Consumption Tax Cuts vs Stimulus Payments

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Recent work shows that across a broad range of macroeconomic models with non-Ricardian consumer behavior, uniform transfer payments are macro-equivalent to interest rate cuts. That is, policymakers can use stimulus payments to substitute for conventional monetary policy when, say, the zero lower bound on nominal interest rates binds. We argue that in the same class of models, temporarily reducing consumption taxes provides more stimulus than transfers — at the same cost to the taxpayer. Simulating these policies in a quantitative New Keynesian model with heterogeneous households, we find aggregate output expands at least twice as much. This suggests that when governments are unable to manipulate interest rates, they may consider cutting existing taxes rather than sending checks to people. (JEL E21, E62, E63)

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1 Introduction

Standard monetary economics prescribes conducting stabilization policy through changes in short-term interest rates. The prescription works remarkably well most of the time but breaks down when nominal interest rates hit the zero lower bound (ZLB). Economists have long recognized that when monetary policy ceases to be effective, fiscal policy can come in handy. Available fiscal stabilization tools include increasing government purchases, subsidizing firms and workers, sending transfer payments to the population, and temporarily reducing taxes. In recent work, Wolf (2022) shows that across a broad range of business-cycle models with nominal rigidity and non-Ricardian consumer behavior, uniform deficit-financed transfers ("stimulus checks") are macro-equivalent to interest rate cuts. In other words, policymakers can use stimulus checks to perfectly substitute for conventional monetary policy when rates are constrained by the ZLB. Wolf's result is important because it provides theoretical support for a policy that several countries such as the United States have employed in recent recessions.

In this paper, we argue that another readily available fiscal policy tool — temporary reductions in consumption taxes — delivers more stimulus than transfers, at the same cost to the taxpayer. This policy instrument has been used by many countries over the last few years, as Table 1 reports. Germany is a typical example. In June 2020, in the midst of the coronavirus pandemic and as policy rates in the euro area were stuck at zero, the German government announced a temporary cut in the value-added tax (VAT) rate from 19 to 16 percent, effective July 1. It made clear the policy would be reversed six months later, in January 2021. Bachmann et al. (2021) estimate the VAT cut led to a sizable increase in spending, at a relatively moderate cost to public finances.[1]

We consider the same environment as Wolf (2022): a textbook New Keynesian model without capital extended to allow for non-Ricardian consumer behavior. This general framework nests models with a representative agent (RANK), spenders and savers (TANK), overlapping generations (OLG), and heterogeneous agents (HANK). We study a policymaker who for some reason cannot adjust nominal interest rates. This may happen if the ZLB constraint binds or if the country is part of a currency union and delegates its monetary policy decisions to a union-wide central bank. The policymaker has access to two fiscal instruments: consumption tax rates and uniform, lump-sum transfers. Both are financed by deficit and thus vary the amount of government debt outstanding. We compare policies that are budget-equivalent, ie that imply the same path of primary balance.

Our main result is as follows. In all the models considered, any consumption tax cut generates a larger expansion in aggregate output than the budget-equivalent increase in transfer payments. This is true on impact and in cumulative terms. To understand the *impact* response, first recognize that either policy affects the economy primarily by stimulating

[1]The authors estimate the VAT cut increased aggregate consumption spending by 34 billion euros, a little over one percent of Germany's GDP in 2020. The policy cost 7 billion euros in foregone tax revenue.

Table 1: Consumption Tax Cuts Around the World

Country	Sector	Old rate	New rate	Start date	End date
United Kindgom	All	17.5%	15%	Dec 1, 2008	Dec 31, 2009
Austria	Food, drinks	20%	10%	July 1, 2020	Dec 31, 2020
Belgium	Hotels, restaurants	12%	6%	June 8, 2020	Dec 31, 2020
Bulgaria	Hotels, restaurants	21%	10%	July 1, 2020	Dec 31, 2020
Colombia	Hotels, restaurants	8%	0%	May 25, 2020	Dec 31, 2020
Costa Rica	Tourism	13%	0%	July 1, 2020	June 30, 2021
Cyprus	Hotels, restaurants	9%	5%	July 1, 2020	Jan 10, 2021
Czech Republic	Hotels, culture	15%	10%	July 1, 2020	Dec 31, 2020
Germany	All	19%	16%	July 1, 2020	Dec 31, 2020
Greece	Transport, drinks	24%	13%	June 1, 2020	Apr 31, 2021
Ireland	All	23%	21%	Sept 1, 2020	Feb 28, 2021
Jamaica	All	16.5%	15%	Apr 1, 2020	Mar 31, 2021
Kenya	All	16%	14%	Apr 1, 2020	Dec 31, 2020
Lithuania	Hotels, restaurants	21%	9%	July 1, 2021	Dec 31, 2023
Malaysia	Hotels	6%	0%	Mar 30, 2020	June 30, 2021
Mexico	All (some regions)	16%	10%	Nov 27, 2020	Dec 31, 2023
Norway	Hotels, culture	12%	6%	Apr 1, 2020	Dec 31, 2020
Turkey	Hotels, culture	18%	8%	July 31, 2020	Dec 31, 2020
Ukraine	Culture, electricity	20%	10%	Mar 17, 2020	Dec 31, 2020
United Kingdom	Hotels, culture, food	20%	5%	July 15, 2020	Mar 31, 2021

Sources: Avalara VATlive, Global VAT Compliance, ORC International

household consumption demand. Tax cuts and transfers both increase disposable income. As long as consumers do not exhibit Ricardian behavior — eg because they face financial constraints, have finite lives, or are not entirely rational — then this increase in disposable income boosts consumer spending. In fact, it is easy to show that fully hand-to-mouth (or fully impatient) households, that is, agents who do not save but instead consume all income, respond equally to consumption tax cuts and transfers — by increasing consumption demand one-for-one.

But income effects are only part of the story. Changes in consumption taxes also affect intertemporal prices. In particular, a temporary tax cut makes today's consumption goods cheaper than tomorrow's.[2] Households that are not constrained (or not fully inattentive) realize this and decide to substitute present consumption for future consumption, by using up their savings. Think of a family that chooses to anticipate its purchase of consumer goods to take advantage of the tax break. The strength of this substitution effect is, of course, governed by the elasticity of intertemporal substitution, call it γ. We show that for any positive value of γ, consumers respond more on the spot to consumption tax cuts than they do to transfer payments. In sum, while stimulus checks only work through an income channel, consumption tax cuts activate both income and substitution channels. This explains why a dollar spent on tax cuts produces more short-run stimulus than a dollar

[2]Formally, consumption taxes appear in the consumption-savings Euler equation of households, while lump-sum transfers do not. This equation implies that an anticipated increase in the future consumption tax rate is equivalent to a decrease in the current real interest rate (Feldstein 2002; Correia et al. 2013).

spent on transfers.

The reason consumption tax cuts also induce a greater *cumulative* increase in output is the following. By raising consumption, stimulus checks increase the marginal utility of leisure and thus discourage work. This is again the income effect in action. Consumption tax cuts do trigger a similar negative income effect on labor supply but, at the same time, they *encourage* work through a substitution effect. This is because a lower tax means higher disposable income, which raises the marginal value of work and thus stimulates labor supply. More hours worked, in turn, lift income and consumption. We establish that, thanks to this substitution effect on labor supply, the net present value output response is always higher under a consumption tax policy than under an equally-costly transfer policy.

Our study thus clarifies how consumption tax changes transmit to the economy. Tax cuts spur consumer demand, like transfers, but in a swifter, front-loaded way. In addition, consumption tax cuts incentivize labor supply, just like labor tax cuts. It turns out there exists an equivalence between these three policy instruments. We prove that any aggregate allocation the policymaker can implement with a consumption tax-only policy can also be implemented with a mix of transfer and labor income tax policies, and vice versa. This equivalence result underscores the dual propagation mechanism of consumption taxes — via consumption demand and labor supply — and makes it easy to see why consumption tax cuts dominate transfers alone when it comes to boosting economic activity.

Are the differences between consumption tax cuts and stimulus checks large in practice? To address this question, we turn to a quantitative HANK model calibrated for the US economy. We set up two budget-equivalent consumption tax and transfer policies that last a few quarters and initially cost one percent of GDP. Our simulations indicate that the response of aggregate output is about twice as large under the consumption tax policy, both on impact and in cumulative terms. These results are robust to changes in key parameters, including the elasticity of intertemporal substitution γ; the elasticity of labor supply; the share of constrained households in the economy; the level of idiosyncratic risk; the quantity of liquid assets; and the degree of price and wage rigidity.

We conduct two decomposition exercises to expose the mechanisms at play. First, we examine the distributional effects of the two programs. As hinted by the analytical results, asset-poor households eagerly consume more in response to either policy. Wealthy households, however, behave very differently depending on the instrument. They increase spending sharply following the tax cut but only moderately following the stimulus check. Intuitively, these individuals have large asset holdings and so behave much like permanent-income consumers. Perceiving the check as a transitory increase in income, they spend it over multiple periods, initially saving most of it. By contrast, upon learning about the temporary tax cut, they correctly anticipate that prices will rise in the future, and thus decide to bring forward future consumption by drawing down their assets. This cross-sectional analysis reveals that the consumption tax policy is more effective at stimulating output than the transfer policy because it prompts a strong response from all households in the wealth distribution, including the rich whose consumption represents a large share in aggregate spending.

The second decomposition exercise helps quantify the role of each channel operating after a consumption tax change. To be clear, households consume more in response to a temporary tax cut because i) they are richer (demand income effect); ii) they want to take advantage of the currently lower price of goods (demand substitution effect); iii) they potentially work more and earn higher labor income (labor supply income and substitution effects). In HANK, it turns out the demand substitution effect largely dominates the other two. This holds even i) in the presence of a large margin of zero-wealth households with a high marginal propensity to consume (MPC); ii) if one sets an arbitrarily low elasticity of intertemporal substitution γ; iii) if one sets an arbitrarily high elasticity of labor supply for all workers.

All in all, our results suggest consumption tax cuts present a key advantage over transfers. Unlike transfers which can be saved, tax cuts target spending directly, since consumers have to buy goods to benefit from the policy. Besides, in practical terms VAT tax changes are quick to implement and easy to communicate to the public.[3] So what could possibly go wrong? A potential limitation is that in most countries bar the United States, firms set *after-tax* prices. Thus, VAT cuts work only to the extent that businesses pass the lower tax through to consumer prices. An empirical literature estimates that pass-through is incomplete but usually high (Blundell 2009; Benzarti et al. 2020; Fuest, Neumeier, and Stöhlker 2021). To address this concern and make our results more general, we consider an extension of the model with VAT and plausibly calibrated, partial pass-through. We find the results are only slightly weakened. The central conclusion holds: VAT cuts are more powerful than stimulus checks.

Related Literature.—This paper contributes to the literature on fiscal policy in a liquidity trap (Krugman 1998; Christiano, Eichenbaum, and Rebelo 2011; Eggertsson 2011; Woodford 2011; DeLong and Summers 2012; D'Acunto, Hoang, and Weber 2022). An influential study by Correia, Farhi, Nicolini, and Teles (2013) shows how, in a standard New Keynesian model, one can mimic negative interest rates by adopting over time an increasing path for consumption taxes together with a decreasing path for labor and capital income taxes. Relative to their paper, we explore the merits of adjusting a single policy instrument rather than three at once. We find that in a large class of macroeconomic models, including state-of-the-art quantitative ones with rich heterogeneity, this instrument alone is sufficient to stabilize an economy facing a sizable demand shortfall.

