it comes to genuine gifts, then, there is little cause for concern. I recommend that donors and donees be afforded the option of declaring transfers (perhaps with some threshold), but it would not seriously undermine the design of the tax if they decline to.

Insincere gifts are the true concern. The standard cash-flow treatment would allow a high-rate taxpayer to transfer money to a low-rate confederate, who could in turn kick it back to the donor. Under a progressive tax system, a false donor could exploit this strategy to reduce his net tax burden, even with the confederate taking a cut. A similar problem exists under an income tax since wealthy taxpayers can funnel resources to lower-rate family members through fictitious or exaggerated employment schemes. This is especially true for business owners and other individuals who can more easily mask gifts as phoney compensation. In the case of the cash-flow consumption tax, there are three apparent solutions: (1) devote more resources to auditing declared gifts; (2) set a higher threshold on declarable gifts; and (3) exclude gifts from the set of deductible cash flows. If there exists no combination of (1) and (2) that can achieve effective monitoring of gift-giving at reasonable expense, then option (3) is not a terrible outcome despite its deviation from the consumption tax ideal. This is especially true if the equilibrium gift size proves sensitive to its tax treatment. For example, instead of transferring \$10,000 and the associated tax liability, a donor might transfer \$8000 and retain the tax liability.

#### *3.4.7. Charitable Contributions and Medical Expenses*

The existing tax code allows (limited) deductions for charitable contributions and out-of-pocket medical expenses. The case for or against the deductibility of such items is the same under a cash-flow consumption tax as it is under an income tax,

namely whether one thinks there are normative reasons for excluding them from an individual's assessed taxable capacity. Since this is not a cash-flow-specific issue, I omit any further discussion.

#### *3.4.8. Tuition and Education Expenses*

It is in keeping with the guiding principle of cash-flow consumption taxation to treat human capital investments no differently than other investments. Consequently, deductions should be allowed for spending on education and training ("saving"). As with ordinary saving, taxes are levied later on the "withdrawals", which here take the form of higher future earnings. Of course, certain education-related expenses have dubious human capital content. Some fraction of the tuition at expensive schools and colleges is undoubtedly tied to its value as an experience good or a status good. Thus, some fractional or limiting rule should apply, though how that rule should be specified is not without ambiguity. As an example, the 1995 USA bill provided a \$2000 deduction per person up to a maximum of \$8000 per household.

#### *3.4.9. In-Kind Compensation*

Another administrative difficulty is the treatment of in-kind compensation. The spirit of the cash-flow consumption tax demands that the full value of non-cash benefits and other forms of in-kind compensation (including, but not limited to, cars, cell phones, meals, child care and recreational facilities) be attributed to individuals as part of their declared taxable remuneration. Alternatively, such expenses could be deemed nondeductible by the firm for the purposes of calculating taxable income. The latter treatment might be preferable for goods and services that are difficult to apportion among the the workforce, e.g. staff parties. A more nefarious practice is the deliberate use of corporate structures to finance private consumption and evade

taxes, e.g., business expense fraud. It is important to remark, however, that income tax systems are plagued by these same difficulties. In-kind compensation is both labor income and consumption.

#### *3.4.10. Existing Wealth*

Imposing a new consumption tax of any form generates a windfall loss on existing wealth-holders since it reduces the consumption value of their assets. There are several ways of handling this transitional problem. Examples include: (1) make no provision for existing wealth and let the windfall gains and losses fall where they may; (2) make compensatory transfers to existing wealth-holders to offset their windfall losses in full or in part; and (3) treat existing wealth as non-qualified assets. That is, exclude from the tax base all withdrawals, realizations and other flows from existing assets and liabilities. Apply the cash-flow treatment to new saving and borrowing only.

The first two options are unsatisfactory for distributional and administrative reasons. In contrast, the third allows for a natural and smooth transition from the existing tax code. Existing tax-advantaged savings accounts are converted into new unrestricted tax-deductible accounts. Wealth currently held in other forms remains as is. Over time, as older cohorts draw down existing wealth and younger cohorts enter the economy, the system as a whole will converge to the cash-flow treatment. Or at least to an adequate approximation of it. Few direct transitional measures are needed.

This desirable feature is unique to the cash-flow form of consumption taxation. There can be no neutral introduction of a retail sales tax or a VAT without an auxiliary administrative apparatus to mitigate windfall gains and losses. Because those forms are de-personalized by definition, there is no way to distinguish between a dollar spent out of old wealth and a dollar spent out of new wealth. It follows that a large-scale

adoption of consumption taxation in the US might be more politically feasible with a direct cash-flow tax rather than an indirect form like the VAT.

### 3.5. Summing Up

In the previous chapter, I formally showed how household heterogeneity and non-linear rate schedules break the equivalency between consumption-based tax systems and earnings-based tax systems. In this chapter, I discussed the mechanics of implementing a progressive consumption tax. The main points of discussion are these: first, it is difficult to construct a flexibly progressive structure using indirect taxes like the RST or the VAT; second, it is feasible to tax consumption directly using the cash-flow method, thereby allowing for any arbitrary rate schedule; and third, the cash-flow method poses some degree of added complexity.

The most notable administrative complications relate to the treatment of durables and to tax evasion schemes. In my opinion, the problem of durables is surmountable. The consensus recommendation, *viz.*, allow non-qualified saving and exclude secured loans, generates zero incremental compliance cost. Rather, the problem of durables is that the stream of tax obligations under the recommended treatment will generally fail to match the associated stream of consumption services. This is particularly true for owner-occupied housing, the most important durable in the household's portfolio. As such, the ideal consumption tax is not obtained. But as I showed analytically in the previous chapter and assess numerically in the next, the relative merit of the cash-flow tax is not the consumption base *per se*, but rather its facilitation of endogenous tax-smoothing by households, thereby mitigating distortions on intertemporal labor supply. While imperfect, the recommended treatment of durables enables an imperfect form of tax-smoothing, so it is not unreasonable to expect that most of the

gains are still captured.

Tax evasion is the more serious challenge. Estimating the cost of monitoring qualified gifts and closely-held businesses is beyond the scope of this study, but the costs are certainly not trivial. There are also compliance costs associated with bringing traditionally excluded financial transactions like life insurance and unsecured consumer debt into the tax code. These administrative costs cannot be ignored, nor can it be denied that a progressive labor income tax is considerably simpler overall.

Given these practical difficulties, the contest between the two tax bases must be settled by first *quantifying* the relative advantages of progressive consumption taxation and then measuring them against the additional administration and compliance costs. The next chapter sets out to perform the first of those two steps. If the welfare gains are large, then the effort of enacting a full-fledged cash-flow tax may be worthwhile.

## CHAPTER 4 : The Quantitative Case for Consumption Taxation

There is a general agreement that a system of taxation should be adjusted in more or less steep graduation, to people's incomes: or better still to their expenditures.

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Alfred Marshall, *Principles of Economics* (1890)

Are consumption taxes better than labor income taxes? In Chapter 2, I showed that consumption taxes outperform labor income taxes in the presence of wage heterogeneity and non-linear taxation. In Chapter 3, I discussed the feasibility and administration of a non-linear consumption tax. But the question is ultimately a quantitative one. In this chapter, I numerically assess the transition to a consumption base using a heterogeneous agents macro model calibrated to the U.S. economy. This reform generates moderate welfare gains for future households.

### 4.1. The Quantitative Model

I develop a standard incomplete markets model where finitely-lived households supply labor elastically and self-insure against idiosyncratic wage and mortality risk as in Huggett (1993) or Aiyagari (1994). Time is discrete and indexed by  $t = 0, 1, \dots, \infty$ . In each period, a single final good is produced according to a neoclassical production function and used for private consumption, investment, and government goods and services. All markets are competitive.

#### 4.1.1. Households

**Demographics** The economy is populated by agents who live for at most  $J$  periods (and hence by  $J$  overlapping generations). A continuum of new agents is born in

each period and begins working immediately. Education and training occur prior to economic birth and are not modelled. The working life continues until an exogenously-specified retirement age  $j_R \leq J$ , after which the household collects social security benefits. The conditional probability of surviving from age  $j - 1$  to age  $j$  is denoted by  $\psi_j$ , with  $\psi_{J+1} = 0$ . The unconditional probability of surviving to age  $j$  is denoted by  $\Psi_j$  and defined by:

$$\Psi_j \equiv \prod_{k=1}^j \psi_k$$

The population is assumed to grow at a constant rate  $n$ . By a law of large numbers and the stationarity of the demographic structure,  $\frac{n\Psi_j}{\Psi_{j+1}}$  tracks the relative size of adjacent cohorts.

**Endowments** Agents are endowed with one unit of time in every pre-retirement period, a fraction of which is endogenously devoted to labor market activities. Each unit of work time generates  $\rho(j, m, n)$  productivity units, where  $m \in \mathcal{M}$  denotes a fixed ability type drawn from a distribution  $F_m$  and  $n \in \mathcal{N}$  denotes an idiosyncratic stochastic component that follows an age- and type-independent Markov chain with transition matrix  $\pi(n'|n)$ . Thus, productivity varies across households for three reasons: (1) age, which substitutes for experience; (2) pre-market differences, whether intrinsic or acquired; and (3) unanticipated shocks that (potentially) accumulate over the life cycle. Letting  $w$  denote the market price per productivity unit, the household's wage rate is given by  $w \cdot \rho(j, m, n)$ .

Households are born with zero wealth but receive two types of transfers. Retired households collect a social security benefit, denoted  $b$ , while working households receive a bequest, denoted  $q$ . The bequest comes from the unintended estates of non-terminal-age decedents, which are appropriated by the government and distributed

evenly among the working-age population.

**Preferences** Households maximize utility by choosing consumption  $c_j$  and, if not retired, hours  $h_j$  at every age. Preferences over stochastic streams of consumption and hours are ordered by:

$$\mathbb{E} \left[ \sum_{j=1}^{j_R-1} \beta^{j-1} \Psi_j u(c_j, h_j) + \sum_{j=j_R}^J \beta^{j-1} \Psi_j \tilde{u}(c_j) \right] \quad (4.1)$$

where  $\beta$  denotes the common discount factor and  $u$  and  $\tilde{u}$  denote the period utility functions for working years and retirement years, respectively.

#### 4.1.2. Government

The government raises revenue to finance exogenous expenditures  $G$ , service its accumulated debt  $B$ , and fund a social security system that delivers a benefit  $b$  to each retired household. It does so by levying taxes and issuing new debt. Its set of available fiscal instruments includes linear taxes on both consumption and the return to capital, denoted  $\tau_c$  and  $\tau_k$  respectively. It also operates a non-linear tax-and-transfer scheme based on labor earnings, denoted  $\hat{T}(\cdot)$ . No part of the tax code can be conditioned on taxpayer age.

Finally, as alluded to above, the government collects accidental bequests and redistributes them among the working-age population in a lump-sum fashion. The exclusion of retirees from the spoils of unspent nest eggs is a crude way of accounting for the age distribution of beneficiaries.

#### 4.1.3. Markets



**Output Market** A representative firm produces the economy's only good by operating a constant returns-to-scale technology. The aggregate production function is:

$$Q = F(K, N) = AK^\alpha N^{1-\alpha} \quad (4.2)$$

where  $Q$ ,  $A$ ,  $K$  and  $N$  denote the aggregate levels of output, technology, capital and labor supply. Capital earns an output share  $\alpha \in (0, 1)$  and depreciates at rate  $\delta > 0$ .

**Factor Markets** Spot markets exist for capital and labor with prices denoted by  $r$  and  $w$ , respectively.

**Asset Markets** A representative intermediary trades the economy's sole financial asset: a one-period risk-free bond that pays an interest rate  $i$  or, equivalently, a gross rate  $R \equiv 1 + i$ . This intermediary supplies capital to the representative firm and facilitates the intertemporal transfer of resources for both households and government. Notably, there are no assets with which the household can explicitly insure against idiosyncratic wage risk or the uncertainty of survival and death. Moreover, the scope of self-insurance is limited by a stringent borrowing constraint applied to all households. The government, on the other hand, is limited only by its ability to pay back debts.

#### *4.1.4. Equilibrium*

**Household's Problem** I formulate the household's problem recursively. Individual state variables are age  $j$ , assets  $a$ , ability type  $m$ , and current productivity  $n$ . Let  $z = (j, a, m, n)$  denote the agent's state and  $\Phi_t$  denote a probability measure describing the distribution of individual states at time  $t$ . Given a sequence of prices and policies,

the Bellman equation for the working household ( $j < j_R$ ) is:

$$\begin{aligned}
 (H1) \quad v(j, a, m, n) &= \max_{h, c, a'} u(c, h) + \beta \psi_{j+1} \int v(j+1, a', m, \tilde{n}) \pi(\tilde{n}|n) d\tilde{n} \\
 \text{s.t.} \quad &(1 + \tau_c)c + a' = Y^d(w\rho(j, m, n)h) + Ra + q \\
 &c, a' \geq 0, h \in [0, 1]
 \end{aligned}$$

where  $Y^d(y) \equiv y - \hat{T}(y)$  denotes after-tax earnings. The Bellman equation for a retired household ( $j \geq j_R$ ) is simpler:

$$\begin{aligned}
 (H2) \quad \tilde{v}(j, a) &= \max_{c, a'} \tilde{u}(c) + \beta \psi_{j+1} v(j+1, a') \\
 \text{s.t.} \quad &(1 + \tau_c)c + a' = Ra + b \\
 &c, a' \geq 0
 \end{aligned}$$

**Firm's Problem** The representative firm hires capital and labor to maximize profits, which are zero in equilibrium by construction. Its optimality conditions are:

$$\begin{aligned}
 r &= \alpha A(N/K)^{1-\alpha} - \delta \\
 w &= (1 - \alpha)A(K/N)^\alpha
 \end{aligned} \tag{4.3}$$

**Intermediary's Problem** The competitive markets assumption implies zero profits for the financial intermediary. Combined with a no-arbitrage condition, this gives:

$$R \equiv 1 + i = 1 + (1 - \tau_k)r \tag{4.4}$$

**Government Budget** Government budget deficits (surpluses) are absorbed by increases (decreases) in the stock of public debt.

$$G_t + \sum_{j=j_R}^J \Psi_j b_t + R_t B_t = \int \hat{T}_t(w_t \rho(j, m, n) h_t(j, a, m, n)) d\Phi_t + \tau_{c,t} \int c_t(j, a, m, n) d\Phi_t + \tau_{k,t} r_t K_t + B_{t+1} \quad (4.5)$$

**Accidental Bequests** Estates must be assigned in order to close the model. I assume that they are collected and redistributed in full to the working-age population.

$$q_t = \begin{cases} \left( \sum_{k=1}^{j_R-1} \Psi_k \right)^{-1} \int \Psi_{j-1} (1 - \psi_j) R_t a_0 d\Phi_0 & \text{if } t = 0 \\ \left( \sum_{k=1}^{j_R-1} \Psi_k \right)^{-1} \int \Psi_{j-1} (1 - \psi_j) R_t a_t(j, a, m, n) d\Phi_{t-1} & \text{otherwise} \end{cases} \quad (4.6)$$

**Market Clearing** The market-clearing conditions for factor markets are:

$$K_t = \begin{cases} \int a_0 d\Phi_0 & \text{if } t = 0 \\ \int a_t(j, a, m, n) d\Phi_{t-1} & \text{otherwise} \end{cases} \quad (4.7)$$

$$N_t = \int \rho(j, m, n) h_t(j, a, m, n) d\Phi_t$$

Letting  $C_t = \int c_t(j, a, m, n) d\Phi_t$ , the resource constraint is:

$$C_t + K_{t+1} + G_t = AK_t^\alpha N_t^{1-\alpha} + (1 - \delta)K_t$$

although this can be safely ignored by Walras' law.

**Definition 1.** Index time by  $t = 0, 1, \dots, \infty$ . Fix a sequence of government expenditures  $\{G_t\}$  and initial conditions  $B_0$  and  $\Phi_0$ . A **recursive competitive equilibrium** is a sequence of value functions  $\{v_t\}$ , allocations  $\{h_t, c_t, a_{t+1}, K_t, N_t\}$ , prices

$\{w_t, r_t, i_t\}$ , government policies  $\{\hat{T}_t, \tau_{c,t}, \tau_{k,t}, b_t, B_t\}$ , transfers  $\{q_t\}$ , probability measures  $\{\Phi_t\}$ , and laws of motion  $\{H_t\}$  such that for all  $t$ :

1. Given prices, policies and transfers,  $\{v_t\}$  solves problems H1 and H2, with  $\{h_t, c_t, a_{t+1}\}$  being the associated decision rules;
2. Given prices, the firm's allocation  $\{K_t, N_t\}$  satisfies (4.3);
3. Prices  $\{r_t, i_t\}$  satisfy the no-arbitrage condition (4.4);
4. The government budget (4.5) is balanced;
5. Estates are redistributed in their entirety, as per (4.6);
6. Markets clear, as per (4.7); and
7. The distribution over individual states evolves according to  $\Phi_{t+1} = H_t\Phi_t$ , where the aggregate laws of motion  $\{H_t\}$  are consistent with the decision rules  $\{h_t, c_t, a_t\}$  and the transition matrix  $\pi$ .<sup>1</sup>

**Definition 2.** A **stationary recursive competitive equilibrium** is a recursive competitive equilibrium where the distribution over individual states is stationary. That is,  $\Phi_{t+1} = \Phi_t$  for all  $t = 1, \dots, \infty$ . A stationary equilibrium is also called a **steady state** of the economy.

## 4.2. Calibration

The quantitative analysis begins by making functional form assumptions and choosing values for model parameters. There are two distinct sets of parameters. Externally calibrated parameters are taken directly from other sources or can be estimated

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<sup>1</sup>For a formal characterization of this statement, see any number of papers (co-)authored by Dirk Krueger.

independently of the model. Internally calibrated parameters are selected so that model-generated data match a certain set of targets. Although each internally calibrated parameter is associated with a particular target, it is important to keep in mind that they are jointly determined. All parts of the calibration exercise proceed under the assumption of a stationary equilibrium.

**Demographics** One model period corresponds to one year. Agents enter the economy at age 23 ( $j = 1$ ), retire at age 65 ( $j_R = 42$ ), and die no later than at age 95 ( $J + 1 = 73$ ). The Social Security Administration’s Actuarial Life Table for men<sup>2</sup> is used to determine age-dependent survival probabilities  $\{\psi_j\}_{j=1}^J$ , with  $\psi_{J+1}$  set to zero. The population growth rate is 1.1%, the long-run average value for the USA.

**Preferences** I assume the following functional form for the period utility function:

$$u(c, h) = \frac{c^{1-\sigma}}{1-\sigma} - \varphi \frac{h^{1+\gamma}}{1+\gamma} \quad (4.8)$$

The parameters  $\sigma$ ,  $\varphi$  and  $\gamma$  govern risk aversion, disutility of work, and the intertemporal elasticity of substitution for labor supply. I set  $\sigma = 2$  and  $\gamma = 2$ . Both values are standard in the literature.<sup>3</sup> Disutility of work  $\varphi$  is chosen so that working households devote, on average, one third of their time endowment to labor market activities. The final preference parameter is the discount factor  $\beta$ , which is chosen to generate an equilibrium capital-output ratio of 2.75 or, equivalently, an interest rate of 4.0%. Given additive separability of consumption and hours, the retirement utility function is naturally defined as  $\tilde{u}(c) = u(c, 0)$ .

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<sup>2</sup><http://www.ssa.gov/OACT/STATS/table4c6.html>.

<sup>3</sup> The choice of  $\gamma$  implies an after-tax Frisch elasticity of 0.5, as recommended by Chetty et al. (2011). More recently, Blundell et al. (2016) report Frisch elasticity estimates of 0.68 for men and 0.96 for women. See Keane (2011) for a survey of the earlier microeconomic literature

**Productivity** Recall that household productivity depends on age, pre-market differences and unanticipated shocks. With that in mind, consider the following specification for the evolution of the agent’s productivity.

$$\begin{aligned}
\ln e(j, m, n) &= \beta_{0m} + \beta_{1m}(j - 1) + \beta_{2m}(j - 1)^2 + \zeta(n) & \beta_m &\sim \mathcal{N}(\beta, \Sigma) \\
\zeta(n) &= \eta_j + \varepsilon_j & \varepsilon_j &\sim \mathcal{N}(0, \sigma_\varepsilon^2) \\
\eta_j &= \phi\eta_{j-1} + \nu_j & \nu_j &\sim \mathcal{N}(0, \sigma_\nu^2) \quad |\phi| < 1 \\
\eta_0 &= 0
\end{aligned}
\tag{4.9}$$

Ability types are associated with a particular coefficient vector  $\beta_m = (\beta_{0m}, \beta_{1m}, \beta_{2m})$ , with each being an independent draw from the same distribution. Ability, therefore, governs the shape and scale of the household’s expected wage profile. The covariance matrix  $\Sigma$  is unrestricted, allowing for correlation between the components of  $\beta_m$ . Let  $\sigma_i^2$  denote the diagonal elements of  $\Sigma$  and  $\sigma_{ij}$  denote the off-diagonal elements.

The model is silent about why productivity varies from person to person *ex ante*. We might think that the dispersion in intercepts is due to pre-market activities that affect initial human capital (e.g. schooling choice and family background). Similarly, innate differences in the ability to learn and acquire additional human capital might account for variation in the slope and curvature of the wage profile as in Huggett et al. (2011). I abstract from such considerations here and take these *ex ante* differences as exogenous.

The stochastic process linked to state variable  $n$  has two components, a persistent shock  $\eta_j$  that follows an AR(1) process and a transitory shock  $\varepsilon_j$ . Together, these two shocks generate random fluctuations around a deterministic trend. Assume that

the innovations are independent of each other and  $\beta_m$ .

I use data from the Panel Survey of Income Dynamics (PSID) to estimate (4.9) using adjusted male log-wages as the dependent variable. The results are reported in Table 1 and the details of the sample selection and estimation are discussed in Appendix A.5. The estimates are very precise except for the covariance between the person-specific intercept and the person-specific experience coefficients. The results suggest that, on average, real wages grow at about 4% per year early in a person's working life. There is, however, evidence of significant heterogeneity. A person whose  $\beta_{1m}$  falls one standard deviation above (below) the mean will experience initial wage growth of 7% (1.5%) *ceteris paribus*. Over time, these growth rate differentials can generate substantial inequality as initial advantages and disadvantages accumulate over the life-cycle. The effect is partly mitigated by the strong negative correlation between the linear and quadratic coefficients ( $\beta_{1m}$  and  $\beta_{2m}$ ).

The estimate of  $\phi$  indicates moderate persistence. Roughly half of a persistent shock's effect remains after three years. At the ten year mark, over 90% of the shock has dissipated. This level of persistence is significantly lower than estimates obtained for models that exclude heterogeneity in growth rates. Such estimates are typically in the 0.96-1.00 range.<sup>4</sup>

I use a quadrature-based method to approximate both shock processes with discretized Markov chains. I use seven states for the persistent component and three states for the transitory component, meaning that  $n_j$  takes on one of twenty-one values in the finite set  $\mathcal{N}$ . The invariant distributions of these discretized Markov chains are summarized in Table 2.

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<sup>4</sup> See, for example, Abowd and Card (1989), Storesletten et al. (2004) or Karahan and Ozkan (2013).

Table 1: Income Process Estimation Results (log-wages)

Parameter	Estimate	Std Error	t-statistic	P-value	CI <sub>0.025</sub>	CI <sub>0.975</sub>
<u>Common Trend</u>						
$\beta_0$	2.1809	0.1438	15.17	0.00	1.8991	2.4628
$\beta_1$	0.0415	0.0007	59.81	0.00	0.0402	0.0429
$\beta_2$	-0.0008	0.0000	-52.65	0.00	-0.0009	-0.0008
<u>Heterogeneous Trend</u>						
$\sigma_0$	0.2175	0.0239	9.10	0.00	0.1639	0.2602
$\sigma_1$	0.0265	0.0021	12.74	0.00	0.0220	0.0303
$\sigma_2$	0.0006	0.0000	13.67	0.00	0.0005	0.0007
corr <sub>01</sub>	0.1475	0.2052	0.72	0.47	-0.1534	0.7687
corr <sub>02</sub>	-0.4588	0.2585	-1.77	0.08	-1.2076	-0.0658
corr <sub>12</sub>	-0.8749	0.0224	-39.05	0.00	-0.9106	-0.8148
<u>Stochastic Trend</u>						
$\phi$	0.7869	0.0224	35.19	0.00	0.7390	0.8301
$\sigma_\nu$	0.2096	0.0117	17.89	0.00	0.1872	0.2345
$\sigma_\varepsilon$	0.3884	0.0096	40.53	0.00	0.3681	0.4065

The first-stage regression includes 4286 individuals and 67,009 person-year observations.

The second-stage regression includes 932 empirical variance-covariance moments.

Similarly, I approximate the distribution of wage profiles by selecting a finite number of equiprobable types, each of which is characterized by a vector  $\beta_m$ . Constructing the set of types is complicated by the fact that the coefficients are correlated. There are three possible values for the intercept (think: high, medium, low), three possible values for the slope (conditional on the intercept), and three possible values for the curvature (conditional on both the intercept and the slope). Hence,  $\mathcal{M}$  has twenty-seven elements. The details of both discretization procedures are discussed in Appendix A.6.1.



Table 2: Invariant Distributions of Productivity Shocks

State	Value	$\Pi$	State	Value	$\Pi$
$\eta_1$	0.3916	0.0025	$\varepsilon_1$	0.7712	0.1932
$\eta_2$	0.5534	0.0499	$\varepsilon_2$	1.0000	0.6135
$\eta_3$	0.7493	0.2447	$\varepsilon_3$	1.2967	0.1932
$\eta_4$	1.0000	0.4058			
$\eta_5$	1.3345	0.2447			
$\eta_6$	1.8070	0.0499			
$\eta_7$	2.5539	0.0025			

Persistent shock process.

Transitory shock process.

**Government Policy** The main policy of interest is the non-linear tax on labor income, which takes the following log-linear form:

$$\hat{T}(y) = y - \lambda y^{1-\tau}$$

I set  $\tau = 0.136$  as estimated by Kaplan (2012) and choose  $\lambda$  to balance the government's state-steady budget.<sup>5</sup> The capital income tax rate is set to  $\tau_k = 28.3\%$  as in Kindermann and Krueger (2021). The linear consumption tax rate is set to  $\tau_c = 4.4\%$ , which is equal to the sum of general and selective sales taxes collected by all state and local governments divided by total nominal personal consumption expenditures in 2017.

With respect to the other side of the public ledger, I choose exogenous government spending such that it accounts for 17% of total output. I then take the implied *level* of government expenditures as fixed in all ensuing tax reform experiments. I choose social security benefits  $b$  to equal 35% of average earnings and the stock of outstanding public debt  $B$  to yield an equilibrium debt-to-output ratio of 0.97, as in the data.

<sup>5</sup>Wu and Krueger (2021) estimate the same labor income tax function and obtain a similar estimate of  $\tau = 0.133$ .

The government is also responsible for collecting and redistributing accidental bequests. Though not a parameter,  $q$  is an equilibrium object that must be solved for within the model.

**Technology** Three parameters  $(A, \alpha, \delta)$  characterize the production technology. I set the capital share to  $\alpha = 0.33$  and the depreciation rate to  $\delta = 8\%$ . The level of technology  $A$  is normalized so that the equilibrium wage rate is unity.

**Summary** The key non-productivity parameters are summarized in Table 3, with internally calibrated parameters in bold.