This article also adds to the debate on fiscal multipliers. On the one hand, the literature estimates large tax multipliers (Blanchard and Perotti 2002; Romer and Romer 2010;

[3]For example, the 2008 temporary VAT cut in the United Kingdom came into effect seven days after being announced by the government. In a business survey, Myant and Hawkins (2010) report that 90% of firms respond having been given enough time to comply with the tax change.

Cloyne 2013; Mertens and Ravn 2013; Ramey 2019), and in particular, large consumption tax multipliers (Riera-Crichton, Vegh, and Vuletin 2016; Gaarder 2019; Nguyen, Onnis, and Rossi 2021; Bachmann et al. 2021). On the other hand, unconditional transfer multipliers appear to be small, as reflected by MPCs averaging 0.25–0.45 (Johnson, Parker, and Souleles 2006; Parker et al. 2013; Baker et al. 2020; Chetty et al. 2020; Coibion, Gorodnichenko, and Weber 2020; Armantier et al. 2021; Karger and Rajan 2021; Bayer et al. 2022). Our analysis makes clear that HANK theory is consistent with these two sets of empirical findings. The key to matching aggregate multipliers is to reproduce the substantial heterogeneity in MPC observed in microeconomic data, as pointed by Kaplan, Moll, and Violante (2018) and Kaplan and Violante (2018) in the context of monetary policy shocks.

Finally, on a methodological level, our proof of policy cost-effectiveness relies on expressing equilibrium in sequence space (Boppart, Krusell, and Mitman 2018; Auclert, Bardóczy, Rognlie, and Straub 2021). Following Auclert, Rognlie, and Straub (2023) and Wolf (2022), we derive analytical results by constructing matrices of intertemporal MPCs for transfers, and we extend the approach to the analysis of consumption taxes.

Outline.—The rest of the paper proceeds as follows. Section 2 describes the model environment. Section 3 establishes the main theoretical results. Section 4 performs policy simulations in a calibrated quantitative HANK model. Section 5 concludes.

2 Environment

Section 2.1 lays out our general environment, a New Keynesian model with heterogeneous households. Section 2.2 describes particular models that serve as special, analytical cases of our general framework. The whole setup is purposefully similar to Wolf (2022).

2.1 A One-Asset Heterogeneous Agent New Keynesian Model

Time is discrete and runs from $t = 0$ to infinity. Four types of agents populate the economy: households, firms, labor unions, and the government. Households are heterogeneous due to uninsurable idiosyncratic risk. The rest of the setup closely follows the textbook New Keynesian model (Galí 2015).

The economy starts in the deterministic steady state. There is no aggregate uncertainty. In period $t = 0$, the government announces paths for its policy instruments. We study perfect foresight transition paths back to the steady state. Let x_t denote the realization of variable x at time t along the transition path; $\boldsymbol{x} = \{x_t\}_{t=0}^{\infty}$ the entire time path of x; $\bar{x}$ the steady-state value of x; and $\widehat{x}_t$ the deviation of x from its steady state.

Households.—A continuum $i \in [0,1]$ of households enjoy utility over consumption c_{it} and labor ℓ_{it}

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_{it}^{1-\frac{1}{\gamma}} - 1}{1-\frac{1}{\gamma}} - \frac{\ell_{it}^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \right\} \right], \tag{1}$$

where γ denotes the elasticity of intertemporal substitution and φ is the Frisch elasticity of labor supply. Purchases of goods and services are subject to a flat-rate consumption tax τ_{ct}. Households receive idiosyncratic productivity shocks e_{it}, with $\int_0^1 e_{it} di = 1$. They earn labor income $(1-\tau_{\ell t}) w_t e_{it} \ell_{it}$, where w_t is the wage rate and $\tau_{\ell t}$ is a flat-rate labor income tax. Households save into risk-free government bonds b_{it} with real return $1 + r_t = (1 + i_{t-1})/(1 + \pi_t)$, where i_t represents the nominal interest rate and π_t denotes inflation. Households receive uniform lump-sum transfers τ_t from the government and dividends d_{it} from firms. Their period-t budget constraint reads

$$(1+\tau_{ct}) c_{it} + b_{it} = (1-\tau_{\ell t}) w_t e_{it} \ell_{it} + \frac{1+i_{t-1}}{1+\pi_t} b_{it-1} + \tau_t + d_{it}. \tag{2}$$

Incomplete markets impose a borrowing constraint, $b_{it} \geq \bar{b}$. Frictions in the labor market imply households delegate their labor supply decisions to labor unions, described below, and thus take hours worked ℓ_{it} as given. For any sequence of income and asset returns, a generic household i selects a path of consumption $\boldsymbol{c}_i$ and a path of savings $\boldsymbol{b}_i$ to maximize (1) subject to (2) and the borrowing constraint.

Aggregate Consumption Function.—Following Farhi and Werning (2019), Auclert, Rognlie, and Straub (2023), and Wolf (2022), we summarize optimal household behavior by means of an aggregate consumption function $\mathcal{C}(\bullet)$

$$\boldsymbol{c} \;=\; \mathcal{C}(\underbrace{\boldsymbol{\pi}, \quad \boldsymbol{w}, \quad \boldsymbol{\ell}, \quad \boldsymbol{d}}_{\text{equilibrium aggregates}} \; ; \; \underbrace{\boldsymbol{\tau}, \quad \boldsymbol{\tau_c}, \quad \boldsymbol{\tau_\ell}, \quad \boldsymbol{i}}_{\text{policy variables}}). \tag{3}$$

In steady state, the aggregate consumption function satisfies

$$\bar{\boldsymbol{c}} \;=\; \mathcal{C}(\bar{\boldsymbol{\pi}}, \bar{\boldsymbol{w}}, \bar{\boldsymbol{\ell}}, \bar{\boldsymbol{d}}; \bar{\boldsymbol{\tau}}, \bar{\boldsymbol{\tau}}_{\boldsymbol{c}}, \bar{\boldsymbol{\tau}}_{\boldsymbol{\ell}}, \bar{\boldsymbol{i}}).$$

Linearizing (3) around the steady state, we obtain

$$\widehat{\boldsymbol{c}} \;=\; \mathcal{C}_\pi \widehat{\boldsymbol{\pi}} \;+\; \mathcal{C}_w \widehat{\boldsymbol{w}} \;+\; \mathcal{C}_\ell \widehat{\boldsymbol{\ell}} \;+\; \mathcal{C}_d \widehat{\boldsymbol{d}} \;+\; \mathcal{C}_\tau \widehat{\boldsymbol{\tau}} \;+\; \mathcal{C}_{\tau_c} \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}} \;+\; \mathcal{C}_{\tau_\ell} \widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}} \;+\; \mathcal{C}_i \widehat{\boldsymbol{i}}, \tag{4}$$

where for each $x \in \{\pi, w, \ell, d, \tau, \tau_c, \tau_\ell, i\}$, we define $\mathcal{C}_x \equiv \partial \mathcal{C}(\bullet)/\partial \boldsymbol{x}$. The (t,s)th entry of these infinite-dimensional linear maps corresponds to the derivative of aggregate consumption demand at time t with respect to a change in input x at time s. Two of these maps in particular play a central role in this paper

$$\mathcal{C}_\tau \;\equiv\; \frac{\partial \mathcal{C}(\bullet)}{\partial \boldsymbol{\tau}} \quad \text{and} \quad \mathcal{C}_{\tau_c} \;\equiv\; -\frac{\partial \mathcal{C}(\bullet)}{\partial \boldsymbol{\tau_c}}. \tag{5}$$

In words, $\mathcal{C}_\tau$ and $\mathcal{C}_{\tau_c}$ determine how aggregate consumption demand responds to changes in lump-sum transfer and consumption tax, respectively, holding other variables constant. We use the negative sign for the consumption tax in (5) because to stimulate aggregate demand, one has to increase transfers but decrease taxes.

Firms.—The production side of the economy is entirely standard. A continuum of firms j produce final output using a labor-only technology

$$y_{jt} = y(\ell_{jt}). \tag{6}$$

Firms incur a Rotemberg adjustment cost $\psi_t(p_{jt}, p_{jt-1})$ when changing their price p_{jt}

$$\psi_t(p_{jt}, p_{jt-1}) = \frac{\mu_p}{\mu_p - 1}\frac{1}{2\kappa_p}\left[\log\left(\frac{p_{jt}}{p_{jt-1}}\right)\right]^2 y_t,$$

where y_t denotes aggregate output, μ_p is a price markup, and κ_p governs the adjustment cost curvature. Optimal symmetric price setting by firms yields a usual, economy-wide price Phillips curve

$$\log(1+\pi_t) = \kappa_p\left(w_t - \frac{1}{\mu_p}\right) + \frac{1}{1+r_{t+1}}\frac{y_{t+1}}{y_t}\log(1+\pi_{t+1}). \tag{7}$$

Labor Unions.—A continuum of unions k select nominal wage $p_t w_{kt}$ to maximize household utility subject to a labor demand function and a Rotemberg adjustment utility cost

$$\psi_t^w(p_t w_{kt}, p_{t-1}w_{kt-1}) = \frac{\mu_w}{\mu_w - 1}\frac{1}{2\kappa_w}\left[\log\left(\frac{p_t w_{kt}}{p_{t-1}w_{kt-1}}\right)\right]^2,$$

where μ_w is a wage markup and κ_w governs the wage adjustment cost curvature. Optimal symmetric wage setting by unions yields an analog, economy-wide wage Phillips curve

$$\log(1+\pi_t^w) = \kappa_w\left(\ell_t^{1+\frac{1}{\varphi}} - \frac{(1-\tau_{\ell t})w_t\ell_t}{(1+\tau_{ct})\mu_w}\int_0^1 e_{it}c_{it}^{-\frac{1}{\gamma}}\,di\right) + \beta\log(1+\pi_{t+1}^w), \tag{8}$$

where $1+\pi_t^w = (1+\pi_t)w_t/w_{t-1}$ represents wage inflation. Note consumption and labor taxes appear in the wage Phillips curve. Holding everything else constant, a decrease in taxes increases the labor supply. Households find it desirable to work longer hours because they enjoy higher after-tax consumption and after-tax income.

Government.—Revenues from taxes serve to finance transfer payments to the population and interest payment on debt. The government budget constraint reads

$$\tau_t + \frac{1+i_{t-1}}{1+\pi_t}b_{t-1} = \tau_{ct}c_t + \tau_{\ell t}w_t\ell_t + b_t. \tag{9}$$

The policymaker sets uniform transfers τ_t, consumption taxes τ_{ct}, labor taxes $\tau_{\ell t}$, and nominal interest rates i_t subject to the government budget constraint (9) and the requirement that debt does not explode, $\lim_{t\to\infty} b_t = \bar{b}$.

Policy Under Fixed Interest Rates.—We focus on situations when the policymaker is unable to manipulate interest rates to stimulate output. This can arise after large adverse shocks hit the economy and bring rates down to the zero lower bound. Alternatively, this can happen when a member country of a currency union no longer exerts control over its monetary policy. In the same theoretical environment, Wolf (2022) demonstrates that uniform transfers alone can reproduce any allocation that would be obtained via changes in interest rates. In other words, stimulus checks can serve as a substitute for conventional monetary policy, and thus help bypass the ZLB and monetary-union constraints. We propose a *consumption tax-only* policy as an alternative, cost-effective fiscal instrument to the *transfer-only* policy.

Definition 1: *A* consumption tax-only *policy is a policy that sets $i_t = \bar{i}$, $\tau_{\ell t} = \bar{\tau}_\ell$, and $\tau_t = \bar{\tau}$ for all t.*

Definition 2: *A* transfer-only *policy is a policy that sets $i_t = \bar{i}$, $\tau_{\ell t} = \bar{\tau}_\ell$, and $\tau_{ct} = \bar{\tau}_c$ for all t.*

Both policies involve keeping the nominal interest rate and the labor income tax fixed throughout. Each policy, then, consists in manipulating a single instrument — the consumption tax rate τ_{ct} in the first case, lump-sum transfers τ_t in the second — and adjusting new bond issuance such that the government budget constraint (9) holds and debt does not explode, $\lim_{t\to\infty} \widehat{b}_t = 0$.

Equilibrium.—A perfect foresight transition equilibrium is a set of government policies $\{\tau_t, \tau_{ct}, \tau_{\ell t}, i_t, b_t\}_{t=0}^{\infty}$ and a set of macroeconomic aggregates $\{c_t, \ell_t, y_t, \pi_t, w_t, d_t\}_{t=0}^{\infty}$ such that:

1. Consumption $c_t = \int_0^1 c_{it} di$ is consistent with the aggregate consumption function (3);

2. The paths for hours worked, inflation, and wage $\{\ell_t, \pi_t, w_t\}_{t=0}^{\infty}$ are consistent with the price Phillips curve (7) and dividends satisfy $d_t = y_t - w_t \ell_t - \psi_t$;

3. Wage inflation π_t^w and $\{c_t, \ell_t, w_t\}_{t=0}^{\infty}$ are consistent with the wage Phillips curve (8);

4. The goods market clears, $y_t = c_t + \psi_t$; the government budget constraint (9) holds for all t and $\lim_{t\to\infty} b_t = \bar{b}$; and the bond market clears by Walras' law.

2.2 Analytical Models of Household Consumption Behavior

The general HANK model does not admit a closed-form solution for the consumption function (3) and derivative matrices $\mathcal{C}_\tau$ and $\mathcal{C}_{\tau_c}$. In the spirit of Wolf (2022), this section gives examples of special cases of the framework in Section 2.1 that we can solve analytically. Our goal is to derive $\mathcal{C}_\tau$ and $\mathcal{C}_{\tau_c}$ in each of these models and provide intuition for how households react to changes in transfers and consumption taxes.

Permanent-Income Consumers.—The canonical representative-agent model obtains if one sets $e_{it} = 1$ for all households and all periods. Absent idiosyncratic risk, household optimization yields a standard Euler equation with consumption taxes

$$c_t^{-\frac{1}{\gamma}} = \beta \frac{1 + \tau_{ct}}{1 + \tau_{ct+1}} (1 + r_{t+1}) c_{t+1}^{-\frac{1}{\gamma}}. \tag{10}$$

Linearizing the bugdet constraint and Euler equation around the steady state with real interest $1+\bar{r}=1/\beta$, we show in Appendix C that the linear map of Ricardian consumers (superscript R) for transfers satisfies

$$\mathcal{C}_{\tau}^{R}=\begin{pmatrix}1-\beta & \beta(1-\beta) & \beta^2(1-\beta) & \dots\\ 1-\beta & \beta(1-\beta) & \beta^2(1-\beta) & \dots\\ 1-\beta & \beta(1-\beta) & \beta^2(1-\beta) & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}. \tag{11}$$

Following an increase in transfers, permanent-income consumers save the receipt and consume only its annuity value, $\frac{\bar{r}}{1+\bar{r}}$, each period, forever (first column of $\mathcal{C}_{\tau}^{R}$).[4] Anticipated future payments produce similar, but discounted, effects (other columns of $\mathcal{C}_{\tau}^{R}$). Note that if the transfer payment has zero net present value, meaning it is eventually financed by a future increase in taxes, then consumers who are Ricardian have an MPC of exactly zero. Now, contrast this with the linear map for consumption taxes

$$\mathcal{C}_{\tau_c}^{R}=\begin{pmatrix}(1-\beta)(1-\gamma)+\gamma & \beta(1-\beta)(1-\gamma) & \beta^2(1-\beta)(1-\gamma) & \dots\\ (1-\beta)(1-\gamma) & \beta(1-\beta)(1-\gamma)+\gamma & \beta^2(1-\beta)(1-\gamma) & \dots\\ (1-\beta)(1-\gamma) & \beta(1-\beta)(1-\gamma) & \beta^2(1-\beta)(1-\gamma)+\gamma & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}. \tag{12}$$

As the first element of $\mathcal{C}_{\tau_c}^{R}$ makes clear, a one-period reduction in the consumption tax rate raises aggregate consumption demand by $(1-\beta)(1-\gamma)+\gamma$ units, or

$$\underbrace{1-\beta}_{\text{income effect}} \quad + \quad \underbrace{\beta\gamma.}_{\text{substitution effect}} \tag{13}$$

The first term in (13) is exactly the MPC out of transfers, ie the first element of $\mathcal{C}_{\tau}^{R}$. A tax cut increases disposable income, making households richer. The second term in (13) corresponds to the substitution effect arising from a change in intertemporal prices. Households see that a price drop in the current period means prices will go back up next period, and therefore optimally exchange future consumption for current consumption. The intertemporal elasticity γ governs the strength of this substitution effect. Empirically plausible estimates for γ range between 0.3 and 1.3 (Havranek et al. 2015). This implies that in RANK, the MPC out of temporary consumption tax cuts dominates the MPC out of transfers by one, if not two, orders of magnitude.[5] We now show that the intuition carries over to models of non-Ricardian behavior.

[4] To get an idea of the magnitude, an annual real interest rate in the ballpark of four percent translates into a quarterly MPC out of transfers of roughly one percent.

[5] Appendix D generalizes the result to all contemporaneous MPCs, ie the diagonal elements of $\mathcal{C}_{\tau}$ and $\mathcal{C}_{\tau_c}$, in all four analytical models.

Spenders and Savers.—The classic two-agent model incorporates a margin $\lambda \in (0,1)$ of spenders alongside permanent-income savers (Galí, López-Salido, and Vallés 2007; Bilbiie 2008). Spenders live hand to mouth (superscript H), ie they hold no wealth and consume all disposable income

$$(1+\tau_{ct})c_t^H = (1-\tau_{\ell t})w_t\ell_t + \tau_t. \tag{14}$$

Combining the rule-of-thumb behavior of spenders with the consumption function of savers, we obtain an aggregate consumption function (3). The linear maps for TANK (superscript T) satisfy

$$\mathcal{C}_\tau^T = (1-\lambda)\times\mathcal{C}_\tau^R + \lambda\times\begin{pmatrix}1 & 0 & 0 & \dots\\ 0 & 1 & 0 & \dots\\ 0 & 0 & 1 & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}; \quad \mathcal{C}_{\tau_c}^T = (1-\lambda)\times\mathcal{C}_{\tau_c}^R + \lambda\times\begin{pmatrix}1 & 0 & 0 & \dots\\ 0 & 1 & 0 & \dots\\ 0 & 0 & 1 & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}. \tag{15}$$

Intuitively, spenders do not save at all and thus have a unit MPC out of any windfall, expected or not. That is, hand-to-mouth households respond to transfers and consumption tax cuts in the exact same way, by increasing current consumption demand one-for-one. Thus, in aggregate, the presence of spenders alongside savers attenuates the difference between the two policies but does not overturn the result that, on impact, the economy responds more to consumption tax cuts than transfers.

Overlapping Generations.—Another popular heterogeneous-agent model of non-Ricardian behavior is one with overlapping generations and perpetual youth (Blanchard 1985). Households survive from one period to another with probability $\theta \in [0,1]$ and invest their wealth in fair annuities. In Appendix C, we show that

$$\mathcal{C}_\tau^{OLG} = (1-\beta\theta)\times\begin{pmatrix}\Psi_0 & \beta\theta & (\beta\theta)^2 & \dots\\ \theta & \Psi_1 & \beta\theta\Psi_1 & \dots\\ \theta^2 & \theta\Psi_1 & \Psi_2 & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}, \tag{16}$$

where $\Psi_t \equiv 1-\theta+\beta\theta^2\Psi_{t-1}$ for all $t \geq 1$ and $\Psi_0 = 1$. Households are no longer Ricardian because they face a risk of dying. As a result, their MPC, $1-\beta\theta$, is larger than that of permanent-income consumers, $1-\beta$. Households front-load the spending of checks, with decay rate θ (lower triangle of $\mathcal{C}_\tau^{OLG}$). They also respond less to anticipated future checks, discounting the future at rate $\beta\theta$ (upper triangle of $\mathcal{C}_\tau^{OLG}$). The linear map for consumption taxes takes the form

$$\mathcal{C}_{\tau_c}^{OLG} = (1-\beta\theta)(1-\gamma)\times\begin{pmatrix}\Psi_0 & \beta\theta & (\beta\theta)^2 & \dots\\ \theta & \Psi_1 & \beta\theta\Psi_1 & \dots\\ \theta^2 & \theta\Psi_1 & \Psi_2 & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix} + \gamma\times\begin{pmatrix}1 & 0 & 0 & \dots\\ 0 & 1 & 0 & \dots\\ 0 & 0 & 1 & \dots\\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}. \tag{17}$$

An unanticipated one-period reduction in the consumption tax rate raises aggregate consumption demand by $(1-\beta\theta)(1-\gamma)+\gamma$ units, or

$$\underbrace{1-\beta\theta}_{\text{income effect}} \quad + \quad \underbrace{\beta\theta\gamma}_{\text{substitution effect}}. \tag{18}$$

Again, we see how both income and substitution effects are at play. The MPC out of tax cuts is larger than the MPC out of checks, the difference being anywhere between one and two orders of magnitude, depending on how large γ is. Thus, finite lives do not change the main insight: consumers respond immediately more to consumption tax cuts than they do to transfers.