Table 3: Benchmark model parameters

Parameter		Value	Target
Preferences			
$\sigma$	Coefficient of relative risk aversion	2.0	
$\gamma^{-1}$	Frisch elasticity	0.5	
$\varphi$	<b>Disutility of labor</b>	<b>63.3</b>	$\bar{h} = 1/3$
$\beta$	<b>Annual discount factor</b>	<b>0.992</b>	$r = 4\%$
Production			
$\alpha$	Capital income share	0.33	
$\delta$	Depreciation rate	8%	
$A$	<b>Aggregate technology</b>	<b>0.937</b>	$w = 1.0$
Policies			
$\tau$	Labor tax progressivity	0.136	
$\lambda$	<b>Labor tax level</b>	<b>0.666</b>	$G/Q = 0.17$
$\tau_k$	Capital tax rate	28.3%	
$\tau_c$	Sales tax rate	4.4%	
$B$	<b>Public debt</b>	<b>27.1</b>	$B/Q = 0.97$
$b$	<b>Social security benefit</b>	<b>0.198</b>	$b/\bar{y} = 0.35$
Transfers			
$q$	<b>Accidental bequest</b>	<b>0.033</b>	fixed point

Internally calibrated parameters are in bold.

**Brief Remark on Computation** Calibration requires the repeated solution and simulation of the model. To solve for the optimal decisions rules, I use the endogenous grid method, augmented for endogenous labor supply as in Barillas and Fernández-Villaverde (2007). The chosen functional forms for preferences and taxes mean that no root-finding procedures are needed, except when simulating the decisions of a borrowing-constrained household. See Appendix A.6 for a detailed description of the algorithms employed.

**Life-Cycle Profiles in the Baseline Economy** Figure 1 displays average hours and earnings profiles for working-age households and average consumption and asset profiles for all households. Assets rise over the working life as household build buffer stocks to hedge against wage shocks and accumulate wealth to finance retirement consumption. The consumption and asset profiles are also affected by a high degree of patience: the subjective discount rate is 0.8% while the after-tax rate of return is substantially higher at 2.9%.

For reasons explained in Section 2.4, the degree to which consumption and labor income fluctuate from year to year will be an important factor in the comparative assessment of the two candidate tax bases. To that end, I simulate a large number of histories and compute household-specific standard deviations for those two variables. Retirement benefits are counted as labor income for the purposes of this exercise, and all calculations are weighted by survival probabilities and normalized. The densities of these standard deviations are plotted in Figure 2. It is clear from the graph that the model produces considerably less year-to-year variation in consumption relative to earnings.

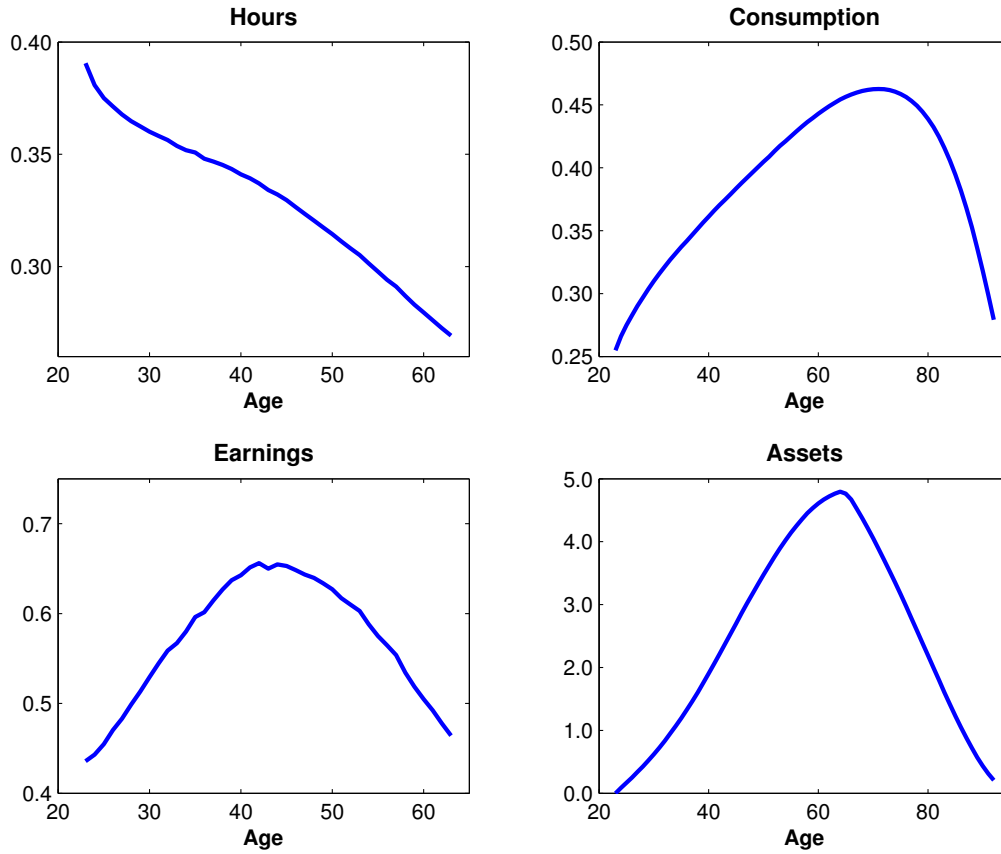


Figure 1: Cross-Sectional Means over the Life Cycle

### 4.3. A Simple Tax Reform

In this section I use the calibrated model to study a simple tax reform that converts the household tax base from labor income to consumption. I begin by describing the experiment in detail, and then set out the main results. I focus on long-run impacts by comparing stationary equilibria, but also discuss the macroeconomic and welfare consequences along the transition path. The simple reform generates moderate welfare gains by tempering distortions on the labor supply responses to productivity shocks.

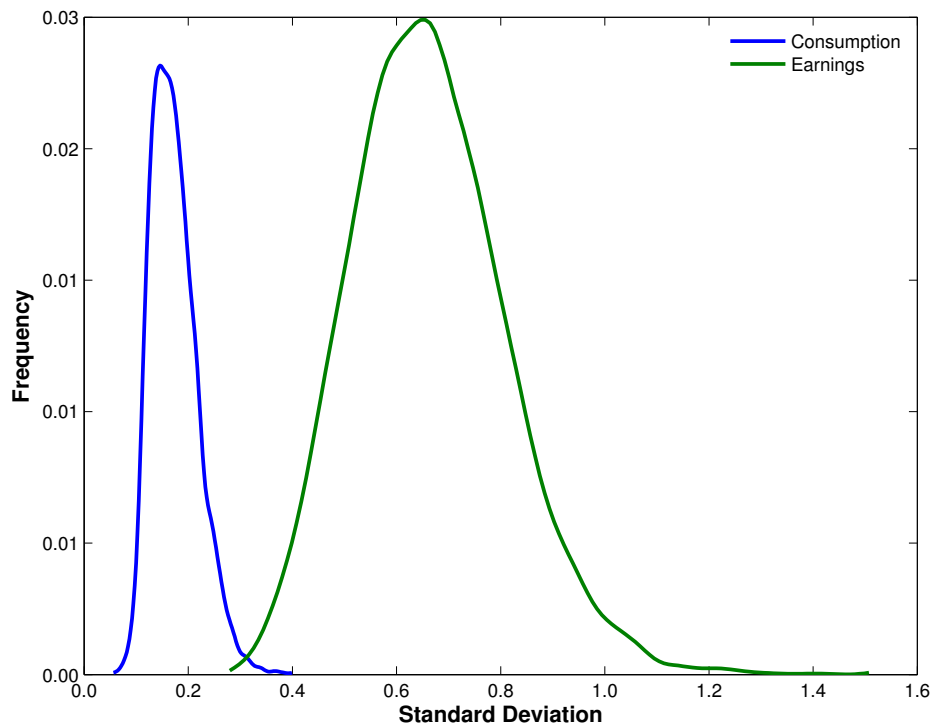


Figure 2: Fluctuations in Consumption and Earnings over the Life Cycle

#### 4.3.1. Description of the Experiment

The economy is in its initial stationary equilibrium at time  $t = 0$  when the government announces a plan to convert the household tax-and-transfer system to a consumption base. Progressivity, indexed by the parameter  $\tau$ , remains fixed while the average tax rate, indexed by the parameter  $\lambda$ , can and will adjust to maintain budget balance. As is standard in the literature, I assume that the policy change is unexpected and the government can credibly commit to making no further changes. Another standard practice I adopt is to fix the *level* of government purchases, allowing the fraction of output devoted to government goods to deviate from its calibrated target.

In practice, this reform is accomplished by allowing a deduction for net savings in the style of IRAs or 401(k) plans. The household's tax base decreases one-for-one

with every dollar it contributes to a savings account and increases one-for-one with every dollar it withdraws. Because consumption equals earnings less net saving, this policy successfully implements the intended reform. Unlike IRAs and other real-world savings plans, investments are not sheltered in whole or in part from ongoing capital income taxation. Neither do I impose any limits, restrictions or penalties. In other words, the policy reform is a cash-flow consumption tax as described in Chapter 3.

I rule out changes to the capital income tax rate  $\tau_k$  for two reasons. First, my goal is to isolate and assess a particular policy choice: that between the taxation of earnings and the taxation of consumption. Because capital taxes have important efficiency and distributional impacts (Fehr and Kindermann, 2015), varying  $\tau_k$  would add noise to the results. Second, unanticipated changes to the capital tax structure mimic a lump-sum tax (or transfer) on the existing capital stock. By levying a tax on an inelastic resource, the government can reduce or even eliminate the need for distorting taxes, thereby generating substantial welfare gains from reform. But there are unmodelled political reasons why a fiscal policy of this sort might be unfeasible. One could imagine, for example, that governments are subject to some sort of commitment constraint that prohibits new taxes on old choices. Or, more simply, it could be difficult to garner political support for a policy that punishes living citizens, who can vote, in order to reward future citizens, who cannot.

A new tax on consumption produces a similar effect. Households that had accumulated assets under the belief that those assets could be liquidated tax-free in the future now face unanticipated tax bills. One way to neutralize this effect is to assign compensatory transfers, as in Auerbach and Kotlikoff (1987). While this approach provides a useful theoretical measurement of a policy's efficiency effects, it would be difficult to implement in practice, fraught as it would be by information frictions,

equilibrium effects, and administrative costs. I adopt an alternative approach, one that is both feasible and easy to imagine in practice. Specifically, I assume that the new tax structure applies only to future generations, that is, those born at time  $t = 1$  or later. Existing cohorts continue to work and save under the rules of the status quo. In this way, they are shielded from the adverse effects of unexpected wealth levies and exposed only to general equilibrium effects on factor prices.

A further detail concerns the balancing of the government budget. One way to do this is to adjust  $\lambda$  in every period along the transition path, thereby keeping the budget balanced period-by-period. This approach, however, produces significant inter-cohort redistribution. A notable feature of consumption is that its time path is delayed relative to the time path of earnings. This is a mechanical consequence of the life-cycle savings motive. Households save when young and productive so that they can consume when old and unproductive. As a result, a consumption tax tends to postpone tax liabilities until later in the life cycle. But this means that the aggregate tax base drops significantly during the early years of the transition, requiring comparatively large tax rates for the government to equalize revenues and expenses in all periods. This constitutes a potentially large transfer from early generations to later generations.

Instead, I set a time-invariant  $\lambda$  for all future households living under the consumption tax regime. Any shortfalls in the sequential budgets are absorbed by new issues of government debt. This debt will accumulate over the transition until it settles at its new long-run level. I also fix the retirement benefit  $b$  throughout the transition.

A related issue concerns the treatment of bequests. Because a consumption tax postpones tax liabilities until later in life, households naturally accumulate more assets over their working years. Their retirement savings must account not just for

targeted consumption needs but also any tax obligations triggered by dis-saving. As a result, accidental estates are mechanically larger in the new steady state. This introduces a potential bias against generations born early in the transition. If the ‘bequest budget’ were balanced year-by-year, these generations would receive the same bequests as their labor-taxpaying neighbours. Unlike those neighbours, however, the consumption-taxpayers would owe tax when they spend their bequests. To sidestep this problem, I assign the terminal (initial) steady state bequest to all new (old) generations in each year of the transition. Any shortfall in the bequest budget is covered by the government and added to the public debt.

There are therefore only two fiscal constitutions. Let subscripts 0 and  $\infty$  denote the initial and terminal steady states, respectively. Pre-reform households of all ages continue to live under the status quo policy  $\{\tau^k, \tau^c, \tau, \lambda_0, b_0, q_0\}$  for the remainder of their lives. Post-reform households of all birth cohorts live under the new policy  $\{\tau^k, \tau^c, \tau, \lambda_\infty, b_\infty, q_\infty\}$  for the entirety of their lives. These policy parameters are reported in Table.

Table 4: The Two Fiscal Constitutions

	tax base	$\tau$	$\lambda$	$\tau^k$	$\tau^c$	$b$	$q$
Baseline	labor income	0.13615	0.6659	28.3%	4.4%	0.1980	0.0331
Reform	consumption	0.13615	0.6591	28.3%	4.4%	0.2456	0.0543

In summary, all households alive at time  $t = 0$  continue to pay taxes on their labor income according to the same rate schedule as before. Agents who enter the economy at time  $t = 1$  or later will instead pay taxes on their consumption, with the same parameter  $\tau$  but with  $\lambda$  selected to ensure the government’s intertemporal budget constraint is satisfied. Government debt adjusts along the transition to absorb any shortfalls. These policy design choices ensure that there are only two operative channels: the direct tax base effect and the associated general equilibrium effects (if any).



Assuming that the economy converges to its new steady state after  $G$  periods, the induced transition path is characterized by sequences of prices  $\{r_t, w_t\}_{t=1}^G$  and debt  $\{B_t\}_{t=1}^G$ .

#### *4.3.2. Steady State Analysis*

### **Long-Run Impact**

The considered tax reform has few consequences for existing households or the short-run macroeconomy. Only in the long run, as labor-income-taxpayers die out and consumption-taxpayers take over, do aggregate quantities reveal the impact of the policy change. A comparison of stationary equilibria is therefore sufficient to effectively demonstrate the relative merits of the two fiscal regimes. Columns 1 and 2 of Table 5 report the relevant details of the pre- and post-reform steady states. Unless otherwise indicated, interpret all quantities as per capita measures, in the tables and charts as well as in the text.

**Hours and Productivity** The tax reform reduces aggregate work hours by a slight 0.1% in the long run. But because work decisions are less distorted, these hours are allocated more efficiently. Consequently, aggregate labor supply, as measured in productivity units, increases by 1.1%. This improvement springs from two possible sources. First, households can work fewer hours during predictably low-wage years and more hours during predictably high-wage years. Second, households can intensify their labor supply responses to productivity shocks, in both positive and negative directions.

It turns out that intertemporal re-allocation does not play an important quantitative role. Figure 3 plots the percentage change in average hours between the two steady

Table 5: The Two Steady States

	(1) Baseline	(2) Reform
<b>Tax regime</b>		
Tax base	Earnings	Consumption
Tax level $\lambda$	0.666	0.659
Tax progressivity $\tau$	0.136	0.136
<b>Quantities (%<math>\Delta</math>)</b>		
Hours worked		-0.13
Labor supply		1.07
Capital stock		1.85
Consumption		1.49
Output		1.33
<b>Ratios</b>		
Investment–Output	0.250	0.252
Government–Output	0.170	0.168
Capital–Output	2.75	2.76
Debt–Output	0.97	3.22
<b>Prices</b>		
Wage rate	1.000	1.003
Interest rate (%)	4.00	3.94
<b>Welfare</b>		
CEV (% $\Delta$ )		0.92
<b>Gini coefficients</b>		
Consumption	0.201	0.200
Earnings	0.343	0.364
Wealth	0.495	0.506

states over the working life (in blue). The change is slightly positive through the first two-thirds of the agent’s career, but drops off substantially after wages peak at age 50 (vertical dashed line). The overall effect is marginally negative. The U-shape pattern in the first half of the working life is an artifact of the strict borrowing constraint, which binds more frequently for the very youngest households.

The household's heightened response to productivity shocks is the important channel. A system that taxes earnings period-by-period penalizes workers for aggressively exploiting temporary wage changes. This penalty disappears under a consumption tax, since the worker can reduce his tax liability by smoothing his consumption. As a result, we see significant re-allocation of effort across *states*, with workers expanding and contracting their labor supply more freely in response to positive and negative changes to their earning power. Heightened sensitivity to wage shocks leads to significantly higher average productivity in the new steady state at every age, as shown by the green line in Figure 3.

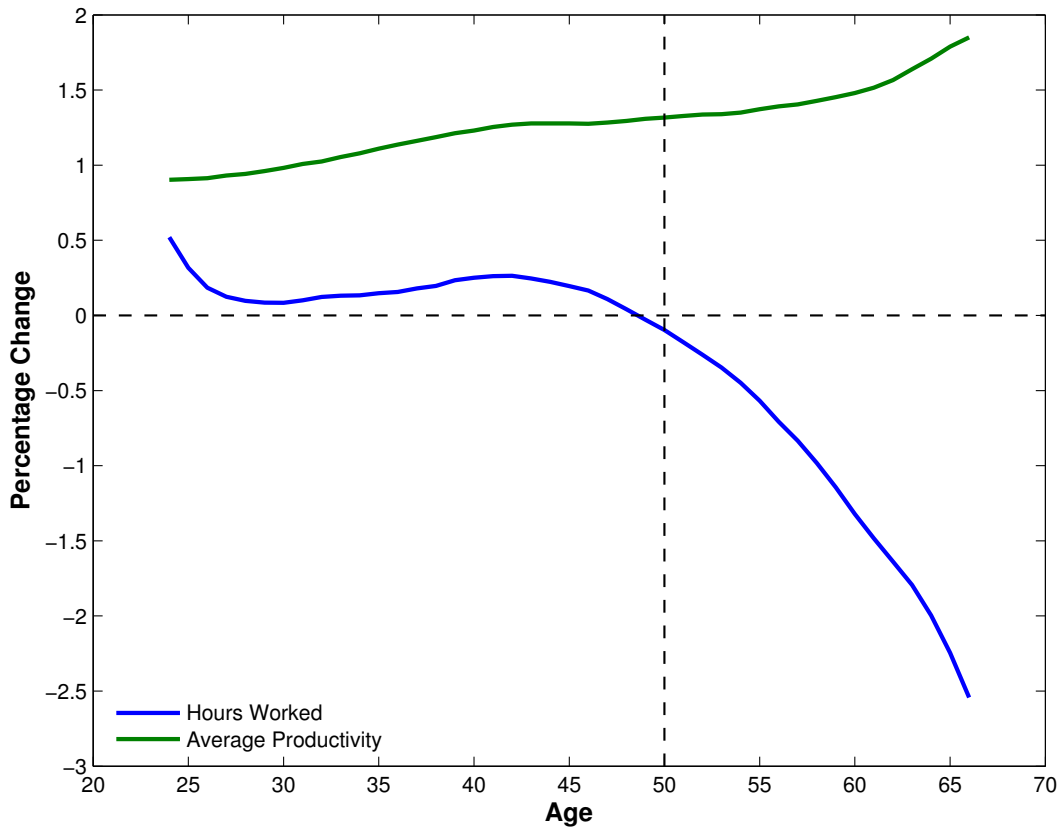


Figure 3: Steady-State Differences in Hours and Productivity by Age

I decompose the aggregate change in labor efficiency as follows. Let  $\bar{n}_{0,j}$  and  $\bar{n}_{\infty,j}$  denote mean labor supplied at age  $j$  in the initial and terminal steady states, respec-

tively. Define  $\bar{h}_{0,j}$  and  $\bar{h}_{\infty,j}$  analogously for hours worked. I then measure the net impact of the intertemporal effect by supposing that life-cycle hours conform to the terminal steady state but, counterfactually, mean productivity follows the life-cycle pattern of the initial steady state. Similarly, the net impact of the intratemporal effect imagines that hours conform to the initial steady state but productivity follows the life-cycle pattern of the terminal steady state. Expressed formally, I calculate:

$$\begin{aligned} \text{intertemporal effect} &= \sum_{j=1}^{j_R} \left( \frac{\bar{n}_{0,j} \cdot \bar{h}_{\infty,j}}{\bar{h}_{0,j}} \right) / \sum_{j=1}^{j_R} \bar{h}_{\infty,j} \\ \text{intra-temporal effect} &= \sum_{j=1}^{j_R} \left( \frac{\bar{n}_{\infty,j} \cdot \bar{h}_{0,j}}{\bar{h}_{\infty,j}} \right) / \sum_{j=1}^{j_R} \bar{h}_{0,j} \end{aligned}$$

I report these calculations in Table 6. Note that the aggregate change in labor efficiency between steady states of 1.2% is due entirely to *intra-temporal* re-allocation of hours across productivity states.

Table 6: Decomposing the Change in Aggregate Labor Efficiency

%Δ in labor efficiency due to..	Effect Size (%)	Share of Total (%)
intertemporal re-allocation of hours	-0.03	-2.3
intra-temporal re-allocation of hours	1.23	102.4
combined re-allocation of hours	1.20	100.0

**Labor Supply Elasticities** We can further illustrate the reform’s supply-side effects by recovering the elasticity of hours worked with respect to innovations to wages. Recall from (4.9) that we can write log-wages for household  $i$  at age  $j$  as:

$$\ln \text{wage}_{ij} = \ln w_j + \beta_{0m} + \beta_{1i}(j - 1) + \beta_{2i}(j - 1)^2 + \sum_{m=1}^{j-1} \phi^{j-m} \nu_{im} + \nu_{ij} + \varepsilon_{ij}$$

where  $\nu$ 's and  $\varepsilon$ 's denote productivity shocks. This motivates a linear regression equation of the following form:

$$\ln h = \epsilon_0 + \epsilon_p \nu + \epsilon_t \varepsilon + \text{error} \quad (4.10)$$

The slope coefficients capture the *contemporaneous* labor supply response to persistent wage shocks  $\nu$  and transitory wage shocks  $\varepsilon$ . To obtain these coefficients, I simulate a large number of histories under both the initial labor tax regime and the terminal consumption tax regime. The sequences of pseudo-random numbers is the same for both sets of histories. I then run the regression in (4.10) on the simulated data.

Pooling the data across age groups yields the aggregate elasticities reported in Table 7. Observe two things. First, and unsurprisingly, model households are more responsive to transitory shocks than they are to persistent shocks. Second, and more importantly, model households are more responsive to shocks of both kinds under the consumption tax.

Table 7: Comparing Labor Supply Elasticities Across Tax Regimes

Parameter		Labor Tax	Consumption Tax
persistent-shock elasticity	$\epsilon_p$	0.2506	0.3092
transitory-shock elasticity	$\epsilon_t$	0.3495	0.4294

Note: The simulated sample covers 13,500 households over 42 years of working life, for a total of 567,000 observations.

By repeating the same regression year-by-year, we can track how labor supply elasticities evolve over the life cycle. The results of this exercises are plotted in Figure 4. Households are much less responsive to wage shocks early in the life cycle when assets are low and many are borrowing-constrained. As households approach retirement, the persistent-shock elasticities (dashed lines) converge to to the transitory-shock elasti-

cies (solid lines), as expected. As with the pooled results, the important takeaway here is that households are uniformly more sensitive to wage shocks when subject to a consumption tax.

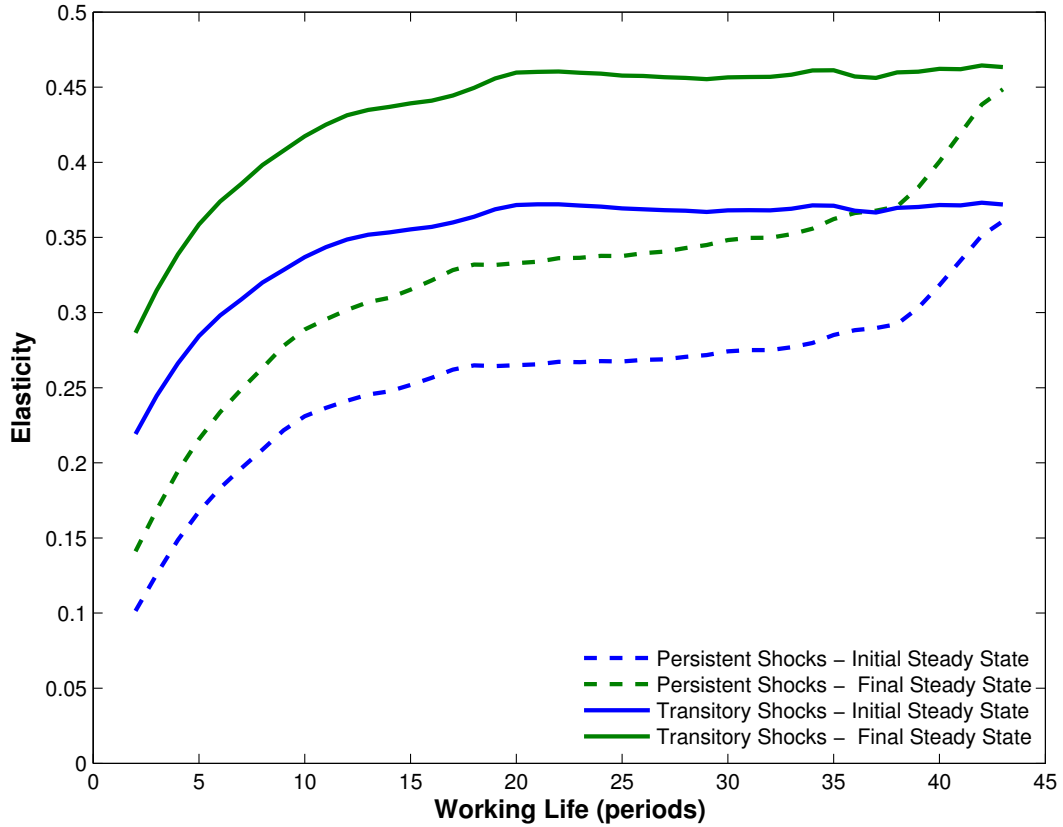


Figure 4: Labor Supply Elasticities Over the Life Cycle

**Aggregate Quantities and Inequality** The tax reform also leads to higher capital accumulation, with the long-run capital stock settling close to 2% above its initial level. Combined with the increase in labor supply, this leads to a long-run increase in GDP of 1.3%. While some of this additional output is used to maintain the larger stock of machinery and equipment, aggregate consumption still increases by a substantial 1.5%.

Table 5 reports Gini coefficients for several relevant variables. Using this measure

of inequality, we see that mitigating the distortion on labor effort amplifies the dispersion in labor earnings and wealth. But consumption inequality remains roughly unchanged. Thus, the aggregate increase in consumption does not come at the expense of long-run distributional concerns. Resources are better exploited but not less equally distributed in the new steady state.

**Welfare Effects** To measure the overall impact on welfare, I solve the following equation for the consumption equivalent variation:

$$W((1 + CEV)c_0, h_0) = W(c_\infty, h_\infty)$$

where  $W$  denotes *ex ante* expected lifetime utility (see Equation 4.1) and  $(c_0, h_0)$  and  $(c_\infty, h_\infty)$  denote allocations in the old and new steady states, respectively. In words, the  $CEV$  is the uniform percentage change in consumption at all ages and in all states of the world required to make the initial allocation as attractive to a future household as the terminal allocation. Because households in the new stationary equilibrium enjoy higher consumption without working more hours, it should not surprise that the  $CEV$  is positive. The proposed reform generates a moderate long-run consumption-equivalent welfare gain of 0.9%.