Tractable HANK.—A close analytical approximation to HANK is the two-agent model with risk of switching from one state to the other (Bilbiie 2021). Consider the TANK model described above but assume that, each period, savers remain savers with probability $\theta \in (0,1)$ and turn spenders with probability $1-\theta$. Once spenders, households consume all their accumulated wealth in the first period and then live hand to mouth. In Appendix C, we show that the MPC of an individual saver out of a one-time consumption tax cut consists of two terms

$$\underbrace{\frac{2(1-\theta)}{1+\beta+\chi-2\theta}}_{\text{income effect}} \quad + \quad \underbrace{\frac{2\beta}{1+\beta+\chi}\gamma}_{\text{substitution effect}}, \tag{19}$$

where $\chi \equiv \sqrt{(1-\beta)^2+4\beta(1-\theta)} > 0$. Savers are no longer Ricardian because they face a risk of becoming financially constrained. As a result, their response to transfers, the first term in (19), is larger than that of permanent-income consumers. The parameter θ governs the strength of this income effect: the higher θ (the lower the risk), the weaker the income effect.[6] The second term in (19) corresponds to the substitution effect coming from temporarily lower after-tax prices. Here too, θ governs the strength of this effect, but in the opposite direction: the higher θ, the stronger the substitution effect.[7] In short, as the risk of being constrained in the future increases, the income effect strengthens while the substitution effect weakens. Still, even when the risk is maximal ($\theta = 0$), households increase spending more after a consumption tax cut than they do after an increase in transfers. This gives the intuition for why, in more elaborate incomplete-market models too, tax cuts deliver higher immediate stimulus than stimulus checks.

To summarize this section, Figure 1 pictures the impact response of consumption demand to a consumption tax cut for different types of consumers. We rank agents according to their planning horizon θ. At one extreme stands the hand-to-mouth consumer, whose

[6]If $\theta = 1$, the saver always remains a saver, so its MPC out of transfers equals $1-\beta$, the same as for a permanent-income consumer. If $\theta = 0$, the saver turns spender next period with certainty, its MPC is $1/(1+\beta) \approx 0.5$, ie the agent splits the check roughly equally over this period and the next.

[7]If $\theta = 1$, the substitution effect equals $\beta\gamma$, the same as for a permanent-income consumer. If $\theta = 0$, the substitution effect equals $\beta\gamma/(1+\beta) < \beta\gamma$.

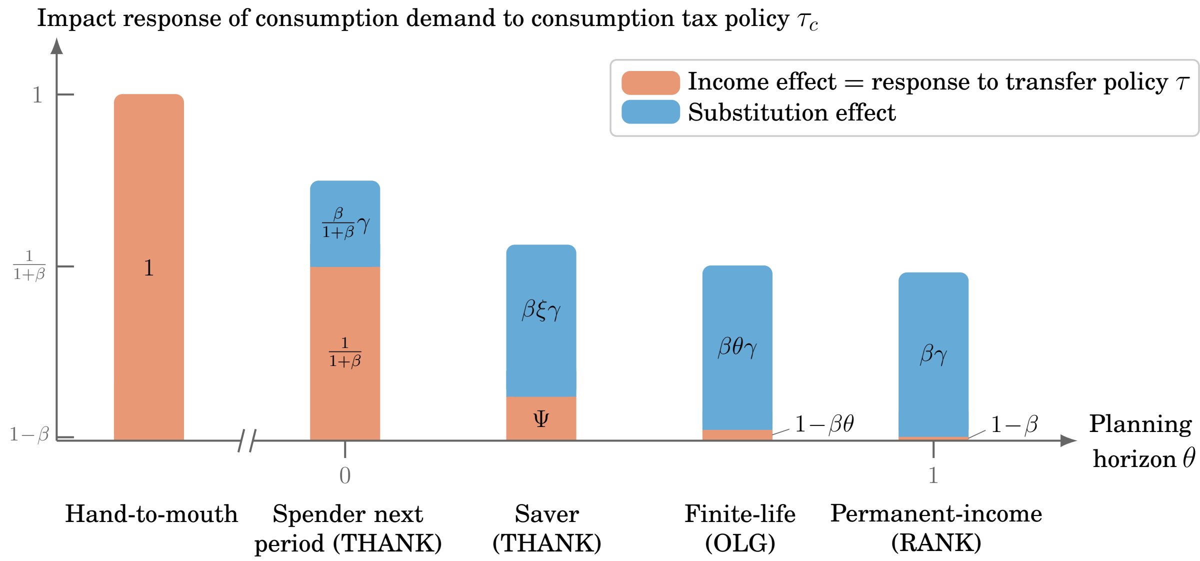

Figure 1: Effect of Consumption Tax Cut on Consumption Demand

Notes: In tractable HANK (THANK), θ is the probability of remaining saver. In OLG, θ is the survival rate. Spender next period: $\theta = 0$. Permanent-income: $\theta = 1$. The position of savers vis-a-vis finite-life agents assumes that the probability of remaining saver is lower than the risk of dying. Here $\xi \equiv \frac{2}{1+\beta+\sqrt{(1+\beta)^2-4\beta\theta}}$ and $\Psi \equiv \frac{2(1-\theta)}{1+\beta+\sqrt{(1+\beta)^2-4\beta\theta-2\theta}}$.

response is totally driven by the income effect. At the other extreme stands the permanent-income consumer, whose response is almost entirely due to the substitution effect. Financially constrained agents, finitely-lived individuals, or for that matter behavioral consumers, lie in between the two extremes. Relative to Ricardian consumers, their income effect is stronger and their substitution effect is weaker. The bottom line is that for all these intermediate cases, consumption tax cuts induce a greater boost in consumption demand than stimulus payments do.

The analysis so far focuses on the immediate, partial-equilibrium impact of our two policies. In the next section, we compare the entire time paths of responses induced by the policies, in general equilibrium. We show that in our HANK framework, the consumption tax policy causes a larger period-by-period expansion in aggregate output than the transfer policy, at the same cost to public finances.

3 Consumption Tax Cuts vs Stimulus Checks

This section presents our main theoretical results. We begin with a policy equivalence statement between consumption taxes and a combination of transfers and labor taxes. This result is interesting in its own right, but more importantly, it paves the way for explaining why consumption tax cuts dominate transfers alone — our central finding.

3.1 Policy Equivalence

Following Wolf (2022), we define the notion of *strong Ricardian non-equivalence*, a property of the linear map $\mathcal{C}_\tau$. Just like this property is a sufficient condition for Wolf's equivalence result between interest rate cuts and stimulus checks, it is also a sufficient condition for our equivalence result between consumption tax cuts and a mix of checks and labor tax cuts.

Definition 3: *A consumption function $\mathcal{C}(\bullet)$ exhibits strong Ricardian non-equivalence if the linear map $\mathcal{C}_\tau$ is invertible. We denote its inverse by $\mathcal{C}_\tau^{-1}$.*

The permanent-income model does not satisfy the strong Ricardian non-equivalence property because $\mathcal{C}_\tau$ has rank 1, so is not invertible. In the other analytical models of Section 2.2, $\mathcal{C}_\tau$ is full rank, ie is invertible. Intuitively, Ricardian households do not alter their consumption in the face of time-varying lump-sum transfers so long as the policy's present value is zero (Barro 1974). For non-Ricardian consumers, however, the timing of lump-sum transfers matters for spending. In our HANK model, it is easy to verify numerically that strong Ricardian non-equivalence holds provided a non-zero mass of constrained households exist. We are now ready to state our policy equivalence result.

Proposition 1: *Consider the model of Section 2 and suppose that strong Ricardian non-equivalence holds. Then the consumption tax-only policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ is macro-equivalent to a combination of transfer policy $\widehat{\boldsymbol{\tau}}$ and labor income tax policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}$. That is, any aggregate allocation that is implementable with $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ is also implementable jointly with $\widehat{\boldsymbol{\tau}}$ and $\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}$.*

Proof. See Appendix A.

Intuition.—Key to understanding Proposition 1 is to identify how each policy directly perturbs the model's equilibrium conditions. All three instruments enter the household budget constraint (2) and so stimulate household *consumption demand* via an income effect. Consumption taxes show up in the consumption-savings Euler equation, further stimulating demand via a substitution effect. In addition, consumption and labor taxes — but not transfers — appear in the wage Phillips curve (8) and thus directly impact household *labor supply*. In linearized form, this equation reads

$$\widehat{\ell}_t = \underbrace{-\frac{\varphi}{\gamma}\widehat{c}_t}_{\text{income effect}} - \underbrace{\frac{\varphi}{1+\bar{\tau}_c}\widehat{\tau}_{ct}}_{\text{substitution effect}} - \underbrace{\frac{\varphi}{1-\bar{\tau}_\ell}\widehat{\tau}_{\ell t}}_{\text{substitution effect}}. \tag{20}$$

We encounter yet again our income and substitution effects — this time impacting labor supply. Any policy that raises consumption reduces labor supply through a standard income effect, as the first term on the right side of (20) makes clear. The second and third terms on the right side of (20) indicate how consumption tax cuts and labor income tax cuts stimulate labor supply via a standard substitution effect. By raising after-tax consumption and income, respectively, they make working more attractive.

Based on these insights, the proof of Proposition 1 shows how a policymaker can mimic the effects of any consumption tax policy by choosing a judicious combination of transfer and labor tax policies. Take a path of consumption tax-only policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ with zero net present value. For example, think of $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ involving temporary consumption tax cuts which are financed down the road with future consumption tax hikes. Since the policy has zero net present value, it is consistent with the government budget constraint (9) and the transversality condition $\lim_{t\to\infty} b_t = \bar{b}$. In partial equilibrium — ie before any general equilibrium feedback in prices and quantities — the consumption tax policy induces paths of net excess consumption demand $\widehat{\boldsymbol{c}}^{PE}_{\tau_c}$ and net excess labor supply $\widehat{\boldsymbol{\ell}}^{PE}_{\tau_c}$. The policymaker can select a particular path of labor income taxes $\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}$ such that the second and third terms on the right side of (20) are equalized

$$\frac{\varphi}{1+\bar{\tau}_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}} \;=\; \frac{\varphi}{1-\bar{\tau}_\ell} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}. \tag{21}$$

Intuitively, the policymaker employs the labor tax to replicate the substitution effect of consumption tax changes on labor supply. Having achieved this, the policymaker can complement the labor tax path with a particular path of transfers $\widehat{\boldsymbol{\tau}}$ in a way that equalizes the paths of net excess consumption demand, $\widehat{\boldsymbol{c}}^{PE}_{\tau} + \widehat{\boldsymbol{c}}^{PE}_{\tau_\ell} = \widehat{\boldsymbol{c}}^{PE}_{\tau_c}$. Identical demand paths imply identical income effects on labor supply. Since substitution effects are also identical, it follows that the paths of net excess labor supply coincide, $\widehat{\boldsymbol{\ell}}^{PE}_{\tau} + \widehat{\boldsymbol{\ell}}^{PE}_{\tau_\ell} = \widehat{\boldsymbol{\ell}}^{PE}_{\tau_c}$.

The remainder of the proof proceeds as follows. Given that the consumption tax policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ and the combination of transfer $\widehat{\boldsymbol{\tau}}$ and labor tax $\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}$ policies perturb the model's aggregate consumption function $\mathcal{C}(\bullet)$ and labor supply conditions by exactly the same amounts period after period, we use the method developed by Wolf (2023) to show that they also induce identical allocations in general equilibrium.

3.2 Policy Dominance

The equivalence result of Section 3.1 is a stepping stone to the understanding of our central finding, which compares consumption tax cuts with transfers alone. We begin by making a further definition.

Definition 4: *Two policies are* budget-equivalent *if they generate the same path of primary deficit, that is the same path of government revenue from taxes less government expenses.*

Applying the definition of budget equivalence to any pair of fiscal policies enables us to conduct a cost-effectiveness analysis. We are now in position to state our main policy dominance result.