**Taxation Patterns** Table 8 reports tax collections by source as a share of total revenue. The household tax includes retirement benefits. For comparison's sake, I also report the equivalent figures from the benchmark economy in Kindermann and Krueger (2021). The sales tax in my baseline calibration yields a slightly smaller share of revenue than in theirs. They set the sales tax rate somewhat higher at 5%. Note that capital income taxes account for a larger share of government revenue in the terminal steady state, a mechanical response to greater demand for assets in a

consumption-based tax system.

	Baseline	Reform	K & K
Capital income tax	21.2%	25.7%	20.9%
Proportional sales tax	12.7%	9.7%	15.5%
Household tax-and-transfer	66.0%	64.5%	63.6%

Figure 5 illustrates the impact of the tax base on the life-cycle pattern of tax obligations. I calculate mean net taxes by age in both steady states, where net tax is defined as the sum of capital income taxes, sales taxes, and the household tax net of social security. I then discount these series with the respective interest rates to obtain present values.

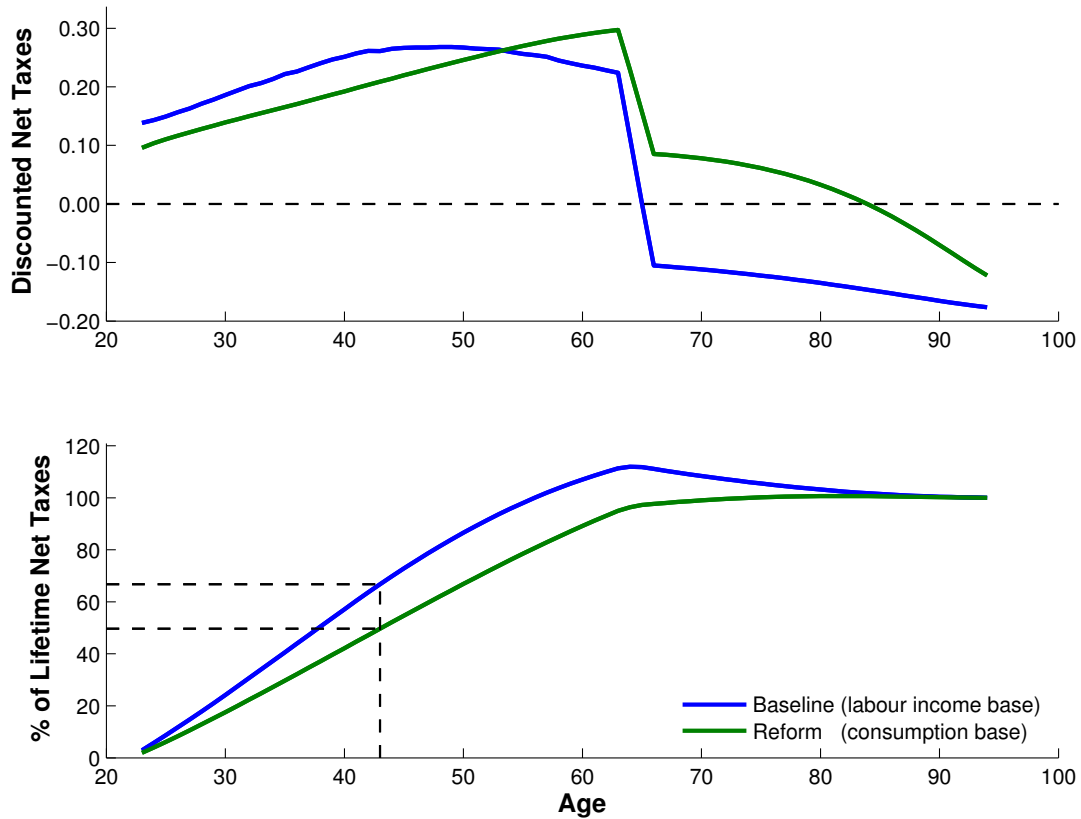


Figure 5: Discounted Net Taxes Over the Life Cycle

The top panel of Figure 5 plots the life-cycle profile of discounted net taxes for



both steady states. The bottom panel plots the cumulative share of lifetime taxes paid. At the mid-career point (shown with a vertical dashed line), the average labor-income-taxpayer has paid two-thirds of her lifetime net tax burden while the average consumption-taxpayer has paid just half. It is clear from both panels that retired households in the initial steady state receive, on average, more money from the government in the form of social security benefits than they pay in capital income taxes and sales taxes. In contrast, the typical retiree in the new steady state remains a positive net contributor to the public treasury well into her 80s.

Figure 5 addresses the reform's impact on the distribution of the tax burden. The top panel plots the cross-sectional Lorenz curves for the household tax in both steady states. The terminal Lorenz curve in green is much closer to the 45 degree line than the initial Lorenz curve in blue, suggesting that the simple reform substantially flattens the tax system and spreads the tax burden much less progressively across taxpayers. But that is only true at a given point in time. Consider the bottom panel of the figure, which plots the lifetime Lorenz curves for the household tax. Here we see that the green curve is only marginally closer to the 45 degree line, showing that the simple reform has little impact on the lifetime progressivity of the household tax.

This is important methodologically since it confirms that parametric progressivity is a consistent index of systemic progressivity across tax bases, at least locally. As such, the actual tax experiment—tax base conversion with constant  $\tau$ —is roughly equivalent to the idealized tax experiment—tax base conversion with constant progressivity. We can be confident, therefore, that our steady-state comparisons are capturing the impact of the change in tax base, not some unintended alteration to the redistributive structure of the tax code.

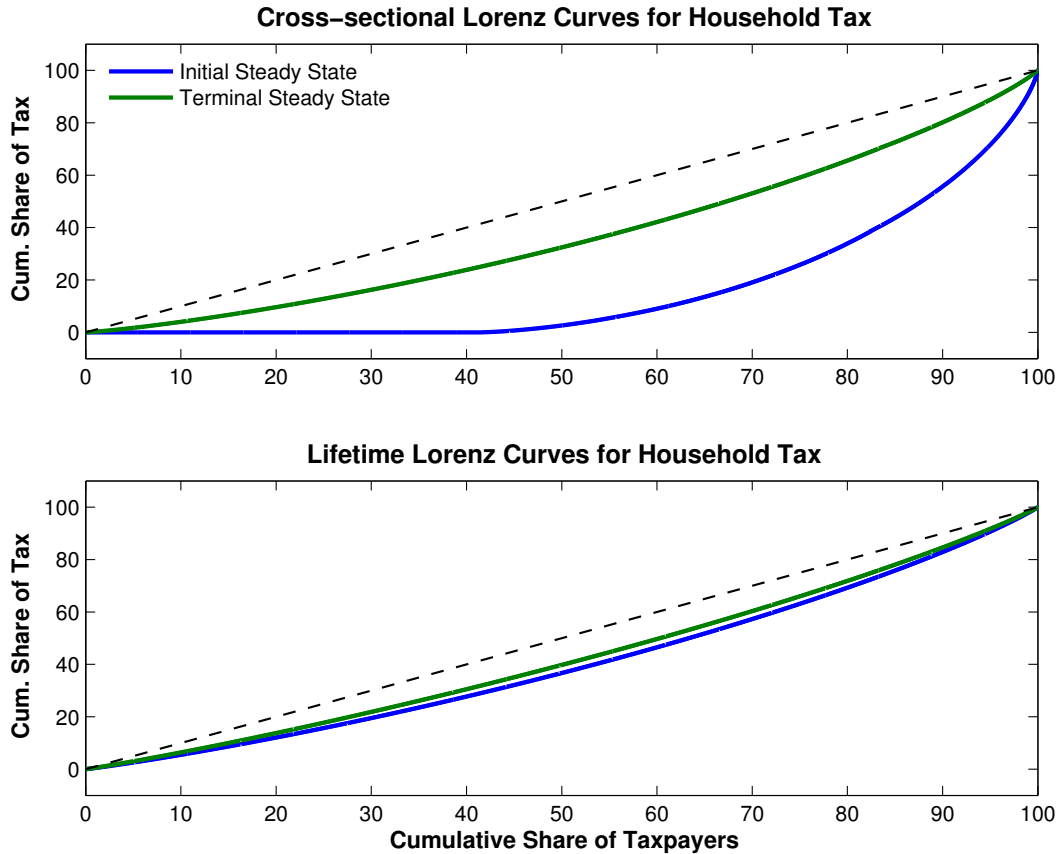


Figure 6: Distribution of the Household Tax Burden

**Distributional Effects** The simple reform generates long-run improvements in aggregate quantities with minimal impact on aggregate inequality and modest aggregate welfare gains. I now turn my attention to micro-level impacts. To sharpen the analysis, I construct a measure of household welfare similar in spirit to Benabou (2002) and Bakış et al. (2015). Specifically, I simulate a large number of histories and compute the lifetime utility for each one. I then calculate the constant consumption stream each household would have to receive to attain the same level of lifetime utility, assuming zero work hours. Denoting household  $i$ 's time paths for consumption and

hours as  $c_{i,j}$  and  $h_{i,j}$ , define its welfare  $\omega_i$  as the solution to:

$$\sum_{j=1}^J \beta^{j-1} \left\{ \left( \frac{c_{i,j}^{1-\sigma}}{1-\sigma} - \varphi \frac{h_{i,j}^{1+\gamma}}{1+\gamma} \right) - \frac{\omega_i^{1-\sigma}}{1-\sigma} \right\} = 0$$

Since preferences are homogenous, this measure allows us to make interpersonal comparisons, a useful feature when evaluating heterogeneous effects.

With an interpretable measure of household welfare in hand, I rank each simulated household in ascending order of lifetime utility, so that household 1 has the lowest  $\omega$ , household 2 has the second lowest  $\omega$ , and so on. I then re-simulate the histories using the decision rules and policy framework of the *new* steady state, keeping the sequences of productivity shocks the same. With two distinct choice histories for each shock sequence, I can answer questions about how certain kinds of households would fare if they were counterfactually subject to a cash-flow tax rather than a labor income tax.

Figure 7 illustrates how the simple reform affects behaviour and outcomes across the welfare distribution. For a range of variables, I calculate the percentage change across tax regimes for each simulated household, and then regress those percentage changes on a quadratic in *initial* welfare ranks. The fitted values and 95% bounds from these regressions are displayed in the figure for a selection of key variables. The horizontal axis of each panel marks the percentiles of initial welfare. To properly interpret these graphs, think of the solid lines as tracing out the expected percentage change as a function of initial welfare rank, and the dashed line as tracing out the associated range of outcomes. Thus, Figure 7 is useful for thinking about the ways in which the simple reform amplifies or mitigates inequalities across households. Is the cash-flow tax better for the utility-rich or the utility-poor?

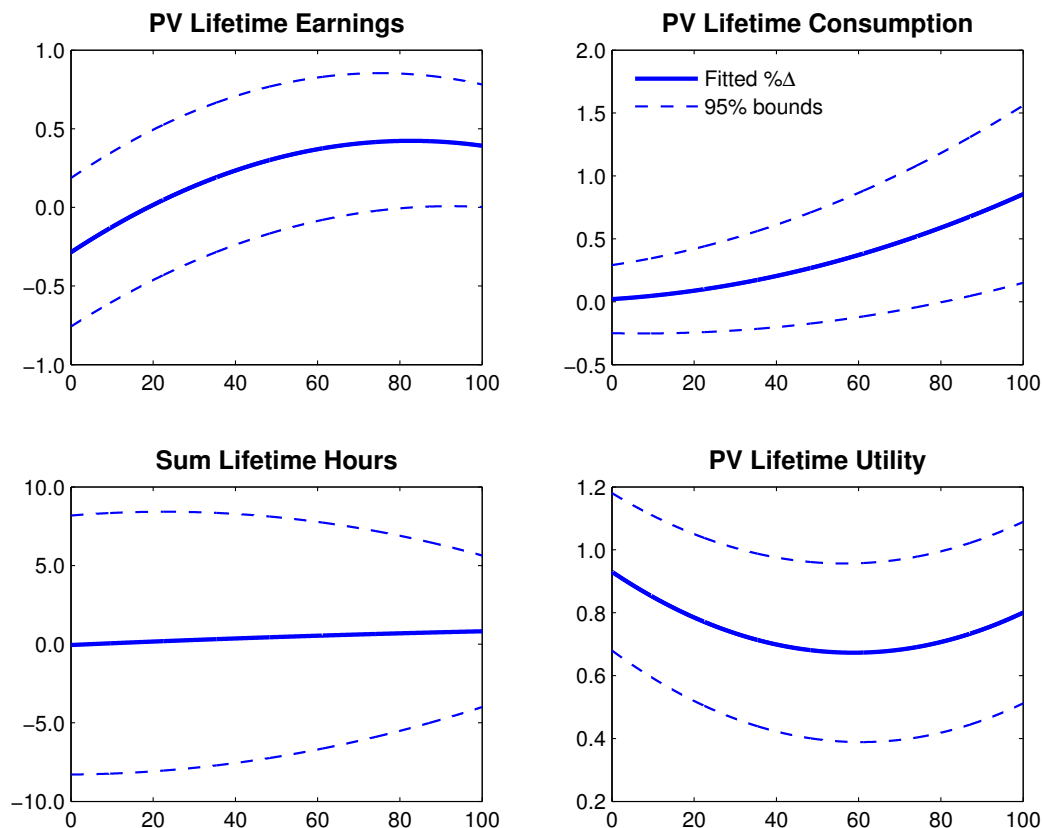


Figure 7: Discounted Net Taxes Over the Life Cycle

The top-left panel shows a clear upward trend in lifetime earnings. The households for whom the cash-flow tax generates the largest impact on earnings are those who already occupy the top percentiles of the welfare distribution. Interestingly, the bottom-left panel indicates a relatively flat average effect on hours. Together, the two left panels indicate that the principal channel through which the simple reform improves welfare—namely, reducing distortions on the labor supply response to changes in wages—operates primarily among high-productivity households.

Compare this result to those in a related study by Nakajima and Takahashi (2020). They evaluate the effectiveness of a reform that finances an increase in lump-sum transfers with a higher linear tax rate on consumption. Importantly, labor is indivisi-

ble in their model, and there is therefore no margin by which working households can adjust their labor supply upwards in response to stronger work incentives. As a result, their reform captures little to no improvement in labor efficiency. This suggests that the existence of an intensive margin may be critical to the quantitative results.

The upward trend in lifetime earnings is inherited by lifetime consumption. While the vast majority of households enjoy an increase in lifetime consumption, the highest ranked households experience the largest gains, as exhibited in the top-right panel. The picture is slightly different for lifetime utility, which is shown in the bottom-right panel. This chart indicates that the largest changes in the household welfare measure accrue to those households with the very lowest rankings in the initial steady state. Overall, the percentage change in welfare across tax regimes exhibits a pronounced U-shape. As with earnings and hours, there is substantial heterogeneity in policy effects for consumption and utility, even after conditioning on initial welfare rank.

#### *4.3.3. The Transition Path*

Figure 8 documents the evolution of key macroeconomic aggregates and prices along the transition path. Notice the absence of discontinuous jumps at the outset of the transition. Although sharp immediate reactions are typical with this sort of quantitative exercise, the short-run macroeconomic response is muted here because the new policy applies exclusively to post-reform generations. Consequently, the economy evolves gradually, converging to the new steady state after one hundred periods or so.

The short-run impact on work effort is mildly positive, with average hours climbing gently over the first two decades of the transition, falling sharply thereafter to the new long-run level. Aggregate labor supply increases steadily before leveling off around

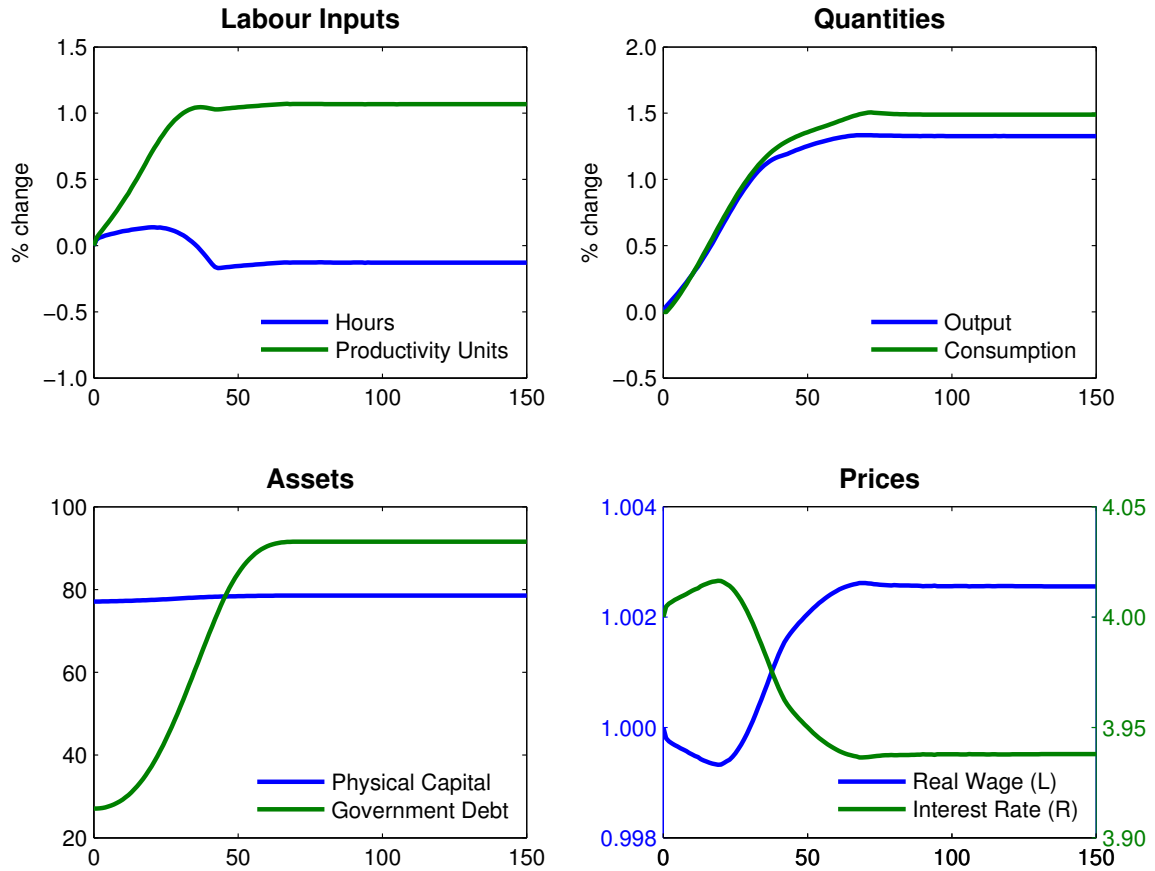


Figure 8: Transition Path for Aggregate Quantities and Prices

the time the last of the existing generations retires from the workforce. Physical capital, total output and consumption all increase monotonically along the transition path. Most of the gains are realized by the time the first post-reform generation dies out.

The reform's immediate impact on labor supply causes wages to fall and interest rates to rise in the short run, though the magnitude of these changes is negligible. After a couple of decades, the effect of higher capital accumulation kicks in and prices begin moving in the opposite directions toward new steady-state values. The real wage ultimately climbs 0.3% while the interest rate falls from 4.0% to 3.9%.

One of the most notable changes is the increase in government debt, which more than triples over the transition on a per capita basis. In the initial stationary equilibrium, government debt accounts for roughly one-quarter of household assets, with physical capital accounting for the rest. By the time the economy converges to the post-reform steady-state, the average portfolio holds more government debt than physical capital. This massive expansion of the public debt is largely mechanical. Because tax liabilities are deferred under the consumption tax regime, the government collects fewer taxes in the early years of the transition. The government offsets these revenue shortfalls by issuing new bonds. Fortunately, there are many willing buyers for this debt since post-reform cohorts know they must eventually finance the significant tax liabilities triggered by their late-in-life consumption. Thus, the net flow of funds between households and the government is, to a rough approximation, no different under the new tax regime. The only difference is that collections are tilted more toward loans and less toward taxes. Indeed, 99% of the increase in household saving consists of government bond purchases.

The rapid and substantial increase in government debt is therefore an artifact of changes to the timing of tax collections over the life cycle, not a sign of weak government finances. That being said, this accumulation of debt underlines the importance of computing the entire transition path when evaluating a policy change. Otherwise, a considerable part of the future fiscal burden would be covertly shifted to the near term, yielding misleading estimates of the reform's long-run effects. My approach avoids this bias by explicitly ensuring equal tax treatment for all cohorts during the transition. Consumption-taxpayers face the same rate schedule no matter when they are born.

As a check on how well my approach isolates the impact of the choice of tax base,

we can chart welfare gains and losses by cohort. The top panel of Figure 9 displays cohorts already alive at the time of the reform. The bottom panel displays cohorts born into the transition. Recall that all post-reform generations are subject to the exact same fiscal policy; the only difference in their economic environments is the path of equilibrium factor prices which evolve over the transition as shown in Figure 8. The same can be said of all pre-reform generations. Thus, we should expect only minimal variation in welfare consequences within each panel. And this is indeed what we see.

The CEVs for existing generations are tiny and range from -0.06% for the very youngest to 0.02% for middle-aged households. The CEVs for post-reform generations range from 0.85% for households born in the 17<sup>th</sup> year of the transition to roughly 0.92% for all cohorts born after the first fifty years. These slight variations in welfare across cohorts are due to small changes in the evolution of wages and interest rates from one steady state to another.

#### *4.3.4. Decomposing the Macroeconomic Effects*

The reform's long-run effects stem from several operative channels. The direct effects include efficiency gains from mitigating the distortions on work decisions and possible impacts on the social insurance system. There are also general equilibrium prices effects. The larger capital stock in the new steady state leads to (slightly) higher wages and (slightly) lower returns to saving. I assess the relative importance of these channels by computing the transitions implied by a series of appropriate counterfactual conditions.

In the first of these exercises, the results of which are reported in column 2 of Table 9, I isolate the impact of the labor supply distortions. In this scenario, no actual changes



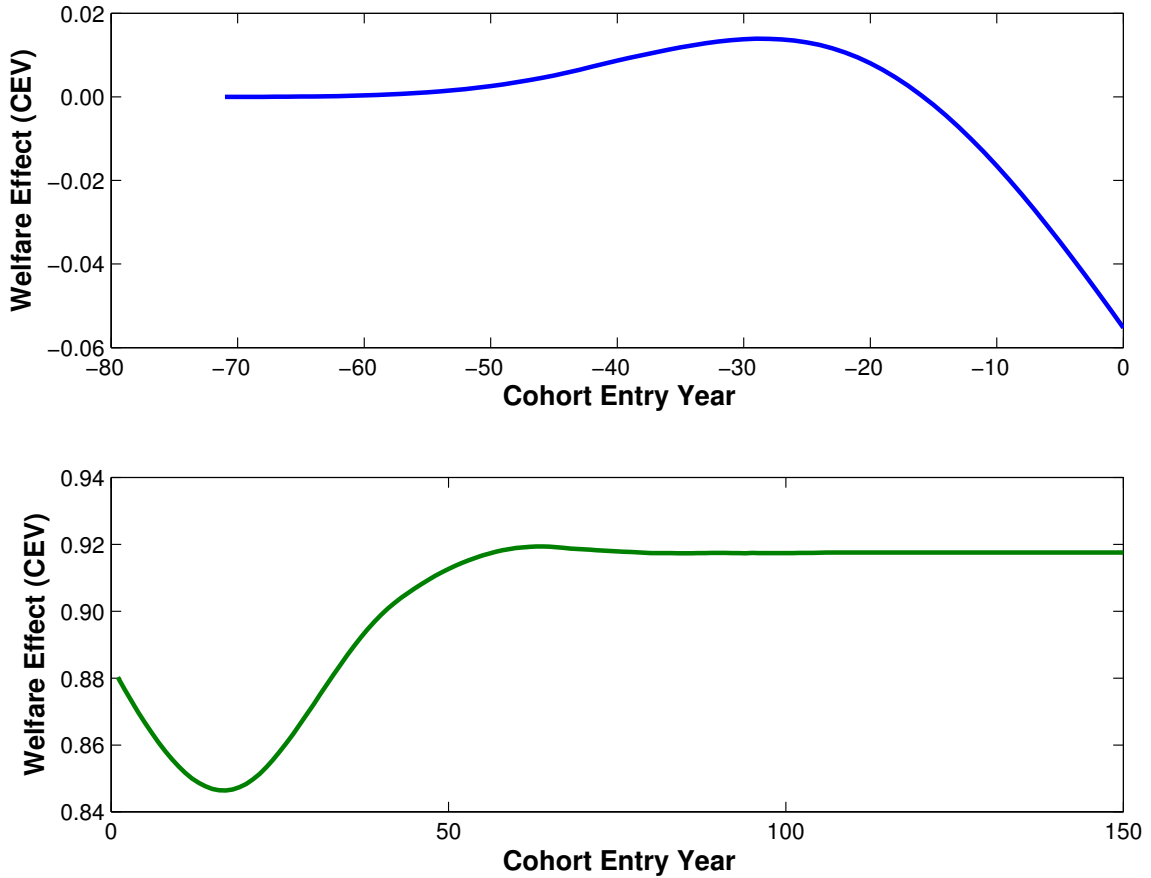


Figure 9: Welfare Effects of Policy Reform by Age Cohort

are made to the tax base. All cohorts, old and new alike, continue to pay taxes on the basis of their earnings. Post-reform households, however, are assumed to act *as though* they were subject to a newly introduced consumption tax. Their decision rules solve an auxiliary problem, one where taxes are levied on consumption, not the actual problem where taxes are levied on earnings. These households are, in a sense, ‘tricked’ to behave in a manner that produces the efficiency gains associated with the switch to a consumption base, but without introducing real changes to the structure of social insurance. In addition, factors prices are fixed at their initial steady-state levels.

Table 9: Decomposing the Macroeconomic and Welfare Effects

	(1)	(2)	(3)	(4)	(5)
	Baseline	Efficiency	Insurance	Fixed Prices	Reform
<b>Tax regime</b>					
Tax base	L	L	C	C	C
Tax level $\lambda$	0.666	0.674	0.653	0.659	0.659
Tax progressivity $\tau$	0.136	0.136	0.136	0.136	0.136
<b>Quantities (%<math>\Delta</math>)</b>					
Hours worked		0.35	-0.41	-0.17	-0.13
Labor supply		1.59	-0.42	1.03	1.07
Capital stock					1.85
Consumption		2.31	-0.57	1.56	1.49
Output					1.33
<b>Prices</b>					
Wage rate	1.000	1.000	1.000	1.000	1.003
Interest rate (%)	4.00	4.00	4.00	4.00	3.94
<b>Welfare</b>					
CEV (% $\Delta$ )		1.35	-0.33	0.95	0.92
<b>Gini coefficients</b>					
Consumption	0.201	0.202	0.201	0.203	0.200
Earnings	0.343	0.364	0.352	0.364	0.364
Wealth	0.495	0.496	0.503	0.505	0.506

The third column reports the results of the reverse exercise: households continue acting as though they are subject to tax on earnings, but tax burdens are in fact assessed according to expenditures. The purpose of this exercise is to isolate the impact on the social insurance system. Does a consumption-based tax code do a better job of redistributing resources from the rich and lucky to the the poor and unlucky? As with the first counterfactual exercise, prices are held fixed.<sup>6</sup>

I then quantify the joint impact of the efficiency and insurance channels by solving

<sup>6</sup>For additional details on the computation of the pseudo-consumption tax case and the pseudo-labor income tax case, see Appendices A.6.4 and A.6.5.

for the terminal steady state in the case of an open economy. The only difference between this scenario and the full reform is that prices do not evolve to reflect changes in aggregate quantities. The results of this exercise are reported in column 4 of Table 9. In all decomposition exercises, it is necessary to compute the transition path of public debt in order to obtain the correct budget-balancing values for tax parameter  $\lambda$ . The true initial and terminal steady states are displayed in columns 1 and 5 of Table 9.

Several observations are worth making. First, the quantitatively important effect is the mitigation of labor supply distortions. Eliminating these distortions, in isolation, produces a 0.4% increase in labor supply and a 1.2% improvement in labor efficiency. Aggregate consumption rises by a sizable 2.3% in the long run, more than enough to offset somewhat higher work hours. This channel is responsible for generating all the positive welfare gains associated with the simple reform.

Introducing the social insurance effect attenuates or reverses many of these aggregate impacts. For example, long-run hours are 0.4% higher after mitigating the labor supply distortion, but 0.4% lower after changing the basis for social insurance. There is no impact on aggregate labor productivity. From a welfare perspective, the social insurance effect is modestly negative. In this setting, the advantage of taxing the superior signal for lifetime resources is clearly dominated by whatever advantage lies in taxing earnings year by year.

Given the small differences in factor prices from one steady state to the other, it is not surprising to see that the small open economy departs only marginally from the closed economy. Equilibrium price effects are simply not large enough to color the welfare consequences of the tax reform.

## 4.4. An Optimal Tax Reform

In the previous section I assessed the impact of converting the tax system from an earnings base to an expenditure base while holding progressivity fixed. This simple reform generates a sustained consumption-equivalent welfare gain of roughly 0.9% for cohorts born into the transition.

However, there is no reason to think *a priori* that the baseline progressivity is optimal for either tax base. The parameter  $\tau$  reflects the tax code as it is, not as it ought to be. The results of the previous section are therefore an approximation of the differences between a progressive labor income tax and a progressive consumption tax, not its definitive measure. To obtain the latter, we must numerically characterize the *optimal* choice of  $\tau$  under *both* tax regimes and then compare. The differences that we observe from the best-on-best comparison could be larger or smaller than before.

To ensure a consistent analysis, the optimal tax reform proceeds along the exact same lines as the experiment described in subsection 4.3.1. In particular, only future cohorts are subject to the new tax code and older cohorts continue to operate under the old policy rules. This is true for all experiments, regardless of whether the tax base is converted to consumption or not.

### 4.4.1. The Optimal Tax Codes

Figure 10 plots welfare gains against the progressivity parameter  $\tau$ . The green and blue dashed lines indicate the locations of the optimal progressivity parameter for the labor income tax and consumption tax, respectively. The vertical black dashed line indicates the location of the baseline progressivity parameter.

There are several important things to notice from this picture. First, the optimal

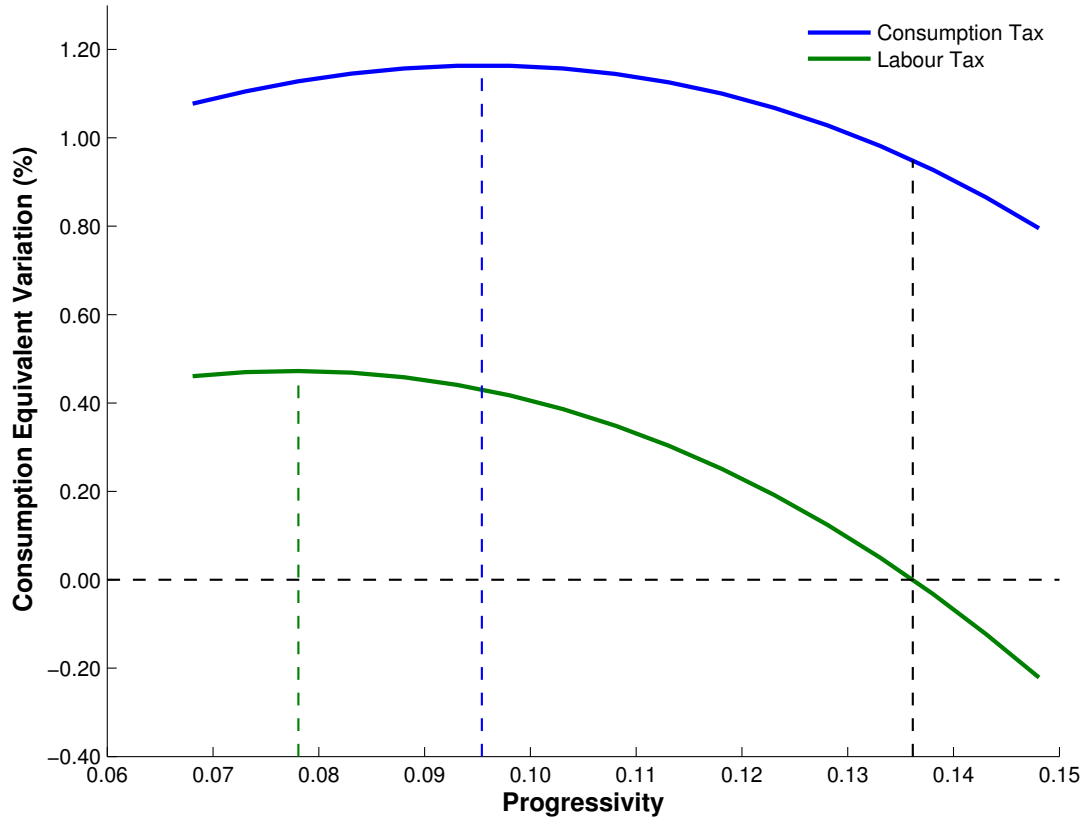


Figure 10: Long-Run Welfare Gains by Tax Base as a Function of  $\tau$

tax code is less progressive, in the sense that  $\tau$  is lower, whether or not the tax system is converted to a consumption base. Second, the  $\tau$  that maximizes welfare for the consumption-based system is higher than the one that maximizes welfare for the earnings-based system. Third, the utilitarian gap between the two tax bases narrows slightly when we compare optima.

Table 10 documents important long-run differences across tax regimes. The numbers for Baseline and Simple Reform are reproduced from Table 5. To those I have added model data for the steady states induced by a transition to the optimal labor income tax (column 2) and the optimal consumption tax (column 4). Both optimal reforms, which reduce the scale of the progressivity parameter, lead to large long-run increases

in aggregate quantities. Labor supply and physical capital expand by roughly 3% and 7%, respectively, and both output and consumption increase well over 4%. Interestingly, the changes in these quantities are very similar under either optimized reform, despite the different tax bases and the different settings for the tax parameters.

Table 10: Terminal Steady States Under Optimal Tax Reform

	(1)	(2)	(3)	(4)
	Baseline	Optimal L-Tax	Simple Reform	Optimal C-Tax
<b>Tax regime</b>				
Tax base	L	L	C	C
Tax level $\lambda$	0.666	0.712	0.659	0.699
Tax progressivity $\tau$	0.136	0.078	0.136	0.095
<b>Quantities (%<math>\Delta</math>)</b>				
Hours worked		2.48	-0.13	2.30
Labor supply		2.94	1.07	3.19
Capital stock		7.16	1.85	6.93
Consumption		4.35	1.49	4.61
Output		4.32	1.33	4.41
<b>Prices</b>				
Wage rate	1.000	1.013	1.003	1.009
Interest rate (%)	4.00	3.68	3.94	3.78
<b>Welfare</b>				
CEV (% $\Delta$ )		0.47	0.92	1.16
<b>Gini coefficients</b>				
Consumption	0.201	0.205	0.200	0.201
Earnings	0.343	0.358	0.364	0.352
Wealth	0.495	0.514	0.506	0.503

Despite the substantial increases in per capita quantities, the long-run welfare impacts of optimized tax reform are surprisingly muted. The CEV is 0.5% for the optimal labor income tax. It is 1.2% for the optimal consumption tax, not much higher than the gain generated by base-conversion alone. Relative to the simple reform, the change

in consumption is 3.12 percentage points greater under the optimal consumption tax. But the change in hours is 2.43 percentage points greater too. The disutility of the incremental work effort erodes most of the welfare improvement from higher consumption.

The simple reform produces a welfare gain of 0.9%. When comparing optima, the performance advantage of consumption taxation narrows to about 0.7%, somewhat smaller than before. In fact, starting from the initial steady state, there are more welfare gains to be had from converting to a cash-flow tax than there are from optimizing the existing labor income tax. The main result stands: adopting a progressive consumption tax generates moderate welfare gains relative to a tax on earnings.

#### *4.4.2. Labor Supply in the New Steady State*

I previously argued that labor efficiency was the main channel through which the simple reform affected aggregate quantities and welfare. I conduct a similar analysis here for the optimal tax reforms.

In Figure 11, I trace out the life-cycle profiles of work effort and average productivity in the stationary equilibria associated with each of the three tax reforms. As shown in the top panel, the two optimal reforms induce similar changes in hours over the life cycle. The slight difference in aggregate hours between these two regimes has its source at the beginning and end of the working life. In contrast, the simple reform has a very marginally negative impact on hours. These results illustrate the impact of the progressivity parameter  $\tau$  on *lifetime* hours, which applies regardless of the tax base.

The bottom panel reveals a starker rank-order with respect to changes in labor productivity, which is defined as total productivity units divided by total hours, as before.

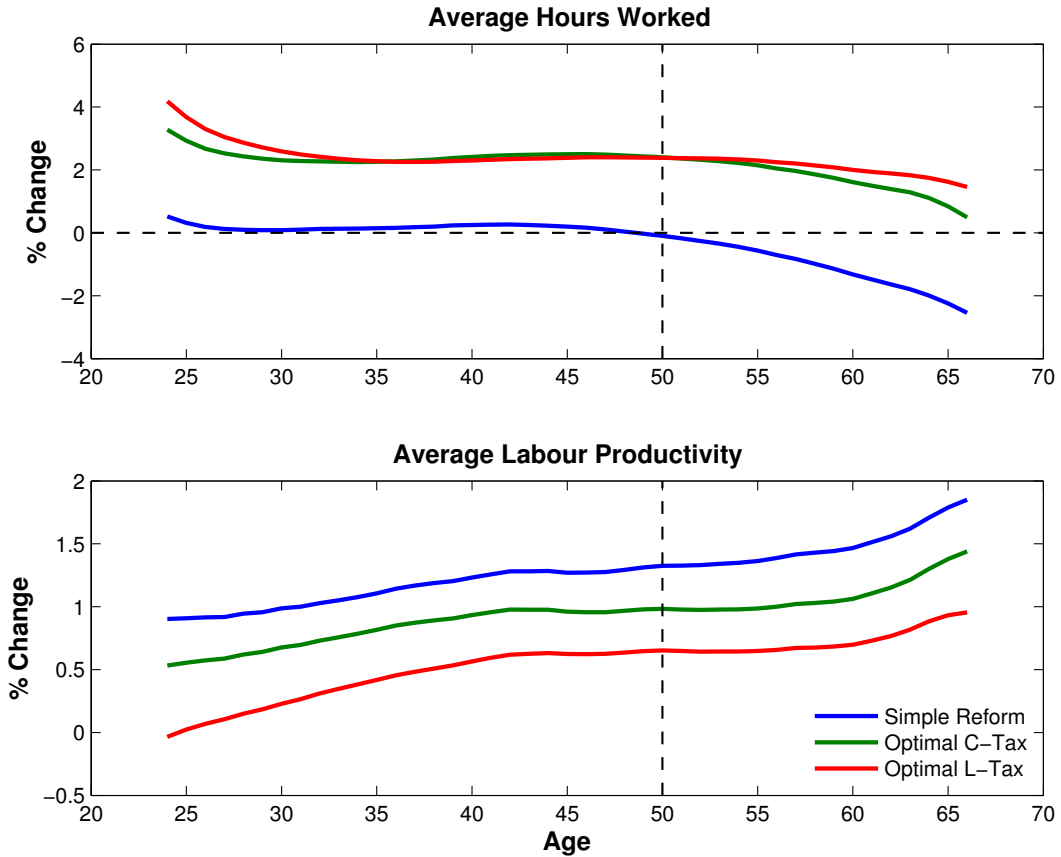


Figure 11: Hours and Productivity Over the Life Cycle by Tax Reform

The simple reform induces the the greatest response along this dimension, greater even than the optimal consumption tax. Under the latter regime, hours are uniformly higher in all states of the world, so the change in average labor productivity is mechanically less pronounced. The optimal labor income tax, which continues to distort the allocation of labor across productivity states—albeit less intensely than before—induces the smallest improvement in labor efficiency.

Table 11 reports the steady-state changes in labor productivity, aggregated across age groups. The story for the optimal reforms is similar to that for the simple reform. There is little re-allocation of work effort across age; the improvement springs entirely from re-allocation of work effort across productivity states.



Table 11: Change in Aggregate Labor Efficiency Across Steady States

$\Delta\%$ in labor efficiency due to..	Simple Reform	Optimal C-Tax	Optimal L-Tax
intertemporal re-allocation of hours	-0.03	-0.02	-0.06
intratemporal re-allocation of hours	1.23	0.89	0.51
combined re-allocation of hours	1.20	0.87	0.45

As I did for the simple reform, I estimate the elasticity of labor supply with respect to persistent and transitory innovations to the productivity process. The life-cycle elasticity profiles are plotted in Figure 12 and the aggregate elasticities are reported in Table 12. All three tax reforms induce marked increases in labor supply sensitivity to shocks of either type. The elasticity profiles of the two consumption-tax steady states are indistinguishable, while workers toiling under the optimized labor income tax are somewhat less responsive, though still much more so than in the benchmark economy.

Table 12: Comparing Labor Supply Elasticities Across Steady States

Parameter		Baseline	Simple Reform	Optimal L-Tax	Optimal C-Tax
persistent-shock elasticity	$\epsilon_p$	0.2506	0.3170	0.2926	0.3092
transitory-shock elasticity	$\epsilon_t$	0.3495	0.4343	0.4132	0.4308

#### 4.5. Sensitivity Analysis

In this section I discuss the sensitivity of my results to the key parametric assumptions. For each alternative specification it is necessary to recalibrate the model to make the results comparable with those reported above for the baseline economy. Throughout this section I focus on results from the simple tax reform described in Section 4.3.

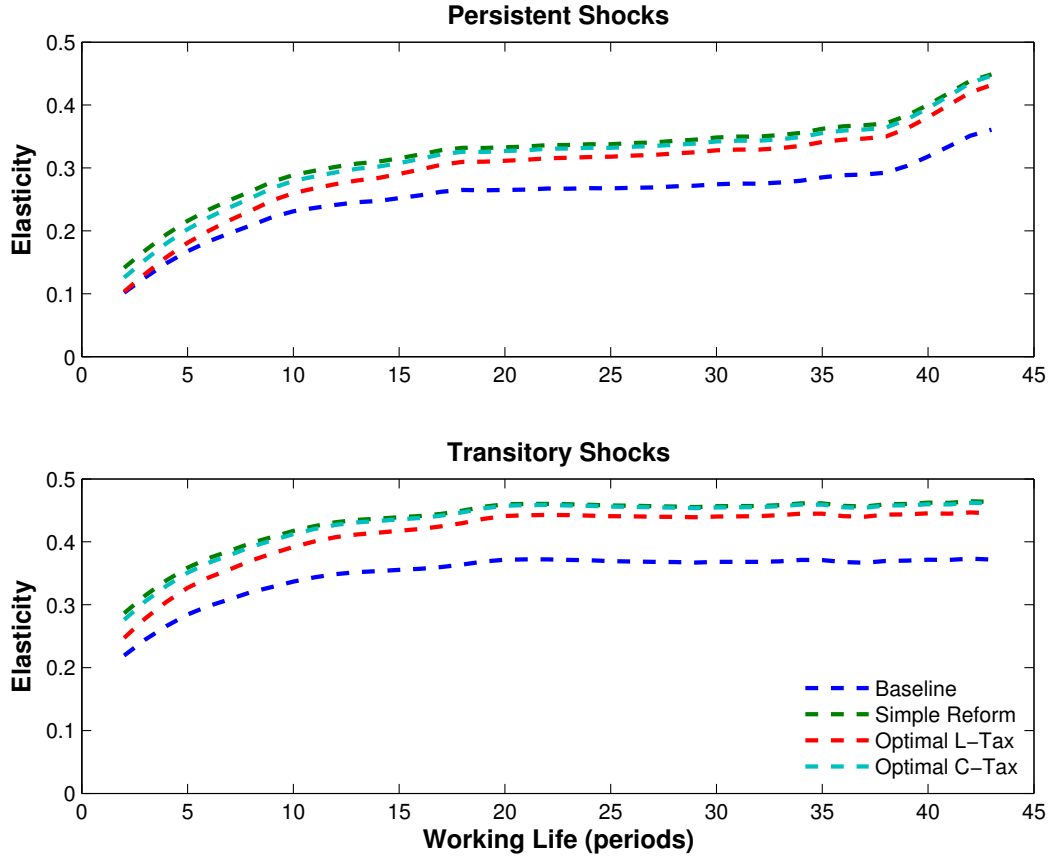


Figure 12: Labor Supply Elasticities Over the Life Cycle

#### 4.5.1. Labor Supply Elasticity

I showed in Section 4.3 that the welfare gains associated with a progressive consumption tax are closely linked to the willingness and ability of households to substitute work hours across productivity states. To check if these results are quantitatively robust, I conduct a sensitivity analysis with respect to the labor elasticity parameter  $\gamma$ . In particular, Table 13 documents how the results change when we set the Frisch elasticity at a lower value (0.25) and a higher value (0.75). Not surprisingly, the impact of the simple tax reform is less dramatic when labor supply is less elastic. Long-run labor efficiency improves by only 0.6% in the low Frisch scenario, about half the baseline increase. Consequently, the welfare gains are more modest, about

0.5% in consumption-equivalent terms.

Table 13: Sensitivity with Respect to Preference Parameters

		Baseline	Low Frisch	High Frisch	Low CRRA	High CRRA
<b>Parameters</b>						
Coefficient of RRA	$\sigma$	2.00			1.00	4.00
Frisch elasticity	$\gamma^{-1}$	0.50	0.25	0.75		
<b>Quantities (%<math>\Delta</math>)</b>						
Hours worked		-0.13	0.13	-0.52	-1.18	0.61
Labor supply		1.07	0.74	1.26	0.14	1.72
Capital stock		1.85	0.43	3.07	-0.75	4.90
Consumption		1.49	0.91	1.87	0.06	2.65
Output		1.33	0.63	1.85	-0.15	2.76
<b>Prices</b>						
Wage rate		1.003	0.999	1.006	0.997	1.010
Interest rate (%)		3.94	4.02	3.86	4.07	3.76
<b>Welfare</b>						
CEV (% $\Delta$ )		0.92	0.55	1.20	0.26	1.69

This table reports the long-run impact of the simple tax reform under alternative specifications of the model. The model is always calibrated so that prices in the initial steady state are  $w = 1$  and  $r = 4\%$ , and so that one-third of the time endowment is devoted to working. The baseline results from Section 4.3 are reproduced here for ease of comparison. Blank cells in the parameter rows indicate no change from the baseline.

#### 4.5.2. Consumption Smoothing

The relative merits of progressive consumption taxation are closely linked to the household's inclination to smooth its consumer spending over time. To test how my choice for the intertemporal elasticity of substitution affects the results, I consider a lower value ( $\sigma = 1$ , that is, log-utility) and a higher value ( $\sigma = 4$ ) for this parameter. The results are reported in Table 13 alongside those from the previous subsection. The key finding here is that the welfare and macroeconomic effects of the simple

reform are quite sensitive to the choice of this parameter. In the log-utility case, the welfare gain of tax-base conversion is much smaller, about 0.3%. In the other case, the welfare gain nearly doubles to 1.7%.

## 4.6. A Rate-Differentiated Indirect Tax System

In this section, I explore the possibility of building a progressive tax system using rate-differentiated indirect taxes on consumption. For reasons discussed in Chapter 3, I consider only the simplest version of this scheme, one in which a subset of final goods and services is exempt from taxation, and all others are taxed at a common rate. This kind of rate differentiation is familiar to taxpayers in many jurisdictions with RSTs or VATs, as it is common to levy below-standard or zero rates on groceries, medicines and other necessities. If the expenditure share on taxable goods increases with total expenditure, then a simple two-rate system can distribute the tax burden across households in a progressive manner.

### 4.6.1. A Model with Basic and Non-Basic Consumption

The model is the same as before with one notable modification. Instead of a single composite good, households divide their spending between basic consumer goods  $c$  and non-basic consumer goods  $d$ . The household's choice is constrained by a minimum basic consumption level  $\underline{c}$ .

Following Conesa et al. (2020), the period utility function takes the following form:

$$u(c, h) = \frac{[(c - \underline{c})^\theta d^{1-\theta}]^{1-\sigma}}{1 - \sigma} - \varphi \frac{h^{1+\gamma}}{1 + \gamma} \quad (4.11)$$

The parameter  $\theta$  governs the share of household expenditures *in excess* of the minimum level that is devoted to basic goods and services. Non-basic consumption is

subject to its own flat tax rate, denoted  $\tau_d$ , and the output good is costlessly converted into either consumption good.

#### *4.6.2. Calibrating the Two-Good Model*

Compared with the baseline model, I need to pin down two additional structural parameters,  $\underline{c}$  and  $\theta$ . These parameters are chosen to capture consumption patterns observed in the 2006-2012 waves of the Consumer Expenditure Survey (CEX).

The first step is to empirically distinguish between basic and non-basic consumption. After restricting the sample along similar lines to Heathcote et al. (2010), I calculate expenditure shares for 12 consumption categories and dozens of associated subcategories. I then separately regress each consumption variable on total expenditure and its square. The results are displayed in Table 20 and are used to classify goods and services into one of two groups. For more details on the sample selection and the classification procedure, see Appendix A.7.

The first group of variables consists of those for which the the estimated constant term is positive and the estimated quadratic coefficient is negative. There are eight such variables: food at home; rented dwellings; utilities; gasoline and motor oil; vehicle insurance; prescription drugs; televisions, radios, and sound equipment; and tobacco and smoking supplies. Because some of these goods are unlikely to be exempted from tax in practice, I choose four of them to serve as my empirical counterpart to the model's basic consumer good, namely: food at home, rented dwellings, utilities, and prescription drugs. These four variables account for 27.3% of total consumer spending. All other variables are subsumed into the non-basic category.

The relationship between expenditure shares and total expenditure is displayed in Figure 13 for selected categories. The basic expenditure share declines steeply with

total expenditure. These categories account for 55.8% of all consumer spending in the bottom decile but only 15.4% of all consumer spending in the top decile.

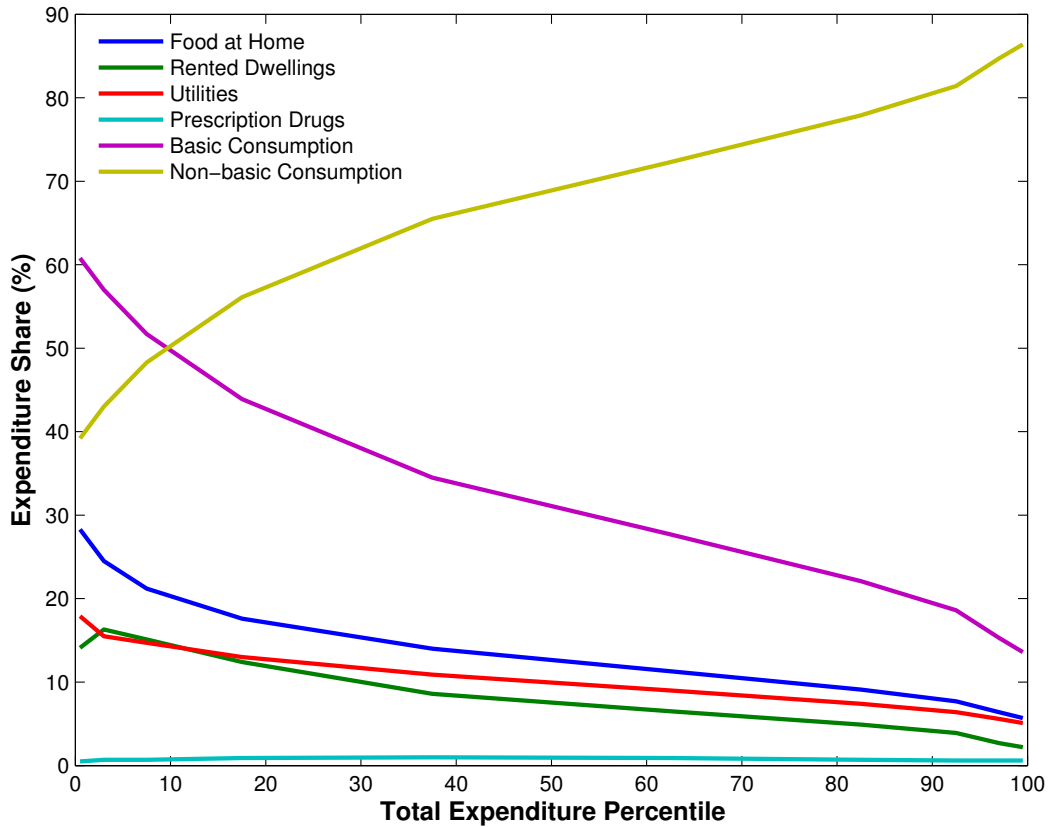


Figure 13: Basic and Non-Basic Consumption

To pin down the new structural parameters, I regress the sum of the designated basic categories on total expenditure and set  $\theta$  equal to the estimated slope coefficient. The value is 0.091, indicating that approximately 91% of consumer expenditures in excess of the basic minimum are devoted to non-basic consumer goods. The minimum consumption  $\underline{c}$  is subsequently chosen to target the empirically observed ratio of non-basic to basic consumption,  $\frac{C}{D} = 2.65$ .

In the initial calibration, the tax rates on both kinds of consumption are set to the same value, 4.4%. All other parameters, whether calibrated externally or internally,

are chosen as in Section 4.2. Select key parameters are summarized in Table 14, with internally calibrated parameters in bold.

Table 14: 2-good model parameters

Parameter		Value	Target
Preferences			
$\sigma$	Coefficient of relative risk aversion	2.0	
$\gamma^{-1}$	Frisch elasticity	0.5	
$\varphi$	<b>Disutility of labor</b>	<b>170.1</b>	$\bar{h} = 1/3$
$\beta$	<b>Annual discount factor</b>	<b>1.015</b>	$r = 4\%$
$\theta$	Basic consumption share	0.091	
$\underline{c}$	<b>Basic consumption minimum</b>	<b>0.062</b>	$\frac{C}{D} = 2.65$
Production			
$\alpha$	Capital income share	0.33	
$\delta$	Depreciation rate	8%	
$A$	<b>Aggregate technology</b>	<b>0.937</b>	$w = 1.0$
Policies			
$\tau$	Labor tax progressivity	0.136	
$\lambda$	<b>Labor tax level</b>	<b>0.656</b>	$G/Q = 0.17$
$\tau_k$	Capital tax rate	28.3%	
$\tau_c$	Basic sales tax rate	4.4%	
$\tau_d$	Non-basic sales tax rate	4.4%	
$B$	<b>Public debt</b>	<b>26.4</b>	$B/Q = 0.97$
$b$	<b>Social security benefit</b>	<b>0.193</b>	$b/\bar{y} = 0.35$
Transfers			
$q$	<b>Accidental bequest</b>	<b>0.029</b>	fixed point

Internally calibrated parameters are in bold.