Proposition 2: *Let $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ be an expansionary consumption tax-only policy, and let $\widehat{\boldsymbol{\tau}}$ be the budget-equivalent transfer-only policy. Then aggregate output expands more under the consumption tax-only policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ than under the transfer-only policy $\widehat{\boldsymbol{\tau}}$.*

Proof. See Appendix B.

Intuition.—The intuition for why output expands more in the short run is straightforward. As we explain with the various analytical examples of Section 2.2, households collectively respond a lot more, on impact, to consumption tax cuts than they do to transfers. Intuitively, they must increase spending *now*, not later, to take advantage of the tax break. As long as consumers have positive asset holdings, they draw down their savings to consume more during the "sale" period. By contrast, they choose to spend their stimulus check over multiple periods.

The reason the consumption tax policy also generates a larger *overall* expansion in output is the following. Consumption tax cuts encourage labor supply via a substitution effect. Higher labor supply results in higher income, which in turn, leads to higher consumption. Transfers do not activate this labor supply channel and thus fail to stimulate aggregate demand as much as consumption tax cuts do. Concretely, take a path of consumption tax cuts $\widehat{\boldsymbol{\tau}}_c$. The policymaker can finance these tax cuts by selecting a path of negative transfers $\widehat{\boldsymbol{\tau}}$ such that the government budget is balanced in all periods. In other words, the two policies are budget-equivalent. We show that the resulting path of excess consumption demand, and thus aggregate output, has positive net present value.

4 Policy Simulations in a Quantitative HANK Model

The previous section establishes that, in a wide range of macroeconomic models with non-Ricardian household behavior, temporary consumption tax cuts stimulate aggregate demand more than uniform transfer payments, at the same cost to the taxpayer. One would like to know whether this difference is large, and how much additional output growth could be gained by using one policy versus the other. In this section, we attempt to answer these questions by simulating the two policies in a quantitative HANK model.

4.1 Model Details

We consider a calibrated version of the HANK model presented in Section 2.1. Table 2 reports the calibration of all parameters. We set the elasticity of intertemporal substitution γ to 0.8 and the Frisch elasticity of labor supply φ to 0.5. We impose that households cannot borrow in the liquid asset, $\underline{b} = 0$. For income risk, we assume idiosyncratic productivity e follows a Markov process with 15 states, a standard deviation of 0.85, and a persistence coefficient of 0.97. These numbers ensure that 26 percent of households own zero assets in the stationary equilibrium, in line with estimates by Kaplan, Violante, and Weidner (2014). For share endowments, we follow McKay, Nakamura, and Steinsson (2016) by making dividends proportional to ability e, ie $d_t = \bar{d}(e_{it})$. We fix the annual return on risk-free bonds at four percent. We then set the discount factor β to target an annual ratio of liquid wealth to output of 150 percent.

On the production side, price and wage markups, μ_p and μ_w, are fixed at 1.2 and 1.1,

Table 2: Calibration of the HANK Model

Parameter		Value
Households		
Discount factor	β	0.98
Average return on bonds	$\bar{r}$	0.01
Elasticity of intertemporal substitution	γ	0.8
Frisch elasticity of labor supply	φ	0.5
Borrowing constraint	$\underline{b}$	0
Persistence of idiosyncratic skills	ρ	0.97
Cross-sectional std of log earnings	σ_e	0.85
Share of households with zero assets		0.26
Firms		
Price markup	μ_p	1.2
Wage markup	μ_w	1.1
Price Phillips curve slope	κ_p	0.1
Wage Phillips curve slope	κ_w	0.05
Government		
Debt-to-GDP ratio	$\bar{b}/\bar{y}$	1.5
Transfer-to-GDP ratio	$\bar{\tau}/\bar{y}$	0.21
Consumption tax rate	$\bar{\tau}_c$	0.06
Labor income tax rate	$\bar{\tau}_\ell$	0.2

respectively. We set the slopes of the price and wage Phillips curves to $\kappa_p = 0.1$ and $\kappa_w = 0.05$.

Regarding policy, we set the steady-state consumption and labor tax rates to 0.06 and 0.2, respectively, consistent with US data. Transfers represent around 21 percent of GDP, mimicking the amount of government spending in the US.

4.2 Aggregate Dynamics

Figure 2 plots the response of the main aggregate variables to two budget-equivalent consumption tax and transfer policies. Each costs one percent of output on impact and lasts for about 10 quarters. Practically, this amounts to reducing the statutory sales tax by one percentage point (ie from 6 to 5 percent) versus sending a $800 check to all residents in the United States. The solid blue line represents the dynamics induced by the consumption tax policy while the dashed red line shows those induced by the transfer policy.

Both policies generate an economic boom. The impact response of output to the tax cut is over twice as large as the response to checks. Intuitively, non-constrained households take advantage of the temporary tax break by bringing forward future consumption. By contrast, these households save most of the transfer payment upon receipt. The cumulative response of the economy is also about twice as large: present value output increases by 2.5 percent with the consumption tax policy, versus 1.25 percent with the transfer policy. Interestingly, inflation response is about the same for both policies. If we look at consumer prices instead of producer prices, the tax policy actually reduces inflation. Thus, the consumption tax cut

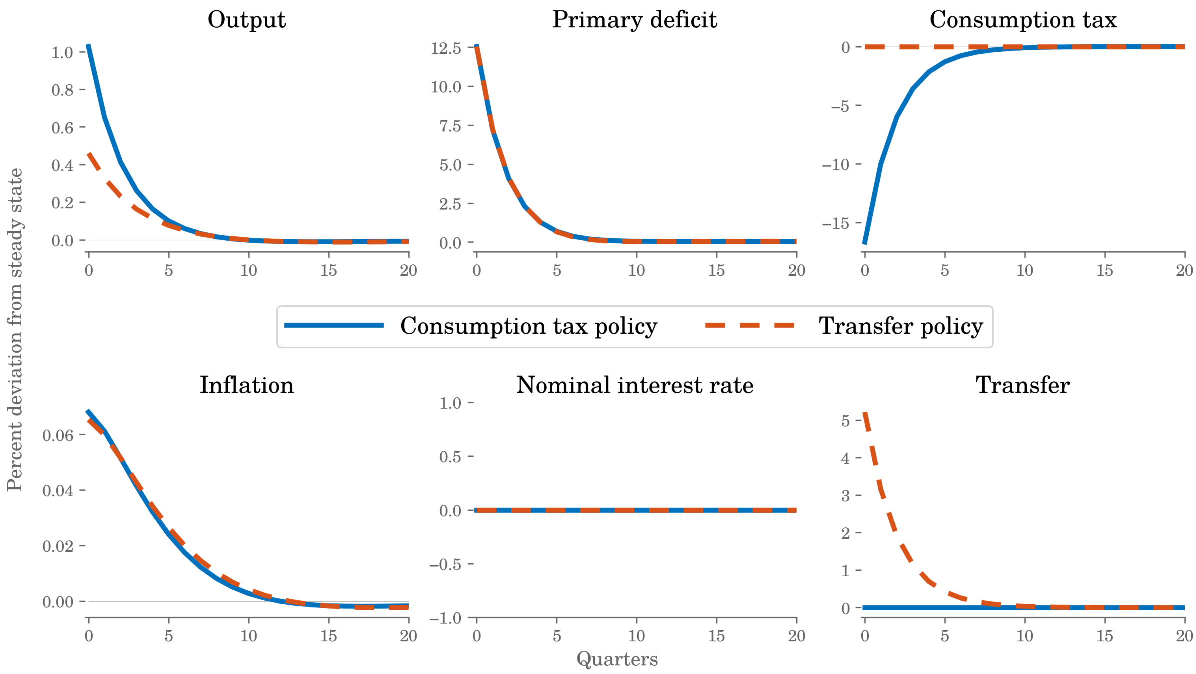

Figure 2: Response to Consumption Tax Cut vs Transfer Increase

provides much more stimulus than the transfer policy at the expense of similar inflation.

These quantitative findings are robust to changes in key parameters. Table 3 presents the difference in impact and cumulative output response between the two policies for different model specifications. The first column shows the baseline model. In column two, we reduce the elasticity of intertemporal substitution γ from 0.8 to 0.4. The impact response is now 1.8 times as large with the tax policy, but the cumulative response is close to five times as large. Column 3 uses a lower elasticity of labor supply φ of 0.1. Results are largely unchanged. We elaborate more on the role of labor supply in the next subsection. Columns 4 and 5 consider an economy with high idiosyncratic risk (σ_e doubles) and low liquid wealth ($\bar{b}/\bar{y} = 0.5$ instead of 1.5), respectively. Both parameterizations induce a large fraction of households with zero assets (around 50 percent) and hence a substantially larger average MPC. The difference between the two policies decreases somewhat, as expected, but the consumption tax policy remains 30 to 60 percent more effective at boosting output. Finally, the last two columns report results for benchmark models, namely a HANK model with flexible wages and the RANK model, equivalent to removing all idiosyncratic risk in HANK. In either case, the relative strength of the consumption tax policy increases considerably.

4.3 Inspecting the Mechanisms

To understand what drives the large difference in aggregate dynamics induced by the two policies, we perform two exercises. First, we examine the distributional implications of each policy. Second, we decompose the total response of aggregate variables into different

Table 3: Impact and Cumulative Differences Between the Two Policies

Variable	Baseline model	Low EIS $\gamma = 0.4$	Low Frisch $\varphi = 0.1$	High risk 50% HtM	Low wealth $\bar{b}/\bar{y} = 0.5$	Flex wage $\kappa_w = \infty$	RANK $\sigma_e = 0$
Impact ratio, consumption tax policy over transfer policy							
Output	2.33	1.77	2.26	1.46	1.44	2.96	5.69
Inflation	1.04	0.69	1.32	0.80	0.98	1.23	1.89
Wage	1.21	0.60	1.74	0.73	1.00	1.41	3.70
Deficit	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cumulative ratio, consumption tax policy over transfer policy							
Output	2.00	4.75	2.01	1.60	1.32	6.38	3.30
Inflation	0.99	0.87	1.01	0.92	0.99	0.99	1.00
Wage	1.05	0.67	1.34	0.78	0.97	1.23	1.89
Deficit	1.00	1.00	1.00	1.00	1.00	1.00	1.00

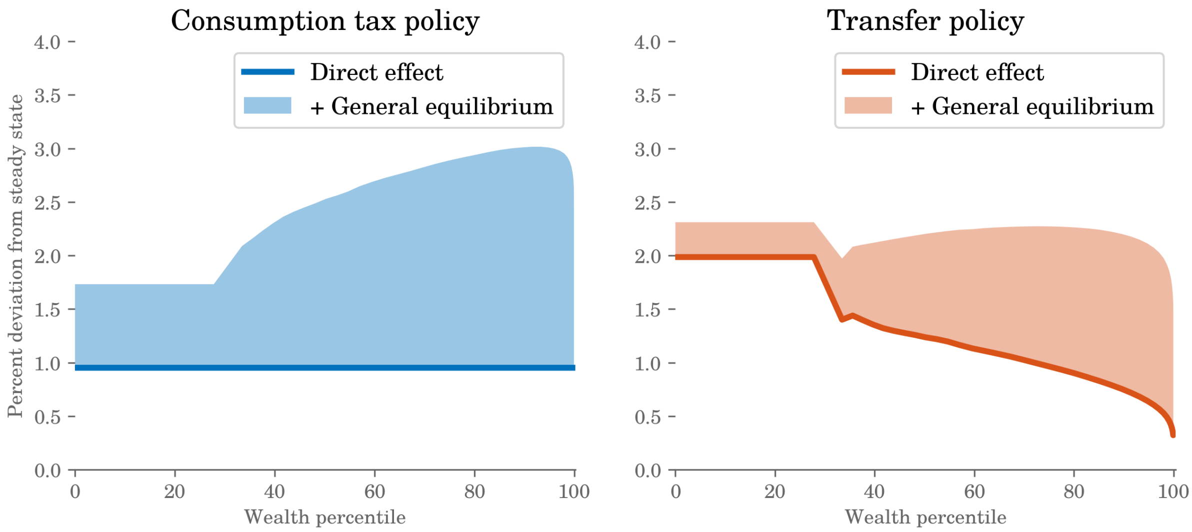

Figure 3: Impact Consumption Response to the Two Policies

partial-equilibrium effects.