#### 4.6.3. Two Routes to a Progressive Consumption Tax

The benchmark quantitative model of Section 4.1 admits a single approach to implementing a progressive consumption tax: the direct cash-flow tax with graduated rates. With the two-good model we can also study the adoption of a rate-differentiated indirect system. In this subsection, I numerically assess and compare these two ap-

proaches.

The tax experiments proceed as in Section 4.3. Pre-reform households remain subject to the existing earnings-based tax system. Post-reform households are subject to the new consumption-based tax system, with fiscal policy parameters and transfers held constant across generations. Public debt adjusts along the transition to absorb any shortfalls in the government budget. Consequently, the only environmental differences across generations (besides status as pre- or post-reform) are general equilibrium price effects.

The cash-flow reform is constructed the same way as before. The base is converted from earnings to consumption, and  $\lambda$  adjusts to ensure budget balance. The design of the rate-differentiation reform is as follows. The progressive labor income tax and the common-rate sales tax are jointly replaced by a dual-rate sales tax. The tax rate on basic goods is exogenously set to zero. The tax rate on non-basic goods is chosen to balance the government budget in the terminal steady state. The difference between the two tax rates, along with the endogenous consumption response, determines the extent of progressivity in equilibrium. The policy parameters of the various reform packages are summarized in Table 15.

Table 15: Consumption-Based Tax Regimes

	direct tax		indirect taxes		transfers	
	$\tau$	$\lambda$	$\tau^c$	$\tau^d$	$b$	$q$
<b>Closed Economy</b>						
Cash-Flow System	0.136	0.574	4.4%	4.4%	0.2427	0.0624
Rate-Differentiation			0.0%	111.5%	0.1932	0.0573
<b>Open Economy</b>						
Cash-Flow System	0.136	0.561	4.4%	4.4%	0.2427	0.0713
Rate-Differentiation			0.0%	112.6%	0.1932	0.0575

The capital income tax rate remains fixed at 28.3% in all experiments.

The consumption-equivalent welfare measure used to evaluate the tax reforms un-



der consideration is defined as before, with some modifications to account for the presence of multiple goods and the consumption floor. Specifically, the consumption equivalent variation is the uniform percentage change in total consumption required to make the initial steady-state allocation as attractive as the terminal steady-state allocation, assuming that the difference is distributed across the two consumer goods in proportion to the amounts consumed in excess of the basic minimum.

Formally, let  $(c_0, d_0, h_0)$  and  $(c_\infty, d_\infty, h_\infty)$  denote allocations in the old and new steady states, and let  $W$  denote *ex ante* expected lifetime utility as a function of the allocation. Then the consumption-equivalent variation is defined as:

$$CEV = \left( \frac{c_0 - \underline{c} + d_0}{c_0 + d_0} \right) \varsigma$$

where  $\varsigma$  is the (unique) solution to:

$$W((1 + \varsigma)(c_0 - \underline{c}), (1 + \varsigma)d_0, h_0) = W(c_\infty, d_\infty, h_\infty)$$

#### 4.6.4. Cash-Flow Direct Taxation vs Rate-Differentiated Indirect Taxation

Table 16 shows the steady-state results for the baseline economy and the various consumption tax reforms. The most salient result is the difference in welfare effects across the two tax structures. Whereas the cash-flow system generates very large welfare *gains*, the rate-differentiated system generates very large welfare *losses*.

The long-run effects of the cash-flow reform are familiar from previous exercises, but with more extreme responses given the modified preference structure in 4.11. Labor productivity increases by 3% across steady states, leading to large increases in capital accumulation, output, and consumption of both goods. The impact is quantitatively

Table 16: Steady-State Comparisons in the Two-Good Model

	(1)	(2)	(3)	(4)	(5)
	Baseline	Cash-Flow Closed	Cash-Flow Open	Dual-Rate Closed	Dual-Rate Open
<b>Tax regime</b>					
Tax base	L	C	C		
Tax level	0.656	0.574	0.561		
Tax progressivity	0.136	0.136	0.136		
Basic sales tax	4.4%	4.4%	4.4%	0.0%	0.0%
Non-basic sales tax	4.4%	4.4%	4.4%	111.5%	112.6%
<b>Quantities (%<math>\Delta</math>)</b>					
Hours worked		1.85	1.39	-11.68	-11.71
Labor supply		4.81	4.18	-10.22	-10.24
Capital stock		16.82		-9.99	
Basic consumption		3.06	3.36	14.69	14.72
Non-basic cons.		11.59	12.73	-26.42	-26.74
Total consumption		9.24	10.15	-15.09	-15.31
Output		8.63		-10.14	
<b>Prices</b>					
Wage rate	1.000	1.036	1.000	1.001	1.000
Interest rate (%)	4.00	3.16	4.00	3.98	4.00
<b>Welfare</b>					
CEV (% $\Delta$ )		15.77	18.09	-10.38	-10.63

similar whether or not we allow prices to adjust in equilibrium. The aggregate welfare gain is 16% in the closed economy-version of the experiment and 18% in the open-economy version.

The indirect tax system generates effects of similar magnitude but opposite sign. Replacing the personal tax with a dual-rate system requires a tax of close to 112% on non-basic consumer goods, a large deviation from the principle of uniform commodity taxation. This severe distortion of relative prices induces both a 15% increase in basic consumption and a 26% decrease in non-basic consumption. The aggregate ratio of

non-basic to basic consumption falls from 2.65 in the initial steady state to 1.68 in the terminal steady state. The distortion of relative prices affects more than just the allocation of spending across different categories of consumer goods. It also creates a disincentive to work and invest, resulting in substantial long-run reductions in hours, labor supply, physical capital and output. In welfare terms, the rate-differentiated system generates a long-run loss of 10%. This effect is consistent with Conesa et al. (2020), who report a steady-state welfare loss of 6.6% when they replace labor and capital income taxes with a dual-rate consumption tax system like the one considered here.

These results quantify the sentiments expressed in the *Mirrlees Review*: “When other more direct instruments exist, using differentiation in the indirect tax system to achieve distributional objectives is likely to be costly and inefficient.”<sup>7</sup> Policy-makers seeking to enact a progressive consumption-based tax system are well-advised to adopt the cash-flow structure instead.

#### 4.7. Concluding Remarks

This dissertation asks a simple question: are consumption taxes better than labor income taxes? Departing from existing analyses in the literature, I focus attention on economies with non-linear taxes and heterogeneous agents. Equivalency between the two candidate tax systems breaks down in such settings for two reasons. First, consumption is endogenously smoothed over the life cycle and is therefore more strongly correlated with lifetime resources. Second, a progressive labor income tax dampens the household’s responsiveness to wage changes in ways that a progressive consumption tax does not. It is the second channel that proves quantitatively important. A

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<sup>7</sup>Mirrlees et al., *Tax by Design: The Mirrlees Review* (Oxford: Oxford University Press, 2011), p. 160.

simple conversion of the existing tax-and-transfer system from an earnings base to an expenditure base yields a welfare gain of 0.9%, all of which is due to the re-allocation of work hours across productivity states. This relative utilitarian advantage narrows to 0.7% when we compare optimized tax systems, as shown in Section 4.4.

The key driver of my results is the interaction between non-linear tax schedules and fluctuating wages. But this is not the only reason to suspect the non-equivalency of consumption taxation and labor income taxation. Several others come to mind. For example, agents in my model trade a single risk-free bond. But the risk-free rate is just one possible component of the return on an investment. Investment returns also reflect risk premia, economic rents and sheer luck. An intriguing feature of consumption-based tax systems is that they effectively tax these other components while leaving the risk-free component untouched. Since most of the theoretical objections to capital income taxation concern the impact on the risk-free rate, a progressive consumption tax could allow policy-makers to tax supernormal returns (at graduated rates) without distorting the basic incentive to save and invest. This aspect of cash-flow taxation presents a promising avenue for future research.

As noted in earlier chapters, the cash-flow tax I study bears a resemblance to existing retirement savings programs like IRAs and 401(k)s. The major plank of all these policies is the deductibility of contributions to savings accounts from the taxpayer's taxable income. One significant difference is that IRAs and 401(k)s are subject to many restrictions, limits and penalties. In contrast, the cash-flow tax studied here has no restraints. An important quantitative question that I leave for future research is the extent to which the restricted extant programs are able to capture the gains identified in this study.

In my model, consumption is especially smooth over the life cycle because there are no

lumpy expenditures or shocks to marginal utility. If expenditures were more volatile, the advantage of the consumption base would begin to dissipate. As discussed in Section 2.5, a feasible solution to such problems is to give households the choice of whether to deduct net savings on their tax returns. A hybrid system of this sort allows households to continue saving in qualified accounts for self-insurance and retirement. But they could also use non-qualified accounts to save for durables and to weather unexpected expenditure shocks. Consequently, I do not consider the absence of such features in my model to be limiting. The main result still applies. By relaxing the distortions on household labor supply, a progressive consumption tax generates aggregate improvements in labor efficiency and modest welfare gains over the long run.

## APPENDIX

### A.1. Endorsements of the Hobbesian Concept of Tax Fairness

Petty (1662, p. 71):

Concluding therefore that every man ought to contribute according to what he taketh to himself, and actually enjoyeth. The first thing to be done is, to compute what the Total of the Expense of this Nation is by particular men upon themselves, and then what part thereof is necessary for the Publick.

Rep. Alanson Houghton (1921), as cited in Bank (2003, p. 2242):

Would you put a tax on a man who by saving increases the total funds of investment money in the country and so develops business, industry, and farming, or would you put the burden on the man who spends it on flowers, in yachting, and a thousand and one ways that do not produce a permanent increase in revenue?

Fisher and Fisher (1942, p. 94):

When rich men are an offense in the eyes of the relatively poor, it is because of their big domestic establishments and their big spendings, not because of their big savings and big industrial plants. Snobbery goes with the idle and extravagant way of living—with diamonds and retinues of servants; but snobbery is seldom seen in a big factory where the owner himself works. In fact, few workers in democratic America object to the rich man who lives and works like a poor man—who puts his gains into instruments of production, not into instruments of consumption.

Kaldor (1955, p. 53):

An Expenditure base would tax people according to the amount which they take out of the common pool, and not according to what they put into it. An inhabitant from Mars, admiring the highly intricate arrangements whereby men in society satisfy their needs in common through mutual co-operation, would surely be puzzled to discover that each individual's contribution to the finance of socially provided benefits depends not on the sum of benefits he receives from the community but on his personal contribution to the wealth of the others. It is only by spending, not by

earning or saving, that an individual imposes a burden on the rest of the community in attaining his own ends. In all his other activities his own interests and the interests of the community run not counter to one another but parallel.

Feldstein (1976, p. 15):

The idea that everyone's tax should depend on how much he consumes, regardless of how that consumption is financed, appeals strongly to our sense of fairness.

Meade (1978, p. xv-xvi):

A modern humane society demands that effective action be taken to prevent poverty and to remove unacceptable inequalities of opportunity, wealth and privilege...An appropriate structure for this purpose would be...a basic reform of direct taxation which levied a charge on what people took out of the economic system in high levels of consumption rather than what they put into the system through their savings and enterprise.

Summers (1984, p. 258):

First, there is the question of choosing a fair base for taxation. Thomas Hobbes argued that there was greater justice in taxing people on what they took from the social pot (their consumption) rather than on what they contributed (as measured by their income). In many cases, this valued judgment seems compelling. Should not some tax be paid by a wealthy man who draws down his wealth to maintain a high rate of consumption? It is not unreasonable for the profligate borrower, who lives beyond his income, to pay taxes on his pleasures?

Seidman (1997, p. 56):

It seems reasonable to contend that a principle of fairness ought to consider what each person adds to and subtracts from the economic pie. It ought to consider how a person's economic behaviour affects others. From this perspective, it seems fairer to tax a person according to what that person subtracts from, rather than adds to, the economic pie.

Hall and Rabushka (2007, p. 61-62):

The underlying concept of consumption taxes is that individuals would be taxed on what they take out of the economy (when they spend money to consume), not on what they produce (reflected in working and saving).

## A.2. Consumption Taxation and Zero Capital Income Taxation

This dissertation emphasizes the importance of evaluating consumption taxation as an alternative to labor income taxation specifically, independently of the treatment of capital. In contrast, the existing literature often treats consumption taxation as an alternative to labor and capital income taxation *jointly*, thereby conflating the economic effects of consumption taxation with those of zero capital income taxation. Here is a non-exhaustive sample.

Mieszkowski (1977, p. 4):

The substitution of an expenditure tax for an income tax, of equal yield, is likely to increase the amount of savings and lead to capital formation and higher overall consumption possibilities in the long run.

Bradford et al. (1977, p. 10):

By eliminating disincentives to saving, the cash flow tax would encourage capital formation, leading to higher growth rates and more capital per worker and higher before-tax wages.

Seidman (1997, p. 1):

According to proponents, the aim of the [consumption tax] is to promote saving and investment.

McNulty (2000, p. 2133):

Another important point made in favor of a flat or graduated rate consumption tax is that it will increase and improve saving.

McCaffery (2002, p. 113):

The Fair Not Flat Tax distorts neither decisions about how much to save nor decisions about the form of savings. Capital is good for us all, and the Fair Not Flat Tax releases capital from the perverse investment incentives of the status quo.

Frank (2005, p. 1):



Replacing the income tax with a progressive consumption tax would stimulate additional savings.

Auerbach and Hassett (2005, p. 5):

The distinction between a consumption tax and an income tax...is that an income tax, at least to some extent, taxes the return on savings and investment, whereas a consumption tax does not.

Zodrow (2006, p. 3):

The primary difference between the income and consumption tax approaches lies in their treatments of capital income.

Hall and Rabushka (2007, p. 63):

The justification for consumption taxes rests on their built-in incentives to save and invest.

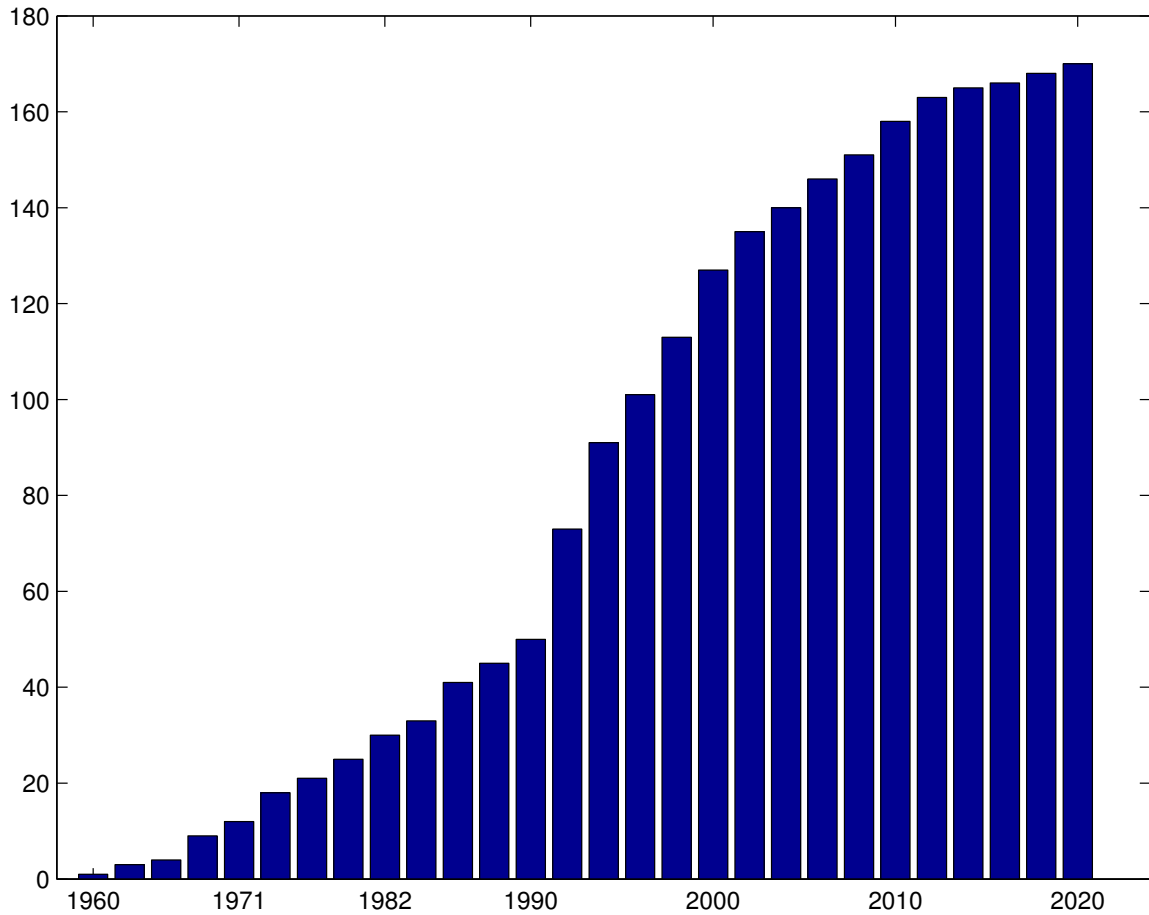
Boadway (2010, p. 11):

What does normative tax analysis suggest about the case for the choice between consumption taxation and income taxation, or equivalently, the case for taxing capital income?’

### A.3. Indirect Consumption Taxes in the OECD

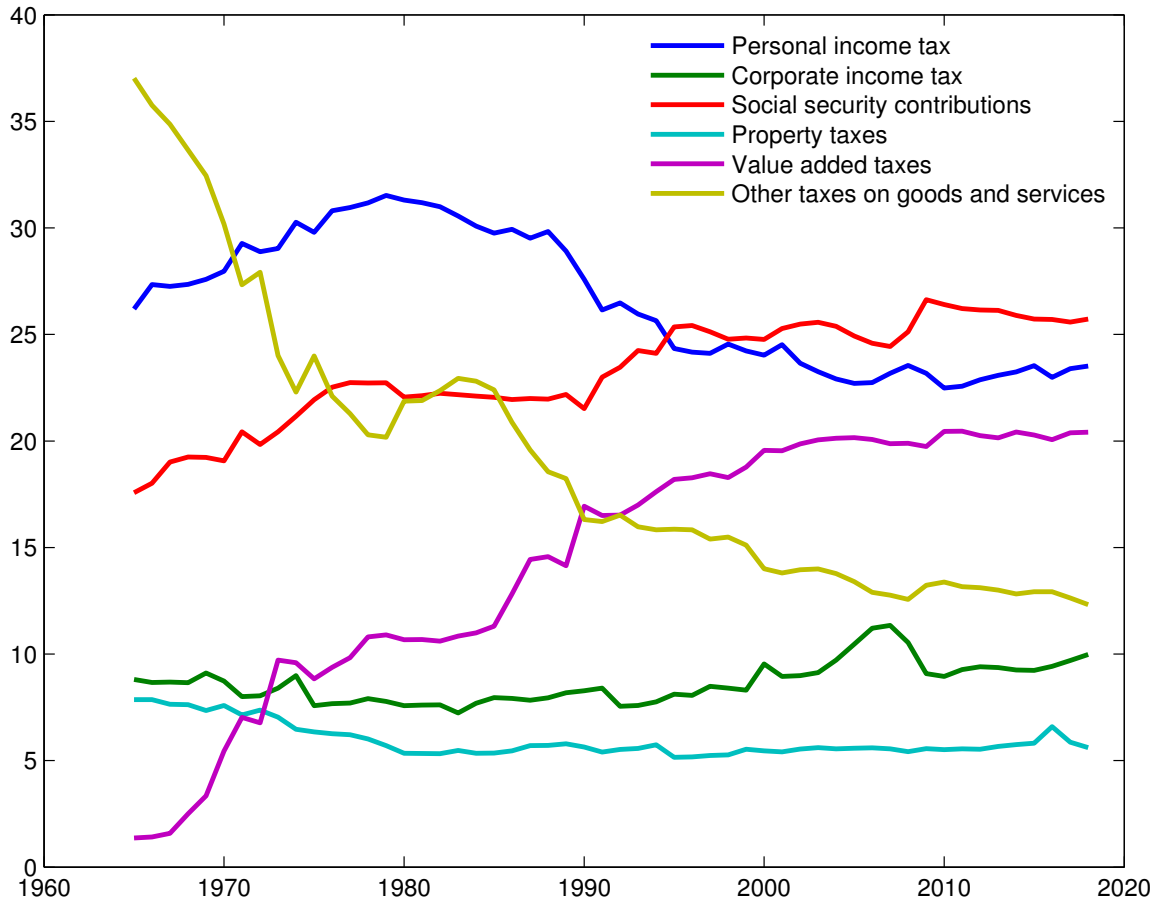
Figure 14 shows the time series for global adoption of the VAT. Figure 15 charts the evolution of the tax structure across the OECD. Table 17 and Table 18 shows the VAT as a percentage of GDP and tax revenue for OECD countries for selected years. Table 19 reports sales tax rates in the U.S.

Figure 14: # of Countries with a Value-Added Tax, 1960-2020



Source: OECD, *Consumption Tax Trends 2020*.

Figure 15: OECD Average Tax Mix as a % of Total Revenues, 1965-2018



Source: OECD, *Revenue Statistics 2020*.

Table 17: Value-Added Taxes in the OECD as a % of GDP

Year	1975	1990	2000	2005	2010	2015	2017	2018
Australia	0.0	0.0	3.4	3.9	3.4	3.6	3.5	3.3
Austria	7.2	8.2	7.9	7.6	7.7	7.6	7.6	7.6
Belgium	6.3	6.8	7.1	6.9	7.0	6.6	6.7	6.8
Canada	0.0	0.0	3.2	3.2	4.2	4.4	4.5	4.5
Chile		6.3	7.9	7.8	7.5	8.3	8.4	8.5
Colombia		2.6	4.3	5.2	5.3	5.2	5.5	5.7
Czech Republic			5.9	6.5	6.6	7.2	7.6	7.6
Denmark	6.4	8.4	9.1	9.7	9.4	9.1	9.5	9.5
Estonia			8.4	8.0	8.5	9.0	9.0	9.0
Finland	5.7	8.3	8.0	8.3	8.3	9.0	9.0	9.1
France	8.1	7.6	7.2	7.2	6.8	6.9	7.0	7.1
Germany	5.0	5.8	6.7	6.1	7.0	7.0	7.0	7.0
Greece	0.0	6.2	6.3	6.7	7.1	7.3	8.1	8.3
Hungary			8.7	8.2	8.5	9.5	9.3	9.7
Iceland	0.0	8.7	10.3	10.8	7.3	8.0	8.9	8.8
Ireland	4.1	6.6	7.1	7.3	6.0	4.5	4.4	4.4
Israel			7.4	7.5	7.5	7.8	7.4	7.5
Italy	3.3	5.3	6.2	5.7	6.1	6.1	6.2	6.2
Japan		1.2	2.3	2.5	2.5	4.2	4.1	4.1
Korea	0.0	3.4	3.6	3.8	3.9	3.6	4.1	4.1
Latvia			7.0	7.4	6.7	7.7	8.1	8.4
Lithuania			7.5	7.1	7.8	7.7	7.8	7.8
Luxembourg	3.8	4.0	4.9	6.0	6.4	6.5	5.9	6.1
Mexico		3.2	2.8	3.3	3.8	3.8	3.7	3.9
Netherlands	5.4	6.5	6.4	6.7	6.7	6.5	6.8	6.8
New Zealand	0.0	8.1	8.1	8.6	9.3	9.5	9.5	9.7
Norway	8.0	7.6	8.2	7.7	7.8	8.2	8.6	8.4
Poland			6.9	7.7	7.6	7.0	7.8	8.1
Portugal	0.0	5.2	7.6	8.2	7.5	8.6	8.6	8.7
Slovak Republic			6.8	7.7	6.1	6.8	7.0	7.1
Slovenia			8.5	8.5	8.1	8.3	8.1	8.2
Spain	0.0	5.0	5.8	6.2	5.2	6.4	6.5	6.6
Sweden	4.6	7.3	8.2	8.5	9.0	8.9	9.2	9.2
Switzerland	0.0	2.8	3.6	3.6	3.4	3.4	3.4	3.3
Turkey		2.7	5.7	5.1	5.4	5.1	5.0	4.8
United Kingdom	3.0	5.5	5.9	6.1	6.1	6.9	6.9	7.0
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unweighted average	3.1	5.1	6.3	6.5	6.4	6.7	6.8	6.8

**Sources:** OECD, *Consumption Tax Trends 2020*; OECD, *Revenue Statistics 2020*.

Table 18: Value-Added Taxes in the OECD as a % of Total Revenue

Year	1975	1990	2000	2005	2010	2015	2017	2018
Australia	0.0	0.0	11.1	13.1	13.4	13.0	12.2	11.7
Austria	19.8	20.8	18.7	18.6	18.7	17.7	18.3	18.0
Belgium	16.2	16.4	16.1	15.9	16.2	15.0	15.2	15.4
Canada	0.0	0.0	9.2	9.9	13.7	13.3	13.5	13.6
Chile		37.4	41.8	37.8	38.5	40.8	41.6	40.2
Colombia		22.6	27.6	28.2	29.3	26.0	29.0	29.4
Czech Republic			18.3	19.1	20.5	21.7	22.0	21.6
Denmark	17.5	18.8	19.5	20.2	21.0	19.9	20.7	21.5
Estonia			27.1	26.9	25.7	27.2	27.7	27.3
Finland	15.6	19.3	17.4	19.9	20.4	20.6	21.0	21.6
France	23.1	18.4	16.7	16.7	16.1	15.2	15.3	15.4
Germany	14.6	16.6	18.4	17.8	19.8	18.8	18.4	18.2
Greece	0.0	24.6	18.9	21.1	22.0	20.0	21.0	21.3
Hungary			22.4	22.5	22.9	24.5	24.4	25.8
Iceland	0.0	28.5	28.5	27.3	22.7	22.6	23.8	23.6
Ireland	14.7	20.4	22.9	24.2	21.7	19.3	19.3	19.3
Israel			21.1	22.3	24.4	24.9	22.9	24.2
Italy	13.7	14.7	15.4	14.6	14.5	14.2	14.8	14.8
Japan		4.4	9.1	9.5	9.6	13.7	13.0	12.8
Korea	0.0	18.7	17.0	17.4	17.5	15.3	16.0	15.3
Latvia			23.9	26.4	23.3	25.6	25.7	27.0
Lithuania			24.4	24.3	27.5	27.0	26.6	25.8
Luxembourg	12.1	12.1	13.2	16.0	17.0	17.5	15.8	15.4
Mexico		26.1	24.7	29.3	29.4	23.9	23.1	24.3
Netherlands	14.4	16.5	17.3	19.2	18.7	17.6	17.4	17.6
New Zealand	0.0	22.4	24.9	23.8	30.7	30.2	30.2	29.6
Norway	20.5	18.8	19.8	18.1	18.6	21.3	22.2	21.2
Poland			21.0	23.2	24.2	21.5	22.8	23.1
Portugal	0.0	19.6	24.4	26.6	24.7	24.9	25.1	25.1
Slovak Republic			20.4	24.6	21.8	20.8	20.5	20.5
Slovenia			22.6	21.6	21.3	22.2	21.8	22.0
Spain	0.0	15.7	17.6	17.7	16.5	19.0	19.2	19.0
Sweden	12.0	14.8	16.8	18.1	21.0	20.8	20.7	21.0
Switzerland	0.0	11.6	13.1	13.4	12.7	12.4	12.0	11.7
Turkey		18.3	24.2	21.8	21.7	20.6	20.1	19.8
United Kingdom	8.9	16.9	18.1	18.6	19.0	21.4	20.9	21.1
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unweighted average	8.8	16.9	19.6	20.2	20.5	20.3	20.4	20.4

**Sources:** OECD, *Consumption Tax Trends 2020*; OECD, *Revenue Statistics 2020*.

Table 19: Retail Sales Tax Rates by State

State	State Tax Rate	Average Local Tax Rate	Combined Tax Rate	Rank	Max Local Tax Rate
Alabama	4.00%	5.22%	9.22%	4	7.50%
Alaska	0.00%	1.76%	1.76%	46	7.50%
Arizona	5.60%	2.80%	8.40%	11	5.60%
Arkansas	6.50%	2.97%	9.47%	3	5.13%
California	7.25%	1.41%	8.66%	9	2.50%
Colorado	2.90%	4.75%	7.65%	16	8.30%
Connecticut	6.35%	0.00%	6.35%	33	0.00%
Delaware	0.00%	0.00%	0.00%	38	0.00%
District of Columbia	6.00%	0.00%	6.00%	47	0.00%
Florida	6.00%	1.05%	7.05%	23	2.50%
Georgia	4.00%	3.31%	7.31%	19	5.00%
Hawaii	4.00%	0.44%	4.44%	45	0.50%
Idaho	6.00%	0.03%	6.03%	37	3.00%
Illinois	6.25%	2.83%	9.08%	6	10.00%
Indiana	7.00%	0.00%	7.00%	24	0.00%
Iowa	6.00%	0.94%	6.94%	27	1.00%
Kansas	6.50%	2.18%	8.68%	8	4.00%
Kentucky	6.00%	0.00%	6.00%	38	0.00%
Louisiana	4.45%	5.07%	9.52%	2	7.00%
Maine	5.50%	0.00%	5.50%	42	0.00%
Maryland	6.00%	0.00%	6.00%	38	0.00%
Massachusetts	6.25%	0.00%	6.25%	35	0.00%
Michigan	6.00%	0.00%	6.00%	38	0.00%
Minnesota	6.88%	0.58%	7.46%	18	2.00%
Mississippi	7.00%	0.07%	7.07%	22	1.00%
Missouri	4.23%	3.96%	8.19%	14	5.63%
Montana	0.00%	0.00%	0.00%	47	0.00%
Nebraska	5.50%	1.43%	6.93%	28	2.50%
Nevada	6.85%	1.47%	8.32%	12	1.65%
New Hampshire	0.00%	0.00%	0.00%	47	0.00%
New Jersey	6.63%	-0.03%	6.60%	30	3.31%
New Mexico	5.13%	2.69%	7.82%	15	4.13%
New York	4.00%	4.52%	8.52%	10	4.88%
North Carolina	4.75%	2.22%	6.97%	26	2.75%
North Dakota	5.00%	1.86%	6.86%	29	3.50%
Ohio	5.75%	1.42%	7.17%	21	2.25%
Oklahoma	4.50%	4.44%	8.94%	7	7.00%
Oregon	0.00%	0.00%	0.00%	47	0.00%
Pennsylvania	6.00%	0.34%	6.34%	34	2.00%
Rhode Island	7.00%	0.00%	7.00%	24	0.00%
South Carolina	6.00%	1.46%	7.46%	17	3.00%
South Dakota	4.50%	1.90%	6.40%	32	4.50%
Tennessee	7.00%	2.53%	9.53%	1	2.75%
Texas	6.25%	1.94%	8.19%	13	2.00%
Utah	6.10%	1.08%	7.18%	20	2.95%
Vermont	6.00%	0.22%	6.22%	36	1.00%
Virginia	5.30%	0.35%	5.65%	41	0.70%
Washington	6.50%	2.71%	9.21%	5	4.00%
West Virginia	6.00%	0.41%	6.41%	31	1.00%
Wisconsin	5.00%	0.46%	5.46%	43	1.75%
Wyoming	4.00%	1.34%	5.34%	44	2.00%
<b>US Average</b>	<b>5.75%</b>	<b>1.66%</b>	<b>7.41%</b>	<b>44</b>	<b>10.00%</b>

**Source:** Tax Foundation, <https://taxfoundation.org/2020-sales-taxes/>

## A.4. Proofs

### A.4.1. Proof of Lemma 2, Part 3

**Lemma.** *Lifetime output is higher under the consumption tax. That is,*

$$y^c = w_1 h_1^C + w_2 h_2^C > w_1 h_1^L + w_2 h_2^L = y^L$$

*Proof.* To show this is true, it will be convenient to define  $\varepsilon = \frac{w_2}{w_1}$  and:

$$g(\hat{\tau}) \equiv (1 - \hat{\tau})(1 + \eta)(\eta + \hat{\tau})^{-1}$$

$$\Gamma_1(\varepsilon) \equiv (1 + \varepsilon^{g(\hat{\tau})})^{\frac{-1}{1+\eta}}$$

$$\Gamma_2(\varepsilon) \equiv (1 + \varepsilon^{-g(\hat{\tau})})^{\frac{-1}{1+\eta}}$$

$$\Gamma(\varepsilon) \equiv \Gamma_1(\varepsilon) + \varepsilon \Gamma_2(\varepsilon)$$

$$\varphi \equiv [2(1 - \tau)\phi^{-1}]^{\frac{1}{1+\eta}}$$

With this notation, write hours under the labor tax as  $h_j^* = \varphi \Gamma_j(\varepsilon)$  and pre-tax earnings as  $y = w_1 \varphi \Gamma(\varepsilon)$ . Now, the only difference under the consumption tax is that the parameter  $\hat{\tau}$  in the  $g$ -function is zero. To adjust the distortion on the hours profile while maintaining the same progressivity, differentiate with respect to  $\hat{\tau}$ .

$$\begin{aligned} \frac{\partial y}{\partial \hat{\tau}} = \varphi \left\{ \left( \frac{-1}{1+\eta} \right) (1 + \varepsilon^{g(\hat{\tau})})^{-\left(\frac{2+\eta}{1+\eta}\right)} (\ln \varepsilon) \varepsilon^{g(\hat{\tau})} g'(\hat{\tau}) \right. \\ \left. - \varepsilon \left( \frac{-1}{1+\eta} \right) (1 + \varepsilon^{g(\hat{\tau})})^{-\left(\frac{2+\eta}{1+\eta}\right)} (\ln \varepsilon) \varepsilon^{-g(\hat{\tau})} g'(\hat{\tau}) \right\} \end{aligned}$$

Since  $g'(\hat{\tau}) = -[(1 - \hat{\tau})(\eta + \hat{\tau})^{-2} + (\eta + \hat{\tau})^{-1} + 1]$ , we have:

$$\frac{\partial y}{\partial \hat{\tau}} = \left( \frac{\varphi \ln \varepsilon}{1 + \eta} \right) \left[ \frac{(1 - \hat{\tau})}{(\eta + \hat{\tau})^2} + \frac{1}{\eta + \hat{\tau}} + 1 \right] \left\{ (1 + \varepsilon^{g(\hat{\tau})})^{-\left(\frac{2+\eta}{1+\eta}\right)} \varepsilon^{g(\hat{\tau})} - \varepsilon \left( \frac{-1}{1 + \eta} \right) (1 + \varepsilon^{g(\hat{\tau})})^{-\left(\frac{2+\eta}{1+\eta}\right)} \varepsilon^{-g(\hat{\tau})} \right\}$$

Note that  $\frac{\partial y}{\partial \hat{\tau}} = 0$  when  $\varepsilon = 1$ . This is sensible because when a household's wages are constant, optimal hours are constant too and no allocation distortion can apply.

Otherwise:

$$\frac{\partial y}{\partial \hat{\tau}} < 0 \iff G(\varepsilon) \ln \varepsilon < 0$$

where  $G(\cdot)$  is short-hand for the terms in the curly brackets.

Without loss of generality, we can examine only the case of an increasing wage profile, that is,  $\varepsilon > 1$ . The argument for the opposite case is symmetrical. When  $\varepsilon > 1$ , the distortion decreases lifetime output ( $\frac{\partial y}{\partial \hat{\tau}} < 0$ ) if and only if:

$$\begin{aligned} G(\varepsilon) < 0 &\iff (1 + \varepsilon^{g(\hat{\tau})})^{-\left(\frac{2+\eta}{1+\eta}\right)} \varepsilon^{g(\hat{\tau})} < \varepsilon \left( \frac{-1}{1 + \eta} \right) (1 + \varepsilon^{g(\hat{\tau})})^{-\left(\frac{2+\eta}{1+\eta}\right)} \varepsilon^{-g(\hat{\tau})} \\ &\iff \varepsilon^{2g(\hat{\tau})-1} < \left( \frac{1 + \varepsilon^{g(\hat{\tau})}}{1 + \varepsilon^{-g(\hat{\tau})}} \right)^{\frac{2+\eta}{1+\eta}} \\ &\iff (2g(\hat{\tau}) - 1) \ln(\varepsilon) < \left( \frac{2 + \eta}{1 + \eta} \right) [\ln(1 + \varepsilon^{g(\hat{\tau})}) - \ln(1 + \varepsilon^{-g(\hat{\tau})})] \end{aligned}$$

Define:

$$\hat{G}(\varepsilon; \hat{g}) \equiv (2\hat{g} - 1) \ln \varepsilon - \left( \frac{2 + \eta}{1 + \eta} \right) [\ln(1 + \varepsilon^{\hat{g}}) - \ln(1 + \varepsilon^{-\hat{g}})]$$

Thus, we have  $G(\varepsilon) < 0$  if and only  $\hat{G}(\varepsilon; \hat{g}) < 0$ . Differentiating the latter function



with respect to  $\hat{g}$ :

$$\begin{aligned}
\frac{\partial \hat{G}}{\partial \hat{g}} &= 2 \ln \varepsilon - \left( \frac{2 + \eta}{1 + \eta} \right) \left[ \frac{\ln \varepsilon \cdot \varepsilon^{\hat{g}}}{1 + \varepsilon^{\hat{g}}} + \frac{\ln \varepsilon \cdot \varepsilon^{-\hat{g}}}{1 + \varepsilon^{-\hat{g}}} \right] \\
&= \left\{ 2 - \left( \frac{2 + \eta}{1 + \eta} \right) \left[ \frac{\varepsilon^{\hat{g}}}{1 + \varepsilon^{\hat{g}}} + \frac{\varepsilon^{-\hat{g}}}{1 + \varepsilon^{-\hat{g}}} \left( \frac{\varepsilon^{\hat{g}}}{\varepsilon^{\hat{g}}} \right) \right] \right\} \ln \varepsilon \\
&= \left\{ 2 - \left( \frac{2 + \eta}{1 + \eta} \right) \left[ \frac{\varepsilon^{\hat{g}}}{1 + \varepsilon^{\hat{g}}} + \frac{1}{1 + \varepsilon^{\hat{g}}} \right] \right\} \ln \varepsilon \\
&= \left( \frac{\eta}{1 + \eta} \right) \ln \varepsilon
\end{aligned}$$

which is strictly positive if  $\varepsilon > 1$ , as assumed. Recalling that  $g' < 0$ , this implies that

$$\frac{\partial G(\varepsilon)}{\partial \hat{\tau}} = \exp\{\hat{G}(\varepsilon)\} \frac{\partial \hat{G}}{\partial \hat{g}} \frac{\partial g(\hat{\tau})}{\partial \hat{\tau}} < 0$$

We have the following result: if  $\varepsilon > 1$  and  $G(\varepsilon) \leq 0$  for some  $\hat{\tau}$ , then  $G(\varepsilon) < 0$  for any  $\tau > \hat{\tau}$ . So consider the no-distortion case of  $\hat{\tau} = 0$  where  $g(0) = \frac{1+\eta}{\eta}$ . Returning to an earlier inequality, we obtain:

$$G(\varepsilon) \leq 0 \iff \varepsilon^{2\left(\frac{1+\eta}{\eta}\right)-1} \leq \left( \frac{1 + \varepsilon^{\frac{1+\eta}{\eta}}}{1 + \varepsilon^{-\frac{1+\eta}{\eta}}} \right)^{\frac{2+\eta}{1+\eta}}$$

Raising both sides of the inequality to the power  $\frac{1+\eta}{2+\eta}$  gives:

$$G(\varepsilon) \leq 0 \iff \varepsilon^{\frac{1+\eta}{\eta}} \leq \frac{1 + \varepsilon^{\frac{1+\eta}{\eta}}}{1 + \varepsilon^{-\frac{1+\eta}{\eta}}} \iff \varepsilon^{\frac{1+\eta}{\eta}} \leq \frac{1 + \varepsilon^{\frac{1+\eta}{\eta}}}{1 + \varepsilon^{-\frac{1+\eta}{\eta}}} \iff 1 + \varepsilon^{\frac{1+\eta}{\eta}} \leq 1 + \varepsilon^{\frac{1+\eta}{\eta}}$$

which holds with equality. Therefore,  $G(\varepsilon) = 0$  when  $\hat{\tau} = 0$  (again, this is sensible because there is no distortion in this case). And based on what was already demonstrated, this implies that  $G(\varepsilon) < 0$  for all  $\varepsilon > 1$  and  $\tau > 0$ . Conclude that  $\frac{\partial y}{\partial \hat{\tau}} < 0$  when  $\varepsilon > 1$ .

As remarked earlier, the case of a decreasing wage profile can be approached with symmetrical arguments. Putting it all together, we see that lifetime output is invariant to the tax regime for households with constant wage profiles, but is otherwise higher under the consumption tax.  $\square$

#### A.4.2. Expanded Proofs for Lemmas 3 and 4

For sake of clarity and concision, the proofs in the main text omitted certain details, mainly algebraic ones. The proofs are produced here in full.

**Lemma.** *The dynamic Ramsey problem is isomorphic to the static Ramsey problem, but only when the tax system is consumption-based.*

*Proof.* Using Lemma 1 to replace distutility terms in (2.7), the value function for the household under a progressive consumption tax is given by:

$$U^C(w; \lambda, \tau) = 2 \log \lambda + 2(1 - \tau) \log \left( \frac{w_1 h_1^* + w_2 h_2^*}{2} \right) - 2 \left( \frac{1 - \tau}{1 + \eta} \right) \quad (\text{A.1})$$

Now use (2.4) and (2.5) to substitute for  $h_1^*$  and  $h_2^*$ .

$$\begin{aligned} \log \left( \frac{w_1 h_1^* + w_2 h_2^*}{2} \right) &= \log \left( \frac{1}{2} \left( w_1 + w_2 \cdot \frac{h_2^*}{h_1^*} \right) h_1^* \right) \\ &= \log \left( \frac{1}{2} \left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1}{\eta}} \right) \left( 2(1 - \tau) \phi^{-1} \left( 1 + \left( \frac{w_2}{w_1} \right)^{\left( \frac{1+\eta}{\eta} \right)^{-1}} \right)^{\frac{1}{1+\eta}} \right) \right) \\ &= \log \left( \left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1}{\eta}} \right) \left( 1 + \left( \frac{w_2}{w_1} \right)^{\frac{1+\eta}{\eta}} \right)^{\frac{-1}{1+\eta}} 2^{\left( \frac{-\eta}{1+\eta} \right)} \right) \\ &\quad + \left( \frac{1}{1 + \eta} \right) (\log(1 - \tau) - \log(\phi)) \end{aligned} \quad (\text{A.2})$$

Substituting (A.2) into (A.1) we get:

$$U^C(w; \lambda, \tau) = 2 \left\{ \log \lambda + (1 - \tau) \log(w_C) + \left( \frac{1 - \tau}{1 + \eta} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \quad (\text{A.3})$$

where  $w_C$  denotes the agent's "pseudo-static" wage:

$$w_C = \left[ w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1}{\eta}} \right] \left[ 1 + \left( \frac{w_2}{w_1} \right)^{\frac{1+\eta}{\eta}} \right]^{\frac{-1}{1+\eta}} 2^{\left( \frac{-\eta}{1+\eta} \right)} \quad (\text{A.4})$$

The **pseudo-static wage** is the constant wage that is output-equivalent to the agent's actual wage profile. That is, for given wage profile  $w = (w_1, w_2)$ , the associated pseudo-static wage solves:

$$w_1 h_1^* + w_2 h_2^* = 2 \cdot w_C \bar{h}$$

where we use the fact that  $\bar{h}$  is the optimal labor supply when productivity is constant over the life cycle. By rearranging this equation, it becomes clear that the pseudo-static wage can also be thought of as the household's hours-adjusted average wage:

$$w_C = \left( \frac{1}{2} \cdot \frac{h_1^*}{\bar{h}} \right) w_1 + \left( \frac{1}{2} \cdot \frac{h_2^*}{\bar{h}} \right) w_2$$

It turns out that  $w_C$  is given by (A.4) when the utility function and tax code take the assumed functional forms. If wages are constant, i.e.,  $w_1 = w_2 = \tilde{w}$ , then:

$$w_C = (\tilde{w} + \tilde{w})(1 + 1)^{\left( \frac{-1}{1+\eta} \right)} 2^{\left( \frac{-\eta}{1+\eta} \right)} = \tilde{w} \cdot 2^{\frac{(1+\eta)-1-\eta}{1+\eta}} = \tilde{w}$$

When wages are not constant, i.e.,  $w_1 \neq w_2$ , the pseudo-static wage is greater than than  $\frac{w_1 + w_2}{2}$ , the arithmetic mean wage.

Notice that (A.3) is identical to (2.3), the household's value function in the static version of the model, except scaled up by the number of periods and with  $w_C$  in place of  $w$ . It is also easy to demonstrate that the government's budget constraint can be expressed in terms of the distribution of pseudo-static wages, rather than the distribution of wage profiles. Consequently, we can re-write the government's dynamic Ramsey problem as:

$$\begin{aligned} \max_{\tau, \lambda} \quad & 2 \left\{ \log \lambda + (1 - \tau) \mathbb{E}[\log w_C] + \left( \frac{1 - \tau}{1 + \eta} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ \text{s.t.} \quad & 2 \left\{ \mathbb{E}[w_C] \bar{h} - \lambda \mathbb{E}[(w_C)^{1-\tau}] \bar{h}^{1-\tau} - g \right\} = 0 \end{aligned}$$

This multi-period problem is identical to the single-period problem R1, except that  $w$  is replaced everywhere by  $w_C$ . Hence, the dynamic problem is isomorphic to the static problem, implying that a period-by-period tax levied on current consumption can replicate a lifetime tax levied on earnings.

Can the same be said when taxes are based on labor income? The household's value function in this case is given by (2.7).

$$U^L(w; \lambda, \tau) = 2 \log \lambda + 2 \log \left( \frac{(w_1 h_1^*)^{1-\tau} + (w_2 h_2^*)^{1-\tau}}{2} \right) - \phi \frac{h_1^{*(1+\eta)}}{1 + \eta} - \phi \frac{h_2^{*(1+\eta)}}{1 + \eta}$$

Let  $X = ((w_1 h_1^*)^{1-\tau} + (w_2 h_2^*)^{1-\tau})/2$ . Then, proceeding along similar steps as before,

we have:

$$\begin{aligned}
X &= \frac{1}{2} \left( w_1^{1-\tau} + \left( w_2 \frac{h_2^*}{h_1^*} \right)^{1-\tau} \right) (h_1^*)^{1-\tau} \\
&= \frac{1}{2} \left( w_1^{1-\tau} + \left( w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\eta+\tau}} \right)^{1-\tau} \right) \left( 2(1-\tau)\phi^{-1} \left( 1 + \left( \frac{w_2}{w_1} \right)^{\frac{(1-\tau)(1+\eta)}{(\eta+\tau)}} \right)^{-1} \right)^{\frac{1-\tau}{1+\eta}} \\
&= \frac{1}{2^\tau} \left( w_1^{1-\tau} + \left( w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\eta+\tau}} \right)^{1-\tau} \right) \left( 2^\eta \left( 1 + \left( \frac{w_2}{w_1} \right)^{\frac{(1-\tau)(1+\eta)}{(\eta+\tau)}} \right) \right)^{\frac{1+\eta}{1-\tau}} \left( \frac{1-\tau}{\phi} \right)^{\frac{1-\tau}{1+\eta}}
\end{aligned}$$

Multiplying and dividing the right-hand side by  $\left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\tau+\eta}} \right)^{1-\tau}$  yields:

$$\begin{aligned}
X &= 2^{-\tau} \left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\tau+\eta}} \right)^{-(1-\tau)} \left( w_1^{1-\tau} + \left( w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\eta+\tau}} \right)^{1-\tau} \right) \\
&\quad \times \left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\tau+\eta}} \right)^{1-\tau} \left( \left( 1 + \left( \frac{w_2}{w_1} \right)^{\frac{(1-\tau)(1+\eta)}{(\eta+\tau)}} \right)^{\frac{-1}{1+\eta}} 2^{\frac{-\eta}{1+\eta}} \right)^{1-\tau} \\
&\quad \times \left( \frac{1-\tau}{\phi} \right)^{\frac{1-\tau}{1+\eta}} \\
&= (\Omega(w, \tau) \cdot w_L(w, \tau))^{1-\tau} \cdot \left( \frac{1-\tau}{\phi} \right)^{\frac{1-\tau}{1+\eta}}
\end{aligned}$$

where  $w_L$  is the agent's pseudo-static wage under a labor income tax regime:

$$w_L = \left[ w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\eta+\tau}} \right] \left[ 1 + \left( \frac{w_2}{w_1} \right)^{\frac{(1-\tau)(1+\eta)}{(\eta+\tau)}} \right]^{\frac{-1}{1+\eta}} 2^{\frac{-\eta}{1+\eta}} \quad (\text{A.5})$$

and  $\Omega$  is defined as follows:

$$\Omega = \left[ \left( \frac{1}{2^\tau} \right) \left( w_1 + w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\eta+\tau}} \right)^{-(1-\tau)} \left( w_1^{1-\tau} + \left[ w_2 \left( \frac{w_2}{w_1} \right)^{\frac{1-\tau}{\eta+\tau}} \right]^{1-\tau} \right) \right]^{\frac{1}{1-\tau}} \quad (\text{A.6})$$

Thus, we can re-write the value function as:

$$U^L(w; \lambda, \tau) = 2 \left\{ \log \lambda + (1 - \tau) \log (\Omega w_L) + \left( \frac{1 - \tau}{1 + \eta} \right) \left[ \log \left( \frac{1 - \tau}{\phi} \right) - 1 \right] \right\} \quad (\text{A.7})$$

As under the consumption tax, the value function (A.7) is identical to (2.3), except the raw wage  $w$  is replaced by the variable  $\Omega w_L$ . But the Ramsey problem can not be made isomorphic to the static version because the government budget constrained cannot be expressed in the same format. In particular, the Ramsey problem under the labor income tax is:

$$\begin{aligned} \max_{\tau, \lambda} \quad & 2 \left\{ \log \lambda + (1 - \tau) \mathbb{E} \log (\Omega(w, \tau) w_L) + \left( \frac{1 - \tau}{1 + \eta} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ \text{s.t.} \quad & 2 \left\{ \mathbb{E}[\square w_L] \bar{h} - \lambda \mathbb{E}[(\Omega(w, \tau) w_L)^{1-\tau}] \bar{h}^{1-\tau} - g \right\} = 0 \end{aligned}$$

This problem is not identical to the static analogue because  $\Omega$  does not premultiply  $w_L$  everywhere. In particular, it is “missing” at the location of the red rectangle.  $\square$

**Remarks** The proof defined several new objects, namely the pseudo-static wages  $w_C$  and  $w_L$  and the function  $\Omega$ . These objects are not mere algebraic objects, but have important economic meanings.

It is not always obvious whether one wage profile is ‘better’ than another. The arithmetic mean wage is not a good measure since it ignores fact that agents can allocate more effort to high-wage periods and less effort to low-wage periods. The

pseudo-static wage, on the other hand, explicitly accounts for optimizing behaviour, and therefore serves as a reliable measure of lifetime earnings capacity.

Because the consumption tax leaves intertemporal work decisions undistorted, the pseudo-static wage under that tax regime provides the true ranking of lifetime productivity. If agent A's  $w_C$  is higher than agent B's, then it is correct to say that A is more productive than B. This ordering is generally not preserved under a labor tax. Moreover, the intertemporal distortion generated by progressive earnings taxation implies that  $w_C > w_L$  for all wage paths. This follows directly from Lemma 2. The difference between  $w_C$  and  $w_L$ , therefore, represents the adverse effect of the intertemporal distortion.

Now,  $w_L$  is premultiplied by  $\Omega$  in (A.7). This function has the following form:

$$\Omega^p = 2^{p-1} (a^p + b^p) (a + b)^{-p} = \left( \frac{a^p + b^p}{2} \right) \left( \frac{a + b}{2} \right)^{-p} \leq \left( \frac{a + b}{2} \right)^p \left( \frac{a + b}{2} \right)^{-p} = 1$$

Thus,  $\Omega$  is less than unity for all wage paths, holding strictly whenever wages are not constant. It reflects the insurance penalty incurred by households with volatile wages. These households are not well served by a progressive tax on labor income, since such systems will tend to overtax them relative to their economic peers with steadier wage paths.

#### *A.4.3. Proof of Proposition 3*

**Proposition** (Age Dependence). *When consumption paths are non-constant, an age-dependent period-by-period consumption tax can: (1) Eliminate the intertemporal distortion on consumption; and (2) Replicate a progressive tax on lifetime earnings.*

*Proof.* When the household's problem is generalized to admit age-varying tax rates, we get the following (inverse) Euler equation:

$$c_2 = \left(\frac{\lambda_2}{\lambda_1}\right) \left(\frac{\beta_2}{\beta_1}\right)^{1-\tau} c_1 \implies c_2 = \left(\frac{\beta_1^\tau \lambda}{\beta_2^\tau \lambda}\right) \left(\frac{\beta_2}{\beta_1}\right)^{1-\tau} c_1 \implies c_2 = \left(\frac{\beta_2}{\beta_1}\right) c_1$$

where the second equality uses (2.9), the proposed age-conditioned tax plan. Notice that by allowing taxes to depend on age in the right way, we can easily eliminate the intertemporal wedge in the household's Euler equation. This modification works because it 'age-adjusts' a household's annual expenditures before assessing tax liability.