Consider the first exercise. Figure 3 displays the impact response of consumption as a function of assets. The consumption tax cut causes a change in behavior across the entire wealth distribution (left panel). Taking advantage of the temporary tax break, consumers increase their spending now and, to a lesser extent, expand their labor supply. This contrasts with the response to the stimulus checks (right panel). Unconstrained households, especially those with large wealth holdings, respond little. As explained in Section 3, these individuals behave much like permanent-income consumers. They spread out the transitory income increase over multiple periods by saving most of the transfer receipt. Asset-poor households, however, spend virtually all the amount of the checks as soon as they receive them. This is because marginal utility of consumption is very high at the borrowing constraint. But since these individuals have low productivity and thus earn low wages, they contribute only a fraction to the economy's total spending. Hence, the aggregate impact of

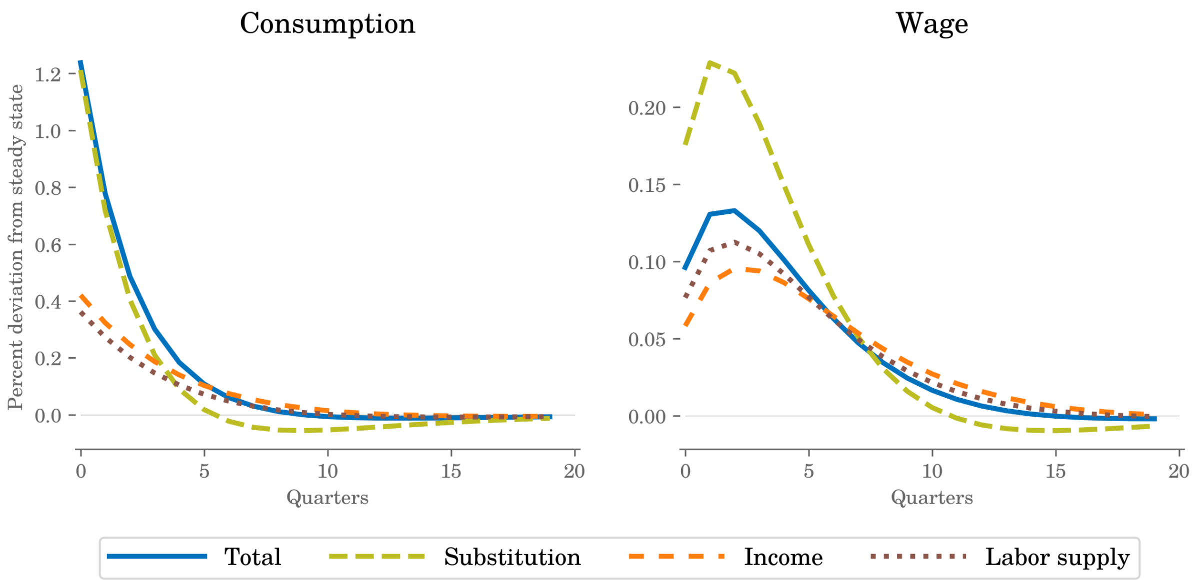

Figure 4: Decomposing the Effects

checks is much lower. To sum up, the consumption tax policy is a more cost-efficient way to stimulate short-run demand because by changing relative prices, it drives all households in the economy to purchase more goods and services now instead of later. Stimulus checks, on the other hand, mainly boost consumption of the asset-poor while increasing savings of the asset-rich.

The second exercise sheds light on the strength of the different channels at play. We summarize the three key channels. First, as one can see in the budget constraint (2), a reduction in the consumption tax today mechanically increases disposable income. This is the income channel. Note that this is the only channel through which stimulus checks boost aggregate demand. Second, by committing to higher taxes in the future, the government decreases the price of today's consumption goods relative to tomorrow's. Looking at the Euler equation (10), one can see that this is equivalent to lowering the real interest rate. This is the intertemporal substitution channel, emphasized by Correia et al. (2013) as a way to conduct optimal policy in representative-agent economies. Third, lower consumption taxes may incentivize households to work more, through a combination of income and substitution effects, as evidenced by the wage Phillips curve (20). This is the labor supply channel. Figure 4 depicts the contribution of each of these channels to the total response of consumption and wage following a consumption tax cut.

As the figure makes clear, all three channels work in the same direction by stimulating consumption (left panel). But the substitution channel matters more quantitatively. Higher disposable income mechanically increases consumption, while more hours worked increase labor earnings, thus stimulating consumption. While certainly not negligible, these effects combined do not match those of the substitution channel.[8]

Turning to the wage (right panel), we see that the total increase in the wage is attenuated by the labor supply channel. As households are willing to work more, firms are able to pay them relatively lower wages. This feeds into lower inflation and explains why the consumption tax policy is relatively less inflationary for a given increase in output. In summary, this analysis shows that the power of the consumption tax policy stems mainly from its intertemporal substitution channel: anticipating higher prices in the future due to scheduled tax increases, households swiftly consume more today, providing a strong boost to the economy.

4.4 An Extension with Value-Added Taxes

Most countries in the world (over 165), including all developed countries except the United States, employ a form of VAT as a way to tax consumption. It is therefore interesting to study the implications of an economy that has firms set their after-VAT prices. Following Barbiero et al. (2019) and Silva (2023), we extend the model to allow for VAT and incomplete pass-through. Let τ_{vt} be the VAT rate. Assume that only a fraction $\iota \in [0, 1]$ of the VAT is passed through instantaneously from producer price p_{jt} to consumer price p^c_{jt}

$$p^c_{jt} = \frac{p_{jt}}{(1 - \tau_{vt})^{\iota}}.$$

This implies firms absorb a fraction $1 - \iota$ of the VAT into their profit margin. Profit of firm j reads

$$d_{jt} = (1 - \tau_{vt})^{\iota} \frac{p_{jt}}{p_t} y_{jt} - w_t \ell_{jt} - \psi_t(p_{jt}, p_{jt-1}).$$

Profit maximization leads to the following price Phillips curve

$$\log(1 + \pi_t) = \kappa_p \left[w_t - \frac{1}{\mu_p}(1 - \tau_{vt})^{\iota} \right] + \frac{1}{1 + r_{t+1}} \frac{y_{t+1}}{y_t} \log(1 + \pi_{t+1}). \tag{22}$$

VAT Cut vs Transfers.—For this version of the model, we switch off the sales tax by setting $\bar{\tau}_c = 0$, and replace it with the VAT, $\bar{\tau}_v = 0.06$. We set the pass-through parameter ι to 0.5. We simulate two budget-equivalent VAT and transfer policies, just like in the previous case with the sales tax. Figure 5 plots the outcome.

On impact, output increases about twice as much with the VAT policy. The cumulative effect is also larger by a factor of two. Thus, our central result holds. Intuitively, even though not all firms lower their prices following the VAT cut, household still expect taxes and prices to increase after a few periods. Therefore, they increase consumption today, boosting aggregate demand in a way that is similar to sales tax cuts.

[8] The effects do not add up to the total response due to negative interaction effects, not shown on the figure.

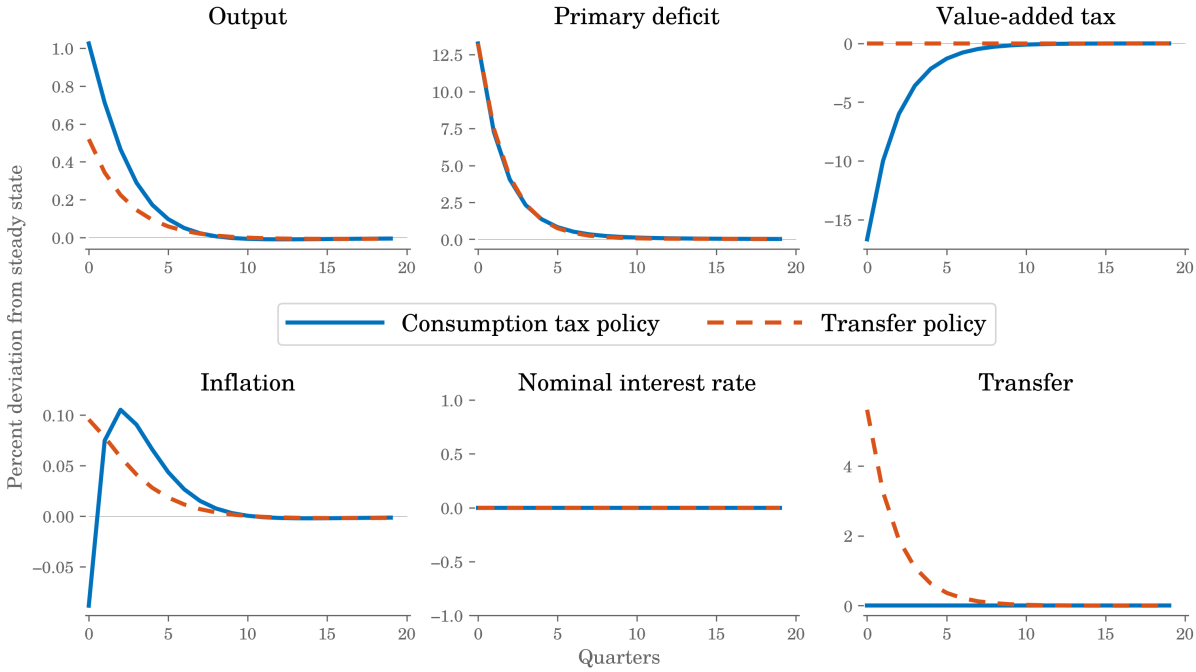

Figure 5: Response to VAT Cut vs Transfer Increase

5 Conclusion

Recent recessions in developed countries have led central banks to cut short-term nominal interest rates to levels close to, or even slightly below, zero. This has not been sufficient to put their economy back on track, so in order to provide much-needed additional stimulus, policymakers have resorted to fiscal policy. In this context, identifying which instrument is more appropriate and cost-effective is paramount.

This paper offers a theoretical policy evaluation of two fiscal tools that have been used lately to combat recessions — temporary consumption tax cuts and uniform stimulus payments. In an important contribution, Wolf (2022) vindicates transfers as a powerful stimulus policy by showing they mimic the effects of conventional interest rate cuts. We claim that in the same class of model economies, sales tax cuts deliver more stimulus than transfer payments. The reason is checks work mostly by lifting spending of the poor while not affecting much consumption of the rich. Consumption tax cuts, on the other hand, spur a change in spending behavior across the entire wealth distribution, by encouraging early consumption in favor of future consumption. In addition, tax cuts stimulate labor supply.

We simulate budget-equivalent consumption tax and transfer policies in a calibrated heterogeneous-agent New Keynesian model. We find large differences between the two. In our baseline specification, output expands twice as much, on impact and in cumulative terms, under the consumption tax policy. This appears to be a free lunch, as the two policies cost the exact same amount to the government. We also consider a version of the model with value-added taxes and incomplete pass-through, and show that the results carry over.

In a world with perfect information, policymakers would be able to precisely identify households that have low or no income, no liquid assets, and thus a high marginal propensity to consume. It might then be desirable to send stimulus checks only to these households. Conditional transfers carry the double advantage of being cheaper than untargeted transfers and reducing inequality in times of crisis. On the other hand, prominent economists including Friedman (1943) have proposed to refine consumption taxation by introducing a progressive consumption tax. In one popular proposal, taxable consumption would be calculated as income minus savings. We leave the promising analysis of targeted transfers and progressive consumption taxes for future work.

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Appendix

This appendix has four sections. Section A proves Proposition 1. Section B proves Proposition 2. Section C details the computation of the linear maps in the four analytical models of Section 2.2. Section D provides additional analytical results.

A Proof of Proposition 1

The economy starts in steady state. At time 0, the government announces paths for its policy instruments. Following Wolf (2023), the aggregate impulse response of consumption to a policy shock path $\boldsymbol{\varepsilon} = \{\boldsymbol{\tau}, \boldsymbol{\tau_c}, \boldsymbol{\tau_\ell}\}$ is

$$\widehat{\boldsymbol{c}}_\varepsilon \equiv \boldsymbol{c}(\boldsymbol{s}^h_\varepsilon; \boldsymbol{\varepsilon}) - \boldsymbol{c}(\bar{\boldsymbol{s}}^h; \bar{\boldsymbol{\varepsilon}}), \tag{A1}$$

where $\boldsymbol{s}^h = (\boldsymbol{\pi}, \boldsymbol{w}, \boldsymbol{\ell}, \boldsymbol{d})$ collects input variables to the household consumption-savings problem. To first order, the aggregate impulse response decomposes into a direct *partial* equilibrium impulse and an indirect *general* equilibrium feedback component

$$\widehat{\boldsymbol{c}}_\varepsilon = \widehat{\boldsymbol{c}}^{PE}_\varepsilon + \widehat{\boldsymbol{c}}^{GE}_\varepsilon \quad \text{where} \quad \begin{cases} \widehat{\boldsymbol{c}}^{PE}_\varepsilon \equiv \boldsymbol{c}(\bar{\boldsymbol{s}}^h; \boldsymbol{\varepsilon}) - \boldsymbol{c}(\bar{\boldsymbol{s}}^h; \bar{\boldsymbol{\varepsilon}}) \\ \widehat{\boldsymbol{c}}^{GE}_\varepsilon \equiv \boldsymbol{c}(\boldsymbol{s}^h_\varepsilon; \bar{\boldsymbol{\varepsilon}}) - \boldsymbol{c}(\bar{\boldsymbol{s}}^h; \bar{\boldsymbol{\varepsilon}}). \end{cases} \tag{A2}$$

We first establish equivalence in partial equilibrium between the consumption tax policy and a mix of transfer and labor tax policies. We then generalize to general equilibrium.

A.1 Partial Equilibrium

Government policies directly impact household consumption demand and labor supply.

Impulse Responses of Consumption Demand and Labor Supply.—The total derivative of aggregate consumption demand in period t with respect to a period-s change in the policy instrument $\varepsilon = \{\tau, \tau_c, \tau_\ell\}$ (with a slight abuse of notation) is given by

$$\frac{d\widehat{c}_t}{d\widehat{\varepsilon}_s} = \frac{\partial \widehat{c}_t}{\partial \widehat{\varepsilon}_s} + \frac{\partial \widehat{c}_t}{\partial \widehat{\ell}_t} \times \frac{d\widehat{\ell}_t}{d\widehat{\varepsilon}_s} \quad \text{where } \varepsilon = \{\tau, \tau_c, \tau_\ell\}. \tag{A3}$$

The first term $\partial \widehat{c}_t / \partial \widehat{\varepsilon}_s$ is simply $\mathcal{C}_\varepsilon(t, s)$. To compute the second term $\partial \widehat{c}_t / \partial \widehat{\ell}_t$, aggregate the individual budget constraint (2) across all households, linearize, normalize $\bar{c} = \bar{\ell} = 1$, and set $\widehat{\pi}_t = \widehat{w}_t = \widehat{r}_t = \widehat{d}_t = 0$

$$(1 + \bar{\tau}_c)\widehat{c}_t + \widehat{\tau}_{ct} + \widehat{b}_t = (1 - \bar{\tau}_\ell)\bar{w}\widehat{\ell}_t + \frac{1}{\beta}\widehat{b}_{t-1} + \widehat{\tau}_t - \bar{w}\widehat{\tau}_{\ell t}. \tag{A4}$$

Take the partial derivative of $\widehat{c}_t$ with respect to $\widehat{\ell}_t$

$$\frac{\partial \widehat{c}_t}{\partial \widehat{\ell}_t} = \frac{1 - \bar{\tau}_\ell}{1 + \bar{\tau}_c}\bar{w} > 0. \tag{A5}$$

To obtain the third term $d\widehat{\ell}_t/d\widehat{\varepsilon}_s$ in (A3), linearize the wage Phillips curve (8)

$$\widehat{\ell}_t = -\frac{\varphi}{\gamma}\widehat{c}_t - \frac{\varphi}{1+\bar{\tau}_c}\widehat{\tau}_{ct} - \frac{\varphi}{1-\bar{\tau}_\ell}\widehat{\tau}_{\ell t}. \tag{A6}$$

Take total derivative of $\widehat{\ell}_t$ with respect to each policy instrument

$$\frac{d\widehat{\ell}_t}{d\widehat{\tau}_s} = -\frac{\varphi}{\gamma}\frac{d\widehat{c}_t}{d\widehat{\tau}_s}; \quad \frac{d\widehat{\ell}_t}{d\widehat{\tau}_{cs}} = -\frac{\varphi}{\gamma}\frac{d\widehat{c}_t}{d\widehat{\tau}_{cs}} - \frac{\varphi}{1+\bar{\tau}_c} \times \mathbf{1}_{t=s}; \quad \frac{d\widehat{\ell}_t}{d\widehat{\tau}_{\ell s}} = -\frac{\varphi}{\gamma}\frac{d\widehat{c}_t}{d\widehat{\tau}_{\ell s}} - \frac{\varphi}{1-\bar{\tau}_\ell} \times \mathbf{1}_{t=s}. \tag{A7}$$

Plug (A5) and (A7) into (A3) and rearrange

$$\begin{aligned} \frac{d\widehat{c}_t}{d\widehat{\tau}_s} &= \frac{1}{\nu}\mathcal{C}_\tau(t,s) \\ \frac{d\widehat{c}_t}{d\widehat{\tau}_{cs}} &= -\frac{1}{\nu}\left(\mathcal{C}_{\tau_c}(t,s) + \frac{(1-\bar{\tau}_\ell)\bar{w}\varphi}{(1+\bar{\tau}_c)^2} \times \mathbf{1}_{t=s}\right) \\ \frac{d\widehat{c}_t}{d\widehat{\tau}_{\ell s}} &= -\frac{1}{\nu}\left(\mathcal{C}_{\tau_\ell}(t,s) + \frac{\bar{w}\varphi}{1+\bar{\tau}_c} \times \mathbf{1}_{t=s}\right), \end{aligned} \tag{A8}$$

where $\nu \equiv 1+(1-\bar{\tau}_\ell)(1+\bar{\tau}_c)^{-1}\bar{w}\varphi\gamma^{-1} > 1$. It follows that the total responses of consumption and labor supply to time paths of transfers, consumption tax, and labor tax are respectively

$$\widehat{\boldsymbol{c}}_\tau^{PE} = \frac{1}{\nu}\mathcal{C}_\tau \times \widehat{\boldsymbol{\tau}}; \qquad \widehat{\boldsymbol{\ell}}_\tau^{PE} = -\frac{\varphi}{\gamma} \times \widehat{\boldsymbol{c}}_\tau^{PE} \tag{A9}$$

$$\widehat{\boldsymbol{c}}_{\tau_c}^{PE} = -\frac{1}{\nu}\left(\mathcal{C}_{\tau_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}} + \frac{(1-\bar{\tau}_\ell)\bar{w}\varphi}{(1+\bar{\tau}_c)^2} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}\right); \qquad \widehat{\boldsymbol{\ell}}_{\tau_c}^{PE} = -\frac{\varphi}{\gamma} \times \widehat{\boldsymbol{c}}_{\tau_c}^{PE} - \frac{\varphi}{1+\bar{\tau}_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}} \tag{A10}$$

$$\widehat{\boldsymbol{c}}_{\tau_\ell}^{PE} = -\frac{1}{\nu}\left(\mathcal{C}_{\tau_\ell} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}} + \frac{\bar{w}\varphi}{1+\bar{\tau}_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}\right); \qquad \widehat{\boldsymbol{\ell}}_{\tau_\ell}^{PE} = -\frac{\varphi}{\gamma} \times \widehat{\boldsymbol{c}}_{\tau_\ell}^{PE} - \frac{\varphi}{1-\bar{\tau}_\ell} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}. \tag{A11}$$

Policy Equivalence in Partial Equilibrium.—Choose any path of consumption tax-only policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ with zero net present value

$$\sum_{t=0}^{\infty}\beta^t\widehat{\tau}_{ct} = 0.$$

Select the path of labor income tax policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}$ that equalizes the second terms of $\widehat{\boldsymbol{\ell}}_{\tau_c}^{PE}$ and $\widehat{\boldsymbol{\ell}}_{\tau_\ell}^{PE}$ in (A10) and (A11)

$$\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}} \;=\; \frac{1-\bar{\tau}_\ell}{1+\bar{\tau}_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}. \tag{A12}$$

Next, select the path of transfer policy $\widehat{\boldsymbol{\tau}}$ such that $\widehat{\boldsymbol{c}}_\tau^{PE} = \widehat{\boldsymbol{c}}_{\tau_\ell}^{PE} - \widehat{\boldsymbol{c}}_{\tau_c}^{PE}$ using (A9), (A10), (A11), the expression for $\widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}}$ from (A12), and $\mathcal{C}_{\tau_\ell} = \bar{w} \times \mathcal{C}_\tau$[9]

$$\widehat{\boldsymbol{\tau}} \;=\; \mathcal{C}_\tau^{-1}\mathcal{C}_{\tau_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}} - \frac{(1-\bar{\tau}_\ell)\bar{w}}{1+\bar{\tau}_c} \times \widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}. \tag{A13}$$

Equation (A13) gives a unique path of transfers, which, together with the unique path of labor income taxes given by (A12), induce the exact same partial-equilibrium responses of consumption demand and labor supply as those induced by the consumption tax-only policy.