To demonstrate the second part of the proposition, I follow the same strategy as in Lemma 3. Some straightforward algebra (omitted here) yields convenient expressions for optimal hours:

$$\begin{aligned} h_1^* &= [(1 + \beta)(1 - \tau)\phi^{-1}(1 + A)^{-1}]^{\frac{1}{1+\eta}} \\ h_2^* &= \left[\left(\frac{1 + \beta}{\beta}\right) (1 - \tau)\phi^{-1}(1 + A^{-1})^{-1}\right]^{\frac{1}{1+\eta}} \end{aligned} \tag{A.8}$$

where  $A = [\beta^{-1} (w_1/w_2)^{1+\eta}]^{\frac{1}{\eta}}$ . Letting  $v$  denote lifetime disutility of effort, we have:

$$\begin{aligned} v &= \phi \left( \frac{h_1^{*(1+\eta)} + \beta h_2^{*(1+\eta)}}{1 + \eta} \right) = \frac{(1 + \beta)(1 - \tau)}{1 + \eta} \left[ (1 + A)^{-1} + (1 + A^{-1})^{-1} \right] \\ &= \frac{(1 + \beta)(1 - \tau)}{1 + \eta} \end{aligned} \tag{A.9}$$



Letting  $y$  denote lifetime earnings, we have:

$$\begin{aligned}
y &= w_1 h_1^* + w_2 h_2^* = \left( w_1 + w_2 \cdot \frac{h_2^*}{h_1^*} \right) h_1^* \\
&= \left( w_1 + w_2 \cdot \left[ \frac{1}{\beta} \cdot \frac{w_2}{w_1} \right]^{\frac{1}{\eta}} \right) \left( \frac{(1+\beta)(1-\tau)}{\phi} \left( 1 + \left[ \frac{1}{\beta} \cdot \left( \frac{w_1}{w_2} \right)^{1+\eta} \right]^{\frac{1}{\eta}} \right)^{-1} \right)^{\frac{1}{1+\eta}} \\
&= (1+\beta) w_C \bar{h}
\end{aligned} \tag{A.10}$$

where  $\bar{h}$  is the static labor supply, defined as before, and  $w_C$  is the agent's pseudo-static wage, re-defined as:

$$w_C = \left[ w_1 + w_2 \left( \frac{1}{\beta} \cdot \frac{w_2}{w_1} \right)^{\frac{1}{\eta}} \right] \left[ 1 + \left( \frac{1}{\beta} \cdot \frac{w_2}{w_1} \right)^{\frac{1+\eta}{\eta}} \right]^{\frac{-1}{1+\eta}} (1+\beta)^{\left( \frac{-\eta}{1+\eta} \right)}$$

Similarly, an agent's lifetime tax liability is given by:

$$\begin{aligned}
y - \lambda_1 x_1^{1-\tau} - \lambda_2 x_2^{1-\tau} &= (1+\beta) w_C \bar{h} - \lambda (w_C \bar{h})^{1-\tau} - (\beta^\tau \lambda) (\beta w_C \bar{h})^{1-\tau} \\
&= (1+\beta) (w_C \bar{h} - \lambda (w_C \bar{h})^{1-\tau})
\end{aligned}$$

The household's value function is:

$$\begin{aligned}
U^C &= \log \left( \lambda \left( \frac{w_1 h_1^* + w_2 h_2^*}{1+\beta} \right)^{1-\tau} \right) + \beta \log \left( \beta^\tau \lambda \left( \frac{\beta (w_1 h_1^* + w_2 h_2^*)}{1+\beta} \right)^{1-\tau} \right) \\
&\quad - \phi \left( \frac{h_1^{*(1+\eta)}}{1+\eta} \right) - \beta \phi \left( \frac{h_2^{*(1+\eta)}}{1+\eta} \right)
\end{aligned}$$

Using (A.9) and (A.10), this simplifies to:

$$U^C = (1+\beta) \left\{ \log \lambda + (1-\tau) \log(w_C) - \left( \frac{1-\tau}{1+\eta} \right) \left( \log \left( \frac{1-\tau}{\phi} \right) - 1 \right) \right\} + \beta \log \beta$$

Notice that the value function is a positive monotonic transformation of the analogous static value function, and in fact reduces to the benchmark two-period version when  $\beta = 1$ . That is,

$$U^C = (1 + \beta) \cdot U^1(w_C; \tau, \lambda) + \beta \log \beta$$

The Ramsey problem can therefore be written as:

$$\begin{aligned} \max_{\tau, \lambda} \quad & (1 + \beta) \left\{ \log \lambda + (1 - \tau) \mathbb{E}[\log w_C] + \left( \frac{1 - \tau}{1 + \eta} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ \text{s.t.} \quad & (1 + \beta) \left\{ \mathbb{E}[w_C] \bar{h} - \lambda \mathbb{E}[(w_C)^{1-\tau}] \bar{h}^{1-\tau} - g \right\} = 0 \end{aligned}$$

This problem is isomorphic to the static problem R1. □

#### A.4.4. Proof of Proposition 4

**Proposition** (Hybrid Taxation). *When consumption paths are non-constant, a period-by-period hybrid tax can: (1) Eliminate the intertemporal distortion on consumption; and (2) Replicate a progressive tax on lifetime earnings.*

*Proof.* The household's problem can be re-written as:

$$\begin{aligned} U^2(w) = \max_{x_1, x_2, h_1, h_2, s} \quad & \log(\lambda x_1^{1-\tau} - s) + \beta \log(\lambda x_2^{1-\tau} + s) - \phi \frac{h_1^{1+\eta}}{1 + \eta} - \beta \phi \frac{h_2^{1+\eta}}{1 + \eta} \\ \text{s.t.} \quad & x_1 + x_2 = w_1 h_1 + w_2 h_2 \end{aligned}$$

Letting  $\mu$  denote the Lagrange multiplier on the budget constraint, the first-order

conditions are:

$$x_1 : 0 = \lambda(1 - \tau)x_1^{-\tau}(\lambda x_1^{1-\tau} - s)^{-1} - \mu \quad (\text{A.11})$$

$$x_2 : 0 = \beta\lambda(1 - \tau)x_2^{-\tau}(\lambda x_2^{1-\tau} + s)^{-1} - \mu \quad (\text{A.12})$$

$$h_1 : 0 = -\beta^{t-1}\phi h_1^\eta + \mu w_1 \quad (\text{A.13})$$

$$h_2 : 0 = -\beta^{t-1}\phi h_2^\eta + \mu w_2 \quad (\text{A.14})$$

$$s : 0 = -(\lambda x_1^{1-\tau} - s)^{-1} + \beta(\lambda x_2^{1-\tau} + s)^{-1} \quad (\text{A.15})$$

From (A.11) and (A.12), we have:  $\lambda x_1 - s x_1^\tau = \lambda x_2 - s x_2^\tau$ . Because  $x_j \geq 0$ , this equality holds if and only if  $x_1 = x_2 = x$ . The first-order condition for unregistered savings gives:  $\lambda x_2^{1-\tau} + s = \beta(\lambda x_1^{1-\tau} - s)$ . Substituting  $x_1 = x_2 = x$  yields:

$$s^* = -\left(\frac{1 - \beta}{1 + \beta}\right) \lambda x^{1-\tau}$$

Notice that  $s^* = 0$  when  $\beta = 1$ . When the desired consumption profile is flat, the household does not need to resort to unregistered financial vehicles to smooth its tax liabilities. A full consumption base is good enough.

The consumption allocation is given by:

$$c_1^* = \left(\frac{2}{1 + \beta}\right) \lambda x^{1-\tau} \quad c_2^* = \left(\frac{2\beta}{1 + \beta}\right) \lambda x^{1-\tau}$$

and so the consumption path is intertemporally undistorted:  $c_2^* = \beta c_1^* \iff u_{c_1} = \beta u_{c_2}$ . From (A.13) and (A.14), we see that the Euler equation for labor supply is also undistorted:  $h_1 = [\beta(w_1/w_2)]^{\frac{1}{\eta}} h_2 \iff u_{h_1} = \beta u_{h_2}$ . Some further algebra yields

expressions for optimal hours:

$$h_1^* = \left[ (1 + \beta)(1 - \tau)\phi^{-1} \left( 1 + (\beta^{-1} (w_2/w_1)^{1+\eta})^{\frac{1}{\eta}} \right)^{-1} \right]^{\frac{1}{1+\eta}}$$

$$h_2^* = \left[ (1 + \beta^{-1})(1 - \tau)\phi^{-1} \left( 1 + (\beta (w_2/w_1)^{1+\eta})^{\frac{1}{\eta}} \right)^{-1} \right]^{\frac{1}{1+\eta}}$$

Not surprisingly, labor supply under the hybrid tax code is the same as under the age-dependent code, which means that lifetime disutility of effort is also the same.

The household's value function can be written as:

$$\begin{aligned} U^H &= \log \left( \left( \frac{2}{1 + \beta} \right) \lambda x^{1-\tau} \right) + \beta \log \left( \left( \frac{2\beta}{1 + \beta} \right) \lambda x^{1-\tau} \right) - v \\ &= (1 + \beta) \left\{ \log \lambda + (1 - \tau) \log(w_C) + \left( \frac{1 - \tau}{1 + \eta} \right) [\log(1 - \tau) - \log \phi - 1] \right\} + \beta \log \beta \\ &= (1 + \beta) \cdot U^1(w_C; \tau, \lambda) + \beta \log \beta \end{aligned}$$

where  $w_C$  is the agent's "pseudo-static" wage, defined as under the age-dependent tax regime:

$$w_C = \left[ w_1 + w_2 \left( \frac{1}{\beta} \cdot \frac{w_2}{w_1} \right)^{\frac{1}{\eta}} \right] \left[ 1 + \left( \frac{1}{\beta} \cdot \frac{w_2}{w_1} \right)^{\frac{1+\eta}{\eta}} \right]^{\frac{-1}{1+\eta}} (1 + \beta)^{\left( \frac{-\eta}{1+\eta} \right)}$$

We complete the proof in the same way as before: by observing that the hybrid Ramsey problem, expressed below, is isomorphic to the static Ramsey problem.

$$\begin{aligned} \max_{\tau, \lambda} \quad & (1 + \beta) \left\{ \log \lambda + (1 - \tau) \mathbb{E}[\log w_C] + \left( \frac{1 - \tau}{1 + \eta} \right) [\log(1 - \tau) - \log \phi - 1] \right\} \\ \text{s.t.} \quad & (1 + \beta) \left\{ \mathbb{E}[w_C] \bar{h} - \lambda \mathbb{E}[(w_C)^{1-\tau}] \bar{h}^{1-\tau} - g \right\} = 0 \end{aligned}$$

□

## A.5. Estimation of the Productivity Process

This appendix describes the data and estimation method used to estimate the evolution of household wages, as specified in 4.9. The point estimates are used to parameterize the productivity process in the model.

### A.5.1. Data

**Source** The data are taken from the Panel Study of Income Dynamics (PSID), a longitudinal survey of US households beginning in 1968. Interviews occurred every year until 1997, but are now conducted on a biannual basis. The initial wave consisted of nearly 2,000 families drawn from a low-income oversample and nearly 3,000 families drawn from a nationally representative core sample. These original families and their members have been tracked ever since. As sample individuals move out of existing households and form new ones, ‘split-off’ households are added to the sample, helping to offset attrition and adding an inter-generational dimension to the data. During the 1990s, additional households were added to the panel to correct for the absence of post-1968 immigrants.

**Sample Selection** A total of 28,066 individuals have appeared as a household head in the PSID. I restrict attention to white males from the core sample who satisfy the following criteria in at least four, not necessarily consecutive, waves: (i) the individual is the head of his household; (ii) the individual’s age is between 24 and 65; (iii) the individual participates in the labour force (i.e. not a student, not retired); (iv) reported annual hours of work are between 500 and 5000; and (v) average hourly wages fall between \$2 and \$500.<sup>1</sup> Individuals who never reported years of completed

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<sup>1</sup>Nominal variables are adjusted to a 2010 basis using the Consumer Price Index as constructed by the Bureau of Labour Statistics.

schooling are also dropped. The final sample include 4286 individuals and 80,987 person-year observations (an average of 19 appearances).

**Definitions** The variables used in the sample selection and estimation are:

*Education.* The PSID records years of completed schooling for household heads. The variable is topcoded at 17 for individuals with any amount of post-graduate study. It is sometimes inconsistent as an individual might be listed as having completed 12 years of school in one year only to be listed as having completed 11 years in a later survey. To deal with this, I let a person's educational attainment be the highest education level ever reported.

*Age.* The age variable in the PSID does not always increase by 1 from one year to the next. Patterns such as (30, 30, 32) are not uncommon, probably because interviews occur at different points in the calendar year. But patterns such as (30, 41, 32) also occur, suggesting other forms of measurement error. I create a consistent age variable by inferring the year of birth that is consistent with the largest number of reports. For example, if the pattern (30, 30, 32) is observed for waves (1980, 1981, 1982), then I assign 1950 as the individual's year of birth.

*Labour Income.* The measure of labour earnings is comprehensive and includes wages, salaries, bonuses, overtime, professional fees and commissions, as well as as the labour part of farm and business income. The variable exists for both heads and wives.

*Hours Worked.* The PSID records annual hours worked. This variable is constructed from answers to questions about the number of hours worked per week and the number of weeks worked per year.

*Hourly Wages.* The average hourly wage is the ratio of labour income to hours

worked. The variable is topcoded, but some missing values can be readily recovered by calculating the wage directly.

### A.5.2. Specification

Supposes wages evolve according to:

$$\begin{aligned}
\log w_{i,t} &= \beta_{0i} + \beta_{1i}t + \beta_{2i}t^2 + \eta_{i,t} + \varepsilon_{i,t} \\
\eta_{i,t} &= \phi\eta_{i,t-1} + \nu_{i,t} \\
\beta_i &\sim \mathcal{N}(\beta, \Sigma) \\
\varepsilon_{i,t} &\sim \mathcal{N}(0, \sigma_\varepsilon^2) \\
\nu_{i,t} &\sim \mathcal{N}(0, \sigma_\nu^2) \quad |\phi| < 1 \quad \eta_{i,-1} = 0
\end{aligned} \tag{A.16}$$

where  $i$  indexes the individual and  $t$  denotes potential labor market experience. That is,  $t = AGE - \max\{EDUC, 12\} - 6$ .

It is convenient to write the person-specific components as:

$$u_{i,t} \equiv \underbrace{\left( \tilde{\beta}_{0i} + \tilde{\beta}_{1i}t + \tilde{\beta}_{2i}t^2 \right)}_{\text{heterogeneous trend}} + \underbrace{\left( \eta_{i,t} + \varepsilon_{i,t} \right)}_{\text{stochastic disturbance}}$$

where  $\tilde{\beta}_i \equiv \beta_i - \beta$ . The covariance structure of  $u_{i,t}$  is given by:

$$\begin{aligned}
Cov(u_{i,t+k}, u_{i,t}) &= \sigma_0^2 + \sigma_1^2 t(t+k) + \sigma_2^2 t^2(t+k)^2 + \sigma_{01}(2t+k) + \sigma_{02}[t^2 + (t+k)^2] \\
&\quad + \sigma_{12}[t(t+k)^2 + t^2(t+k)] + \sigma_\varepsilon^2 \mathbb{1}\{k=0\} + \phi^k Var(\eta_{i,t}) \\
Var(\eta_{i,t}) &= \phi^2 Var(\eta_{i,t-1}) + \sigma_\nu^2 = \left( \frac{1 - \phi^{2(t+1)}}{1 - \phi^2} \right) \sigma_\nu^2
\end{aligned} \tag{A.17}$$

### A.5.3. Identification

Suppose we have a panel of  $N$  households over  $T$  periods. With sufficient cross-sectional variation in age and experience at each point in time, we can identify the parameters of (A.16) as follows:

1. Since  $\epsilon_{i,t} \equiv \eta_{i,t} + \varepsilon_{i,t}$  has mean zero and is independent of  $t$  and  $t^2$ , we can identify the household-specific trend parameters  $\beta_i$  by a linear regression argument. This in turn identifies the distribution parameters  $\beta$  and  $\Sigma$ .
2. To identify the persistence parameter  $\phi$  notice from (A.17) that

$$\frac{Cov(u_{i,t+2}, u_{i,t}) - [\dots]}{Cov(u_{i,t+1}, u_{i,t}) - [\dots]} = \frac{\phi^2 Var(\eta_{i,t})}{\phi Var(\eta_{i,t})} = \phi$$

where  $[\dots]$  is shorthand for terms that depend only on  $t$  and elements of  $\Sigma$  which are already identified.

3. The variance of persistent shocks  $\sigma_\nu^2$  can now be identified from any unused covariance. For example:

$$\sigma_\nu^2 = \phi^{-1} [Cov(u_{i,0}, u_{i,1}) - \sigma_0^2 - \sigma_{01} - \sigma_{02}]$$

4. Finally, any unused variance can serve to identify transitory shocks. For example:

$$\sigma_\varepsilon^2 = Var(u_{i,0}) - \sigma_0^2 - \sigma_\nu^2$$



#### A.5.4. Estimation

The wage process given by (A.16) is a random-effects model with serially correlated errors. I perform a two-step procedure to obtain estimates. In this first step, run the pooled OLS regression:

$$\log \text{WAGE}_{it} = \beta_0 + \beta_1 \text{EXPER}_{it} + \beta_2 \text{EXBERSQ}_{it} + \text{year effects} + u_{it}$$

This yields consistent estimates for the common trend parameters  $\beta$ . Collect the residuals  $\hat{u}_{it}$ .

In the second step, use the first-stage residuals to construct the empirical covariance matrix. This matrix has typical element

$$\hat{C}_{t,k} = N_{t,k}^{-1} \sum_i \hat{u}_{i,t} \hat{u}_{i,t+k}$$

where  $N_{t,k}$  denotes the number of individuals observed at both date  $t$  and date  $t+k$ .

The theoretical covariance structure given by (A.17) suggests a conditionally linear regression model of the following form:

$$y = \delta X + \gamma D + \theta g(\lambda) \tag{A.18}$$

where  $y$  is a vector of empirical moments and the regressors are:

$$\begin{aligned} x_1 &= 1 & x_2 &= t(t+k) \\ x_3 &= t^2(t+k)^2 & x_4 &= 2t+k \\ x_5 &= t^2 + (t+k)^2 & x_6 &= t(t+k)^2 + t^2(t+k) \end{aligned}$$

$$D = \begin{cases} 1 & \text{if } t = k \\ 0 & \text{otherwise} \end{cases} \quad g(\lambda) = \lambda^k \left( \frac{1 - \lambda^{2(t+1)}}{1 - \lambda^2} \right)$$

The coefficients of this model correspond directly to the remaining parameters of interest. Obtaining the least-squares estimates is computationally easy since (A.18) is linear-in-parameters for a given value of  $\lambda$  (that is, for a given value of the persistence parameter  $\phi$ ). We can numerically optimize with respect to  $\lambda$  (that is,  $\phi$ ) by running a simple OLS regression at each iteration.

One advantage of having rich panel data is that we can extract a large number of empirical moments to use in the second stage regression. Indeed, the number of unique elements in the variance-covariance matrix increases at an approximately quadratic rate with experience.<sup>2</sup> A remaining practical concern is deciding which moments to exclude (if any). Somewhat arbitrarily, I cap the covariance lag at 45 years and exclude moments to which fewer than 100 individuals contributed.<sup>3</sup> This leaves me with 932 empirical moments. The results of the estimation are displayed in Table 1 in the main text.

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<sup>2</sup>Recall that  $\sum_{i=1}^n i = 1 + 2 + \dots + n = \frac{1}{2}(n^2 + n)$ .

<sup>3</sup>I also ran the regressions using only moments to which at least 200 individuals contributed. The results were robust to this change.

## A.6. Computation of the Models

This appendix describes the algorithms and other procedures that I use to solve the model and perform tax policy experiments.

### A.6.1. Discretizing the Wage Process

**The Stochastic Trend** The household's stochastic trend consists of an autoregressive component and a transitory component. Since the innovations are Gaussian, I employ a method based on Gauss-Hermite quadrature to discretize both shock processes. I use seven states for the persistent component and three states for the transitory component.

Let  $\{x_i(n)\}_{i=1}^n$  be the roots of the  $n^{\text{th}}$  order Hermite polynomial. Then the Markov chain nodes for the persistent shock are  $\{\sqrt{2\sigma_v^2/(1-\phi^2)}x_i(7)\}_{i=1}^7$  and those for the transitory shock are  $\{\sqrt{2}\sigma_\varepsilon x_i(3)\}_{i=1}^3$ .

**The Deterministic Trend** Recall that the heterogeneous trend parameters (the  $\beta_i$ 's) are jointly drawn from  $\mathcal{N}(\beta, \sigma)$  in an i.i.d. fashion. I approximate this distribution with a number of 'types', chosen in such a way that each is equally likely. This is not necessary, but it is convenient since the same number of simulations can be generated for each type.

I select three values for each trend coefficient, implying a total of 27 types. The procedure for each coefficient is as follows:

1. Let the coefficient be (conditionally) distributed as  $\mathcal{N}(\mu, \sigma)$ .
2. Partition the support into three intervals:  $(-\infty, A)$ ,  $(A, B)$ ,  $(B, \infty)$  where  $A$  and

$B$  are chosen so that the probability mass in each interval is the same, that is,  $1/3$ . Since the model is Gaussian, this means that:

$$\Phi\left(\frac{A-\mu}{\sigma}\right) = 1 - \Phi\left(\frac{B-\mu}{\sigma}\right) = \frac{1}{3} \quad \Rightarrow \quad \begin{aligned} A &= \mu + \sigma\Phi^{-1}(1/3) \\ B &= \mu - \sigma\Phi^{-1}(1/3) \end{aligned}$$

where  $\Phi$  denotes the standard normal cdf.

3. The nodes for each partition are the conditional expectations. Recall the formula for the  $\mathcal{N}(\mu, 1)$  case:

$$\mathbb{E}[X|a < X < b] = \mu + \left[ \frac{\phi(a) - \phi(b)}{\Phi(b) - \Phi(a)} \right]$$

4. The selected nodes end up being  $\{\mu - 1.09\sigma, \mu, \mu + 1.09\sigma\}$  whatever the values of  $\mu$  and  $\sigma$ .

Since  $\beta_0$  and  $\beta_1$  are uncorrelated (by assumption), I can select the nodes for these two coefficients using the marginal distributions. When selecting the  $\beta_2$  nodes, I need to use the conditional distribution where we are conditioning on the previously chosen  $\beta_0$  and  $\beta_1$ . This adds an additional but straightforward step.

#### *A.6.2. Computing Decision Rules: Labour Income Tax*

I solve for the household's decision rules by backward induction, beginning at age  $J$  and using the endogenous grid method (EGM) to iterate on the Euler equation in reverse. This approach requires very few root-finding procedures.

**Household's Recursive Problem** When the tax-and-transfer system is based on earnings, the household's problem is:

$$\begin{aligned}
v_t(j, a, m, n) &= \max_{h, c, a'} \frac{c^{1-\sigma}}{1-\sigma} - \varphi \frac{h^{1+\gamma}}{1+\gamma} + \beta \psi_{j+1} \int v_{t+1}(j+1, a', m, \tilde{n}) \pi(\tilde{n}|n) d\tilde{n} \\
\text{s.t.} \quad c + a' &= \lambda (w_t \rho(j, m, n) h)^{1-\tau} + R_t a + q_t \\
c, a' &\geq 0, \quad h \in [0, 1]
\end{aligned}$$

Letting  $\mu_t(j, a, m, n)$  denote the Lagrange multiplier, the first-order conditions are:

$$c : \quad 0 = c^{-\sigma} - \mu_t(j, a, m, n) \tag{A.19}$$

$$h : \quad 0 = -\varphi h^\gamma + \mu_t(j, a, m, n) \lambda (1-\tau) (w_t \rho(j, m, n))^{1-\tau} h^{-\tau} \tag{A.20}$$

$$a' : \quad 0 = \beta \psi_{j+1} \int \frac{d}{da'} [v_{t+1}(j+1, a', m, \tilde{n})] \pi(\tilde{n}|n) d\tilde{n} - \mu_t(j, a, m, n) \tag{A.21}$$

The envelope condition is:

$$\frac{d}{da} [v_t(j, a, m, n)] = R_t \mu_t(j, a, m, n) \tag{A.22}$$

**Endogenous Grid Method** The classic approach to solving Euler equations is to fix a state  $(j, a, m, n)$  and solve *forwards* for the optimal choice  $a'$ , supposing of course that we know  $v_{t+1}$ . The EGM proposes instead that we fix a *partial* state  $(j, m, n)$  and an optimal choice  $a'$ , and then solve *backwards* for the initial asset position  $a$  that rationalizes the presumed choice. Algorithm 1 details how to perform this bit of ‘reverse engineering’ for the benchmark model. Algorithm 3 describes how to operationalize the principle to approximate the household's entire policy function.

**Algorithm 1** (Unconstrained Case). *Suppose we know the marginal value of wealth in the next period, namely  $\frac{d}{da}[v_{t+1}]$ . Fix a partial state  $(j, m, n)$  at time  $t$  and consider*

a choice  $\hat{a}'$ . Then compute:

$$1. \tilde{v} = \beta \psi_{j+1} \int \frac{d}{da'} [v_{t+1}(j+1, a', m, \tilde{n})] \pi(\tilde{n}|n) d\tilde{n}$$

and, using (A.19)–(A.21):

$$2. c^* = \tilde{v}^{\frac{-1}{\sigma}}$$

$$3. h^* = (\lambda(1-\tau)\varphi^{-1}(w_t\rho(j, m, n))^{1-\tau}\tilde{v})^{\frac{1}{\gamma+\tau}}$$

$$4. \hat{a} = [c^* + \hat{a}' - \lambda((w_t\rho(j, m, n))h^*)^{1-\tau} - q_t]R_t^{-1}$$

These steps yield a complete set of decision rules for the ‘endogenous’ state  $(j, \hat{a}, m, n)$ :

$$h_t(j, \hat{a}, m, n) = h^* \tag{A.23}$$

$$c_t(j, \hat{a}, m, n) = c^* \tag{A.24}$$

$$a_{t+1}(j, \hat{a}, m, n) = \hat{a}' \tag{A.25}$$

A valuable feature of EGM is that by implementing Algorithm 1 for  $\hat{a}' = 0$ , one can precisely identify the binding threshold for the household’s budget constraint. Suppose we do just that and back out  $\bar{a}$  such that  $a_{t+1}(j, \bar{a}, m, n) = 0$ . Then we know that the household is borrowing-constrained in all states  $(j, a, m, n)$  with  $a < \bar{a}$ . In these states, the household solves what is essentially a static problem. Its decisions in this case can be computed by implementing Algorithm 2.

**Algorithm 2** (Constrained Case). *Suppose  $a_{t+1}(j, \bar{a}, m, n) = 0$ . Consider a state  $(j, a, m, n)$  with  $a < \bar{a}$ . The household is borrowing-constrained so we ignore (A.21) and combine the other two first-order conditions to get the following necessary and*

sufficient condition:

$$g(h) = h^{\gamma+\tau}\hat{\Gamma}^\sigma - \lambda(1-\tau)\varphi^{-1}(w_t\rho(j, m, n))^{1-\tau} = 0$$

where  $\hat{\Gamma} = q_t + R_t a + \lambda((w_t\rho(j, m, n))h)^{1-\tau}$ . The derivative of  $g$  is

$$g'(h) = h^{\gamma+\tau}\sigma\hat{\Gamma}^{\sigma-1}(1-\tau)\lambda(w_t\rho(j, m, n))^{1-\tau}h^{-\tau} + (\gamma+\tau)h^{\gamma+\tau-1}\hat{\Gamma}^\sigma$$

Notice that  $g(0) < 0$ ,  $g(\infty) > 0$  and  $g' > 0$ . Thus,  $g$  is strictly increasing and continuously differentiable with a known derivative  $g'$  and a single root on  $\mathbb{R}_+$ , which, not incidentally, happens to be the solution to the household's static labour supply problem. This means we can easily apply Newton's method to find the solution. If the constrained household has zero wealth ( $a = 0$ ), then the numerical root-finding can be skipped entirely as the solution has a closed-form:

$$h_t(j, 0, m, n) = \left((1-\tau)\varphi^{-1}(\lambda(w_t\rho(j, m, n))^{1-\tau})^{1-\sigma}\right)^{\frac{1}{\gamma+\tau+\sigma(1-\tau)}}$$

It can prove useful to use  $h_t(j, 0, m, n)$  to initiate Newton's method for  $a > 0$ .

I am now in a position to describe the full EGM for solving the benchmark model.

**Algorithm 3** (EGM: Labor Tax Model). *Fix the model's parameters and construct the discretized versions of  $\mathcal{M}$  and  $\mathcal{N}$ . Also discretize the state space for the continuous asset variable. Let  $\mathcal{A} = \{a_1, \dots, a_{\max}\}$  denote the fixed asset grid.<sup>4</sup> The objective is to solve for the optimal decisions on  $\mathcal{Z} \equiv \{1, \dots, J\} \times \mathcal{A} \times \mathcal{M} \times \mathcal{N}$ . Begin with  $j = J$  and set  $v_{J+1} = 0$ .*

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<sup>4</sup> There are three important choices for the selection of  $\mathcal{A}$ : (1) the number of grid points; (2) the value of the maximal grid point; and (3) the spacing of grid points. I choose 300 grids points and let the maximal grid point equal a multiple of the highest feasible earnings, high enough so that simulated assets never exceed that level. I use a double-exponential grid so that the grid is much finer at the low end where the decision rules are less linear.

1. Set  $m = 1$  and  $n = 1$ .
2. For all  $a \in \mathcal{A}$ , apply Algorithm 1 with  $\hat{a}' = a$  as the presumed choice. Construct the endogenous asset grid  $\mathcal{G} = (\hat{a}_1, \dots, \hat{a}_{\max})$  while looping through  $\mathcal{A}$  along with the associated decision rules.
3. Now we know the optimal decisions for states  $(j, \hat{a}, m, n)$  where  $\hat{a} \in \mathcal{G}$ . But we want to know the optimal decisions for states  $(j, a, m, n)$  where  $a \in \mathcal{A}$ . To obtain the latter, use the decision rules on the endogenous grid  $\mathcal{G}$  to interpolate for the decision rules on the fixed grid  $\mathcal{A}$ . Note that it is possible—nay, likely—that there exist  $a \in \mathcal{A}$  such that  $a < \hat{a}_1$ . Do not extrapolate below. These are constrained states, so apply Algorithm 2 instead.
4. Select a different  $(m, n)$  and repeat steps 2 and 3 until  $\mathcal{M} \times \mathcal{N}$  is exhausted.
5. Use (A.19) and (A.22) to compute  $\frac{d}{da}[v_t]$  at every grid point in  $\mathcal{Z}$ . Store this for the next iteration.
6. Go to  $j = j - 1$  and repeat steps 1-5. Stop once the steps for  $j = 1$  are complete.

**Remarks:**

**1** Algorithm 3 is very efficient since it eliminates the need for numerical root-finding except when solving for the household's constrained problem. This is possible because of the functional forms taken by preferences and taxes. For alternative parameterizations, Algorithm 1 would require numerical root-finding when computing the optimal labor supply.



**2** An alternative approach is to store the decision rules on the endogenous grid, not the fixed grid, and use these to generate simulated histories. If this option is chosen, Algorithm 2 must be applied at the simulation stage whenever a simulated household is borrowing-constrained. This means potentially many more calls to a root-finding procedure, a disadvantage. The advantage is that the model-generated data would be filtered through a single interpolation step (at simulation), possibly reducing numerical error.

**3** It is not necessary to compute the value functions  $\{v_t\}$ , only their wealth-derivatives. Moreover, it is only necessary to keep  $\frac{d}{da'}[v_{t+1}]$  in memory.

#### *A.6.3. Computing Decision Rules: Consumption Tax*

There is no substantive change to the EGM algorithm when  $\hat{T}$  is based on consumption instead of earnings. Only the equations used in Algorithms 1 and 2 are different. These equations are derived from the optimality conditions of the household's recursive problem, which is now formulated as:

$$\begin{aligned}
 v_t(j, a, m, n) = \max_{h, x, a'} & \quad \frac{(\lambda x^{1-\tau})^{1-\sigma}}{1-\sigma} - \varphi \frac{h^{1+\gamma}}{1+\gamma} + \beta \psi_{j+1} \int v_{t+1}(j+1, a', m, \tilde{n}) \pi(\tilde{n}|n) d\tilde{n} \\
 \text{s.t.} & \quad x + a' = w_t \rho(j, m, n) h + R_t a + q_t \\
 & \quad c, x, a' \geq 0, \quad h \in [0, 1]
 \end{aligned}$$

Here,  $x$  denotes expenditures net of taxes. It proves convenient to formulate the problem this way, with  $x$  as a choice variable instead of  $c$ . Letting  $\mu_t(j, a, m, n)$

denote the Langrange multiplier, the first-order conditions are:

$$\begin{aligned}
x : \quad 0 &= (1 - \tau)\lambda^{1-\sigma}x^{-(\sigma+\tau-\sigma\tau)} - \mu_t(j, a, m, n) \\
h : \quad 0 &= -\phi h^\gamma + w_t\rho(j, m, n)\mu_t(j, a, m, n) \\
a' : \quad 0 &= \beta\psi_{j+1} \int \frac{d}{da'} [v_{t+1}(j+1, a', m, \tilde{n})] \pi(\tilde{n}|n)d\tilde{n} - \mu_t(j, a, m, n)
\end{aligned}$$

These conditions imply that under the consumption tax regime, steps 2-4 of Algorithm 1 are:

$$\begin{aligned}
2. \quad x^* &= \left( \frac{\tilde{v}}{(1-\tau)\lambda^{1-\sigma}} \right)^{\frac{-1}{\sigma+\tau-\sigma\tau}} \\
3. \quad h^* &= (\varphi^{-1}w_t\rho(j, m, n)\tilde{v})^{\frac{1}{\gamma}} \\
4. \quad \hat{a} &= [x^* + \hat{a}' - w_t\rho(j, m, n)h^* - q_t]R_t^{-1}
\end{aligned}$$

Similarly, for Algorithm 2 we now find the positive root of:

$$g(h) = h^\gamma(q_t + R_t a + w_t\rho(j, m, n)h)^{\sigma+\tau-\sigma\tau} - (1 - \tau)\lambda^{1-\sigma}\varphi^{-1}w_t\rho(j, m, n)$$

#### A.6.4. Computing Decision Rules: Pseudo-Consumption Tax

In Subsection 9, I run two decomposition exercises to separate the efficiency and insurance effects of the tax-base conversion. In the first of these exercises, the household is assumed to act as though it is subject to a consumption tax, but its actual tax burden is assessed according to its earnings. The basic structure of the EGM algorithm is the same as before, but the formulas for computing decisions and assets are a mixture of the consumption-tax case and the labour-income-tax case.

Given  $\tilde{v}$ , a pseudo-consumption taxpayer chooses expenditures and hours in the same

way as a genuine consumption taxpayer. Namely:

$$x^* = \left( \frac{\tilde{v}}{(1-\tau)\lambda^{1-\sigma}} \right)^{\frac{-1}{\sigma+\tau-\sigma\tau}}$$

$$h^* = (\varphi^{-1}w_t\rho(j, m, n)\tilde{v})^{\frac{1}{\gamma}}$$

But instead of storing  $x^*$ , which reflects expenditure net of tax, we store the associated consumption level  $c^* = \lambda(x^*)^{1-\tau}$ . Also, we back out start-of-period assets in a way that reflects the actual tax assessment on labour income:

$$\hat{a} = [c^* + \hat{a}' - \lambda((w_t\rho(j, m, n))h^*)^{1-\tau} - q_t]R_t^{-1}$$

In writing the code for this algorithm, special attention must be paid to the computation of the marginal utilities. The household must believe it is paying tax on consumption in the next period as well as in the present one, though of course it is doing so in neither.

#### *A.6.5. Computing Decision Rules: Pseudo-Labour-Income Tax*

The pseudo-consumption tax isolates the impact of the tax base reform on labour efficiency. To isolate the impact on social insurance, we perform the reverse exercise. That is, make the household acts as though it is subject to a tax on earnings, but assess actual tax burdens according to consumption.

In this case, the decisions for consumption and hours are per the equations described

in Algorithm 1:

$$c^* = \tilde{v}^{\frac{-1}{\sigma}}$$

$$h^* = (\lambda(1 - \tau)\varphi^{-1}(w_t\rho(j, m, n))^{1-\tau}\tilde{v})^{\frac{1}{\gamma+\tau}}$$

But we store the required expenditure  $x^* = (c/\lambda)^{\frac{1}{1-\tau}}$  and recover start-of-period assets according to:

$$\hat{a} = [x^* + \hat{a}' - w_t\rho(j, m, n)h^* - q_t]R_t^{-1}$$

#### A.6.6. Computing the Initial Stationary Equilibrium

There are seven parameters and equilibrium objects needing internal calibration. Four, viz.  $(\beta, \lambda, b, q)$ , can only be calibrated by simulating the model repeatedly until specified targets are jointly attained. Two, viz.  $(A, B)$ , can be normalized analytically at each iteration. The final parameter, viz.  $\varphi$ , can be normalized numerically after the rest of the model is calibrated.

**Algorithm 4** (Initial Steady State). *To solve for the stationary equilibrium, iterate on the following steps:*

1. Fix  $r = 0.04$  and  $w = 1.00$ .
2. **Guess**  $(\beta, \lambda, b, q)$ .
3. **Solve** for decision rules  $(c, h, a')$  using Algorithm 3.
4. **Simulate** a large number of histories. Set a specific seed for the pseudo-random number generator so that the same shock histories are used at each iteration.

5. **Aggregate** variables across simulated histories and compute equilibrium objects. In so doing, choose  $A$  and  $B$  so that the implied wage and implied debt-to-output ratio match their targets exactly.<sup>5</sup>
6. **Verify** if the implied values of  $r$ ,  $G/Q$ , and  $b/\bar{y}$  are sufficiently close to their targets, and if the implied  $q$  is sufficiently close to the guess for  $q$ . If so, move to the next step. If not, update the guess for  $(\beta, \lambda, b, q)$  and go back to step 3. Here, ‘sufficiently close’ means that the absolute difference is less than a given tolerance level.
7. The final step is to calibrate  $\varphi$  to the target for mean hours. This step is essentially a normalization since all we’re doing is re-scaling the economy. Adjust all the level parameters and grids appropriately, then repeatedly apply Algorithm 3 for different values of  $\varphi$  until the target is attained. Bisection works fine here as few iterations are typically needed.

**Remark:** In practice, I add another loop to Algorithm 4 by repeatedly calibrating the model for increasingly stringent tolerance levels. This ensures that the solution is approached in a comparatively uniform manner from all dimensions.

#### A.6.7. Computing the Terminal Steady State

I assume that the economy transitions to a new steady state after any change to the policy environment. Certain calibrated parameters are kept fixed, namely  $b$ ,  $B$ ,  $A$  and  $G$ . Certain equilibrium objects must be solved for, namely  $w$ ,  $r$ ,  $\lambda$  and  $q$ .

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<sup>5</sup>Let  $\bar{w}$  and  $\overline{B/Q}$  denote the steady-state targets. Let  $\tilde{N}$  and  $\tilde{A}$  denote implied effective labour and implied total assets, aggregated over simulated histories. Since labour’s share of income is  $wN = (1 - \alpha)Q$ , it is straightforward to set  $B = \overline{B/Q} \cdot \frac{\bar{w}N}{1-\alpha}$ . This implies a capital stock of  $\tilde{K} = \tilde{A} - B$ . Then, along similar lines, we obtain the technology parameter  $A = \frac{\bar{w}}{1-\alpha} \left(\frac{\tilde{N}}{\tilde{K}}\right)^\alpha$ .

**Algorithm 5** (Terminal Steady State). *Fix a terminal public debt  $B'$ . Then iterate on the following steps until convergence.*

1. **Guess**  $(r', \lambda', q')$ .
2. **Assign**  $w'$  using the following function derived from the firm's first-order conditions:

$$w(r) = (1 - \alpha)A \left( \frac{r + \delta}{\alpha A} \right)^{\frac{-\alpha}{1-\alpha}} \quad (\text{A.26})$$

3. **Solve** for decision rules using Algorithm 3.
4. **Simulate** a large number of histories.
5. **Aggregate** variables across simulated histories and compute equilibrium objects.
6. **Verify** that the implied values of  $r'$  and  $q'$  are sufficiently close to their guesses, and that the government budget is balanced. If not, update the guess for  $(r', \lambda', q')$  and go back to step 2.

#### A.6.8. Transition Path

Algorithm 5 assumes a particular level of public debt  $B'$  when computing the new steady state. My algorithm for computing the transition path ensures that this choice is consistent with the behavioural changes induced by the reform.

**Algorithm 6** (Transition path). *Suppose that the economy is in the initial steady state at time  $t = 0$  after which an unexpected policy reform is announced, effective  $t =$*

1. *We are interested in computing the transition induced by this reform. Suppose that*

the economy converges to a new steady state in  $G$  periods or less. Pick  $G$  sufficiently large.

1. **Guess** a terminal debt  $B'$ . Apply Algorithm 5 to find the terminal steady state.
2. **Guess** a sequence of interest rates  $\{r_t\}_{t=1}^G$ .
3. **Assign** a sequence of wage rates  $\{w_t\}_{t=1}^G$  using A.26.
4. **Solve** for the decision rules for each generation  $g = -(J - 1), \dots, G$ , where  $g$  indexes the period in which the cohort enters the economy. That is, generation  $g = 1$  is the generation that is born in the first period of the new policy regime.
5. **Simulate** a large number of histories for each generation.
6. **Aggregate** variables across simulated histories and across generations for each time period. Compute equilibrium objects.
7. **Verify** that the implied interest rates are sufficiently close to their guesses at every point along the transition. If not, update the guess for  $\{r_t\}_{t=1}^G$  and go back to step 3.
8. **Iterate** on the government's period-by-period budget constraint to compute the implied accumulation of public debt along the transition. Verify that the resulting terminal debt is sufficiently close to the guess. If not, update the guess for  $B'$  and go back to step 2.

#### A.6.9. Model with Two Consumption Goods

Section 4.6 considers a variation of the benchmark model with two consumer goods, a basic good and a non-basic good. Preferences over bundles of the two goods are

ordered by a Cobb-Douglas aggregator, as specified in Equation (4.11). Consider the optimization problem facing a consumer with resources  $x$  to allocate:

$$\max_{c,d} (c - \underline{c})^\theta d^{1-\theta} \quad \text{s.t.} \quad x - (1 + \tau_c)c - (1 + \tau_d)d \geq 0 \quad (\text{A.27})$$

The first-order conditions of this problem imply the following relationship:

$$c = \underline{c} + \left( \frac{\theta}{1 - \theta} \right) \left( \frac{1 + \tau_d}{1 + \tau_c} \right) d \quad (\text{A.28})$$

Substituting for  $c$  in (A.27) yields the modified objective function:

$$\left[ \left( \frac{\gamma}{1 - \gamma} \right) \left( \frac{1 + \tau_d}{1 + \tau_c} \right) \right]^{\theta(1-\sigma)} \frac{d^{1-\sigma}}{1 - \sigma} \quad (\text{A.29})$$

which is just the usual CRRA utility function with a multiplicative factor. Thus, the standard algorithms are easily adjusted to the two-good case, as long as sufficient care is taken with the budget constraints.



## A.7. Empirical Mapping for Basic and Non-Basic Consumption

In Section 4.6, I extend the basic model to allow for two types of consumption, basic and non-basic. In order to map the two-good model to the data, I use the 2006-2012 waves of the Consumer Expenditure Survey (CEX). The CEX is a nationally representative rotating panel administered on a quarterly basis by the Bureau of Labor Statistics. It contains detailed information on consumer activities, covering up to 95% of a typical household's expenditures, as well data on income and demographics. Households exit the panel after a maximum of four quarterly interviews.

**Sample Selection** Following the Sample B selection criteria in Heathcote et al. (2010), I drop records if (1) there is no age information for either the head or spouse; (2) the household head is younger than 25 or older than 60; (3) either the head or spouse has positive labor income but zero annual hours; (4) either the head or spouse reports an hourly wage less than half of the federal minimum wage; or (5) quarterly equivalized food consumption is less than \$100 in 2000 dollars.<sup>6</sup> I also exclude households that complete fewer than four consecutive quarterly interviews. As such, each respondent in the sample reports expenditures over a full twelve-month period. I add the four quarterly reports together and work with annualized variables. Finally, I trim the top and bottom 1% of the total expenditure distribution to remove the effect of outliers. The final sample includes 15,218 households.

**Classifying Consumption** The CEX contains 14 main expenditure categories, but two of these—cash contributions and personal insurance and pensions—constitute savings. I focus on the other 12. For each main category and the dozens of associated

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<sup>6</sup>I use the OECD equivalence scale, also known as the Oxford scale, which assigns 1 to the first household member, 0.7 to each additional adult, and 0.5 to each additional child.

subcategories, I run the following regression:

$$y = \beta_0 + \beta_1 \text{exp} + \beta_2 \text{expsq}$$

where  $y$  denotes the category of interest,  $\text{exp}$  denotes total expenditure and  $\text{expsq}$  denotes the square of total expenditure. Table 20 reports the point estimates from these regressions. I classify a variable as a *candidate* basic goods if  $\hat{\beta}_0 > 0$  and  $\hat{\beta}_2 < 0$ , reflecting the idea that basic goods and services are those that must be consumed at some minimal level ( $\hat{\beta}_0 > 0$ ) and for which the excess expenditure share is decreasing ( $\hat{\beta}_2 < 0$ ). Eight variables meet these criteria: food at home; rented dwellings; utilities; gasoline and motor oil; vehicle insurance; prescription drugs; televisions, radios, and sound equipment; and tobacco and smoking supplies.

Because the research goal is to quantify the transition to a two-rate consumption tax regime, we must also consider which of these goods could be made tax-exempt in a politically feasible tax reform. For instance, it seems implausible to consider the elimination of taxes on tobacco products. In the end, I select four categories to serve as my empirical counterpart to the model's basic consumer good, namely: food at home, rented dwellings, utilities, and prescription drugs. I choose these four variables because they are already subject to preferential tax treatment in many jurisdictions that levy indirect consumption taxes. With this empirical mapping in hand, basic consumption accounts for 27.3% of aggregate consumer spending, but the share varies greatly across the expenditure distribution, ranging from 55.8% in the bottom decile to 15.4% in the top decile.

Table 21 presents expenditure shares for a wide range of consumer goods and services. The columns represent different percentile bands of the total expenditure distribution.

Only main categories are reported unless the subcategories exhibit different patterns, in which case the subcategories are reported instead. For example, the food category is disaggregated into food at home and food away from home because the former is classified as a basic good and the latter is classified as a non-basic good.

**Calibrating the New Preference Parameters** Compared with the baseline model, I need to pin down two additional structural parameters,  $\underline{c}$  and  $\theta$ . To do so, I first run the following regression:

$$basic = \beta_0 + \beta_1 exp$$

where *basic* denote the sum of the four basic consumption categories. The output from this regression is reported in Table 22.

Table 22: Basic Consumption vs Total Expenditure

Parameter	Estimate	Std Error	t-statistic	P-value	CI <sub>0.025</sub>	CI <sub>0.975</sub>
$\beta_0$	4601.75	59.39	77.48	0.00	4485.33	4718.16
$\beta_1$	0.0914	0.0020	44.73	0.00	0.0874	0.0954

**Note:** The sample size is N=15,218.

I set  $\theta$  equal to  $\hat{\beta}_1$ , since the slope coefficient reflects the share of household expenditures *in excess* of the minimum level that is devoted to basic goods and services. I subsequently chose  $\underline{c}$  so that the model generates a ratio of non-basic to basic consumption that is consistent with the data, namely  $\frac{C}{D} = 2.65$ .

Table 20: Expenditure Regressions, CEX categories and subcategories

Category	CEX Name	$\beta_0$	$\beta_1 \times 100$	$\beta_2'$
Food	xfood	1223.5020	13.7045	-0.4580
<b>Food at home</b>	xfdhome	1426.9230	7.0506	-0.4490
Food away from home	xfdaway	-203.4204	6.6539	-0.0087
Alcoholic beverages	xalcbev	-109.5542	1.4854	-0.0120
Housing	xhous	220.6914	39.6951	-0.1510
Shelter	xshelt	-372.2168	26.9475	0.0952
Owned dwellings	xowndwe	-1432.1370	23.3068	0.0092
<b>Rented dwellings</b>	xrendwe	1145.6540	3.2251	-0.3660
Other lodging	xothlod	-85.7332	0.4157	0.4520
<b>Utilities</b>	xutil	899.2348	6.4532	-0.3580
Household operations	xhousop	-88.6086	2.6088	0.0758
House furnishing and equipment	xhouseq	-217.7181	3.6857	0.0360
Household textiles	xtextil	-12.1975	0.2379	0.0070
Furniture	xfurntr	-55.8144	0.8721	0.0527
Floor coverings	xfrcvr	-6.0990	0.0693	0.0129
Major appliances	xmajapp	-29.1083	0.6569	-0.0269
Small appliances and miscellaneous housewares	xsmllapp	-9.9318	0.2060	-0.0051
Miscellaneous household equipment	xmisceq	-104.5671	1.6434	-0.0046
Apparel and services	xappar	37.4759	2.3256	0.1620
Clothing for men and boys	xmenboy	-6.5378	0.7624	-0.0082
Clothing for women and girls	xwomgrl	-25.2248	1.1333	0.0252
Clothing for children under 2	xchldr	25.9518	0.0801	-0.0089
Footwear	xfootwr	14.7521	0.3105	0.0069
Other apparel products and services	xothapl	28.5345	0.0393	0.1470
Transportation	xtrans	-990.7137	23.9283	0.1630
New cars and trucks (net outlay)	xcartkn	-372.5258	0.7704	1.2600
Used cars and trucks (net outlay)	xcartku	-462.1273	5.7089	-0.1660
Other vehicles	xothveh	-64.0510	0.5363	-0.0151
<b>Gasoline and motor oil</b>	xgasm	229.0107	7.1151	-0.5980
Vehicle finance charges	xvehfin	-33.4483	1.2341	-0.1070
Maintenance and repairs	xmainrp	-101.7247	2.7987	-0.1520
<b>Vehicles insurance</b>	xvehins	18.7863	2.9322	-0.2140
Vehicle rental, leases, licenses, and other charges	xvrntlo	-100.9157	1.5137	0.0197
Public transportation	xpubtra	-103.7179	1.3189	0.1340
Health care	xhealth	-203.6542	9.0048	-0.5520
Health insurance	xhlthin	-20.9040	4.7488	-0.3320
Medical services	xmedsrv	-179.7946	3.0307	-0.1490
<b>Prescription drugs</b>	xpredrg	9.8933	0.9363	-0.0615
Medical supplies	xmedsup	-12.8489	0.2889	-0.0102
Entertainment	xentert	-329.6345	7.7788	-0.0727
Fees and admissions	xfeadm	-151.5610	1.8475	0.1180
<b>Televisions, radios, and sound equipment</b>	xtvrdio	43.9065	2.7692	-0.1420
Other equipment and services	xotheqp	-221.9800	3.1621	-0.0487
Personal care	xpersca	-49.0375	1.0014	-0.0204
Reading	xread	-36.7294	0.5080	-0.0205
Education	xeduca	146.0641	-1.3468	0.9200
<b>Tobacco and smoking supplies</b>	xtobacc	179.2456	0.4535	-0.0671
Miscellaneous expenditures	xmisc	-87.6557	1.4614	0.1080

**Note:** This table reports parameter estimates for regressions of expenditure categories on total expenditure and its square. The sample size is 15,218 households. Categories are bolded if  $\hat{\beta}_0 > 0$  and  $\hat{\beta}_2 < 0$ .

Table 21: Expenditure Shares, CEX categories and subcategories

	P0-P5	P5-P10	P10-P25	P25-P50	P50-P75	P75-P90	P90-P95	P95-P100	TOTAL
Food at home	26.2	21.2	17.6	14.0	11.3	9.1	7.7	6.0	11.2
Rented dwellings	15.3	15.1	12.4	8.6	6.5	4.9	3.9	2.4	6.5
Utilities	16.6	14.7	13.0	10.9	9.0	7.4	6.4	5.3	8.8
Prescription drugs	0.6	0.7	0.9	1.0	0.9	0.7	0.6	0.6	0.8
<b>Basic goods and services</b>	<b>58.7</b>	<b>51.7</b>	<b>43.9</b>	<b>34.5</b>	<b>27.7</b>	<b>22.0</b>	<b>18.5</b>	<b>14.3</b>	<b>27.3</b>
Food away from home	3.9	4.4	4.9	5.6	5.9	6.1	6.2	6.5	5.8
Alcoholic beverages	0.3	0.4	0.6	0.8	1.1	1.2	1.3	1.3	1.0
Tobacco and smoking supplies	1.8	2.0	1.8	1.4	1.0	0.6	0.4	0.3	0.9
Owned dwellings	7.9	9.0	12.1	15.1	17.8	19.9	20.3	21.2	17.7
Other lodging	0.1	0.2	0.4	0.8	1.2	1.9	2.4	3.4	1.6
Household operations	1.0	1.6	1.8	2.3	2.6	2.7	2.5	3.1	2.5
House furnishing and equipment	1.4	1.8	1.9	2.5	3.0	3.2	3.6	3.6	2.9
Apparel and services	3.1	3.2	2.8	2.8	2.9	3.1	3.1	3.6	3.0
New cars and trucks (net outlay)	0.0	0.0	0.1	0.7	2.2	4.6	6.7	8.2	3.5
Used cars and trucks (net outlay)	0.7	1.2	1.7	2.8	3.5	4.0	4.3	4.0	3.3
Other vehicles	0.0	0.1	0.1	0.1	0.2	0.3	0.6	0.2	0.2
Gasoline and motor oil	7.6	7.9	8.1	7.5	6.5	5.3	4.6	3.3	6.0
Vehicles insurance	1.9	2.5	2.9	2.7	2.5	2.1	1.9	1.5	2.3
Vehicle finance charges	0.5	0.5	0.8	0.9	0.9	0.7	0.6	0.4	0.7
Maintenance and repairs	1.1	1.5	1.7	2.0	2.1	1.9	1.9	1.6	1.9
Vehicle rental, leases, licenses, and other charges	0.4	0.6	0.7	1.0	1.2	1.3	1.5	1.4	1.2
Public transportation	0.7	0.8	0.7	0.9	1.3	1.6	1.7	2.1	1.4
Health insurance	2.7	3.2	4.1	4.3	3.8	3.3	2.9	2.4	3.6
Medical services	0.6	1.0	1.3	1.8	2.0	2.0	1.8	1.8	1.8
Medical supplies	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fees and admissions	0.3	0.4	0.7	1.2	1.6	1.9	2.0	2.5	1.6
Televisions, radios, and sound equipment	2.8	3.0	2.9	2.8	2.6	2.4	2.1	1.9	2.5
Other equipment and services	1.1	1.1	1.3	1.8	2.1	2.4	2.6	2.4	2.1
Personal	0.4	0.5	0.6	0.7	0.8	0.8	0.8	0.8	0.7
Reading	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3
Education	0.3	0.6	0.9	1.3	1.8	2.4	3.3	5.5	2.3
Miscellaneous expenditures	0.5	0.8	0.9	1.2	1.3	1.7	1.8	2.1	1.5
<b>Non-basic goods and services</b>	<b>41.3</b>	<b>48.3</b>	<b>56.1</b>	<b>65.5</b>	<b>72.3</b>	<b>78.0</b>	<b>81.5</b>	<b>85.7</b>	<b>72.7</b>
<b>Total expenditures</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

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