[9] As far as disposable income is concerned, a labor income tax shock is equivalent to a transfer shock up to a constant $\bar{w}$, as the aggregate household budget constraint (A4) makes clear

$$\frac{\partial\widehat{c}_t}{-\partial\widehat{\tau}_{\ell t}} = \bar{w} \times \frac{\partial\widehat{c}_t}{\partial\widehat{\tau}_t}.$$

A.2 General Equilibrium

This part draws extensively on Wolf (2022, 2023). The key insight is that if two policies perturb the same optimality conditions by the same magnitude period after period, then they must also induce the same paths of macroeconomic aggregates in general equilibrium. In our case, the consumption tax-only policy $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$ and the joint transfer and labor tax policy $(\widehat{\boldsymbol{\tau}}, \widehat{\boldsymbol{\tau}}_{\boldsymbol{\ell}})$ both affect the household budget constraint, Euler equation, and wage Phillips curve in a way that the paths of consumption $\boldsymbol{c}^{PE}$ and labor supply $\boldsymbol{\ell}^{PE}$ are identical.

Three types of agents make decisions given a set of policies $\varepsilon = \{\boldsymbol{\tau}, \boldsymbol{\tau}_{\boldsymbol{c}}, \boldsymbol{\tau}_{\boldsymbol{\ell}}\}$. Firms take inputs $\boldsymbol{s}^f = (\boldsymbol{\pi}, \boldsymbol{w})$ to set $(\boldsymbol{d}, \boldsymbol{y}, \boldsymbol{\ell}^f)$. Households take inputs $\boldsymbol{s}^h = (\boldsymbol{\pi}, \boldsymbol{w}, \boldsymbol{\ell}, \boldsymbol{d})$ to set $(\boldsymbol{c}, \boldsymbol{b}^h)$. Labor unions take inputs $\boldsymbol{s}^u = (\boldsymbol{\pi}, \boldsymbol{w}, \boldsymbol{c})$ to set $\boldsymbol{\ell}^h$. A perfect-foresight equilibrium is a sequence $\boldsymbol{z} = (\boldsymbol{y}, \boldsymbol{w})$ such that the resource constraint holds and labor and goods markets clear

$$\begin{aligned} \boldsymbol{c}(\boldsymbol{s}^h(\boldsymbol{z}); \varepsilon) &= \boldsymbol{y}(\boldsymbol{s}^f(\boldsymbol{z}); \varepsilon) \\ \boldsymbol{\ell}^h(\boldsymbol{s}^u(\boldsymbol{z}; \varepsilon)) &= \boldsymbol{\ell}(\boldsymbol{s}^f(\boldsymbol{z}); \varepsilon) \\ \boldsymbol{y}(\boldsymbol{s}^f(\boldsymbol{z}); \varepsilon) &= \boldsymbol{y}. \end{aligned} \tag{A14}$$

Linearize the equilibrium conditions

$$\begin{aligned} \frac{\partial \boldsymbol{c}}{\partial \boldsymbol{z}} \times \widehat{\boldsymbol{z}} + \frac{\partial \boldsymbol{c}}{\partial \varepsilon} \times \widehat{\varepsilon} &= \frac{\partial \boldsymbol{y}}{\partial \boldsymbol{z}} \times \widehat{\boldsymbol{z}} + \frac{\partial \boldsymbol{y}}{\partial \varepsilon} \times \widehat{\varepsilon} \\ \frac{\partial \boldsymbol{\ell}^h}{\partial \boldsymbol{z}} \times \widehat{\boldsymbol{z}} + \frac{\partial \boldsymbol{\ell}^h}{\partial \varepsilon} \times \widehat{\varepsilon} &= \frac{\partial \boldsymbol{\ell}^f}{\partial \boldsymbol{z}} \times \widehat{\boldsymbol{z}} + \frac{\partial \boldsymbol{\ell}^f}{\partial \varepsilon} \times \widehat{\varepsilon} \\ \frac{\partial \boldsymbol{y}}{\partial \boldsymbol{z}} \times \widehat{\boldsymbol{z}} + \frac{\partial \boldsymbol{y}}{\partial \varepsilon} \times \widehat{\varepsilon} &= J_1 \times \widehat{\boldsymbol{z}}, \end{aligned} \tag{A15}$$

where J_1 denotes the infinite-dimensional generalization of the selection matrix selecting the first entry of vector z_t. Assuming equilibrium existence and uniqueness, there exists a unique linear map $\mathcal{H}$ such that

$$\widehat{\boldsymbol{z}} = \underbrace{\mathcal{H}}_{\text{GE adjustment}} \times \underbrace{\begin{pmatrix} \frac{\partial \boldsymbol{c}}{\partial \varepsilon} - \frac{\partial \boldsymbol{y}}{\partial \varepsilon} \\ \frac{\partial \boldsymbol{\ell}^h}{\partial \varepsilon} - \frac{\partial \boldsymbol{\ell}^f}{\partial \varepsilon} \\ \frac{\partial \boldsymbol{y}}{\partial \varepsilon} \end{pmatrix}}_{\text{direct shock response}} \times \widehat{\varepsilon} \qquad \text{where} \quad \mathcal{H} \equiv \begin{pmatrix} \frac{\partial \boldsymbol{y}}{\partial \boldsymbol{z}} - \frac{\partial \boldsymbol{c}}{\partial \boldsymbol{z}} \\ \frac{\partial \boldsymbol{\ell}^f}{\partial \boldsymbol{z}} - \frac{\partial \boldsymbol{\ell}^h}{\partial \boldsymbol{z}} \\ J_1 - \frac{\partial \boldsymbol{y}}{\partial \boldsymbol{z}} \end{pmatrix}^{-1}. \tag{A16}$$

$\mathcal{H}$ is a left inverse, which is unique because the equilibrium is unique.

Policy Equivalence in General Equilibrium.—Our three policy shocks $\varepsilon = \{\boldsymbol{\tau}, \boldsymbol{\tau}_{\boldsymbol{c}}, \boldsymbol{\tau}_{\boldsymbol{\ell}}\}$ have no direct effect on the firm decisions rules, ie $\frac{\partial \boldsymbol{y}}{\partial \varepsilon} = \frac{\partial \boldsymbol{\ell}^f}{\partial \varepsilon} = \boldsymbol{0}$. Therefore, the total impulse response path of consumption satisfies

$$\widehat{\boldsymbol{c}}_{\varepsilon} = \underbrace{\frac{\partial \boldsymbol{c}}{\partial \varepsilon} \times \widehat{\varepsilon}}_{\widehat{\boldsymbol{c}}_{\varepsilon}^{PE}} + \frac{\partial \boldsymbol{c}}{\partial \boldsymbol{z}} \times \mathcal{H} \times \begin{pmatrix} \widehat{\boldsymbol{c}}_{\varepsilon}^{PE} \\ \widehat{\boldsymbol{\ell}}_{\varepsilon}^{PE} \\ \boldsymbol{0} \end{pmatrix} \qquad \text{where} \quad \begin{pmatrix} \widehat{\boldsymbol{c}}_{\varepsilon}^{PE} \\ \widehat{\boldsymbol{\ell}}_{\varepsilon}^{PE} \\ \boldsymbol{0} \end{pmatrix} = \begin{pmatrix} \frac{\partial \boldsymbol{c}}{\partial \varepsilon} \\ \frac{\partial \boldsymbol{\ell}^h}{\partial \varepsilon} \\ \boldsymbol{0} \end{pmatrix} \times \widehat{\varepsilon}. \tag{A17}$$

Now, using the fact that $\widehat{\boldsymbol{c}}_{\tau_c}^{PE} = \widehat{\boldsymbol{c}}_{\tau_\ell}^{PE} - \widehat{\boldsymbol{c}}_{\tau}^{PE}$, we have

$$\widehat{\boldsymbol{c}}_{\tau_c} - \widehat{\boldsymbol{c}}_{\tau_\ell} + \widehat{\boldsymbol{c}}_{\tau} = \widehat{\boldsymbol{c}}_{\tau_c}^{PE} - \widehat{\boldsymbol{c}}_{\tau_\ell}^{PE} + \widehat{\boldsymbol{c}}_{\tau}^{PE} + \frac{\partial \boldsymbol{c}}{\partial \boldsymbol{z}} \times \mathcal{H} \times \begin{pmatrix} \widehat{\boldsymbol{c}}_{\tau_c}^{PE} - \widehat{\boldsymbol{c}}_{\tau_\ell}^{PE} + \widehat{\boldsymbol{c}}_{\tau}^{PE} \\ \widehat{\boldsymbol{\ell}}_{\tau_c}^{PE} - \widehat{\boldsymbol{\ell}}_{\tau_\ell}^{PE} + \widehat{\boldsymbol{\ell}}_{\tau}^{PE} \\ \boldsymbol{0} \end{pmatrix} = \boldsymbol{0}. \tag{A18}$$

Thus, $\widehat{\boldsymbol{c}}_{\tau_c} = \widehat{\boldsymbol{c}}_{\tau_\ell} - \widehat{\boldsymbol{c}}_{\tau}$. The consumption tax-only policy and the joint transfer and labor tax policy induce the same total impulse response of consumption. Using the equilibrium conditions (A14), we conclude that the two policies generate identical allocations. ■

B Proof of Proposition 2

First Policy.—Consider a path of consumption tax cuts $\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}$. To finance these tax cuts, select a path of negative transfers $\widehat{\boldsymbol{\tau}}$ such that in all periods t

$$\widehat{\tau}_t = \widehat{\tau}_{ct} < 0. \tag{B1}$$

Call Policy 1 this joint policy $(\widehat{\boldsymbol{\tau}}_{\boldsymbol{c}}, \widehat{\boldsymbol{\tau}})$. In partial equilibrium, the impulse responses of consumption in period t are

$$\widehat{c}_{\tau_c,t}^{PE} = -\frac{1}{\nu}\sum_{s=0}^{\infty}\left[\mathcal{C}_{\tau_c}(t,s) + \frac{(1-\bar{\tau}_\ell)\bar{w}\varphi}{(1+\bar{\tau}_c)^2} \times \mathbf{1}_{t=s}\right] \times \widehat{\tau}_{cs}; \qquad \widehat{c}_{\tau,t}^{PE} = \frac{1}{\nu}\sum_{s=0}^{\infty}\mathcal{C}_{\tau}(t,s) \times \widehat{\tau}_s. \tag{B2}$$

where $\nu = 1 + (1-\bar{\tau}_\ell)(1+\bar{\tau}_c)^{-1}\bar{w}\varphi\gamma^{-1}$. Compute the present discounted sum of the total impulse response paths and use the fact that $\sum_{t=0}^{\infty}\beta^t\mathcal{C}_{\tau}(t,s) = \sum_{t=0}^{\infty}\beta^t\mathcal{C}_{\tau_c}(t,s) = (1+\bar{\tau}_c)^{-1}\beta^s$ from Section D

$$\sum_{t=0}^{\infty}\beta^t\widehat{c}_{\tau_c,t}^{PE} = -\frac{1}{\nu(1+\bar{\tau}_c)}\left[1 + \frac{(1-\bar{\tau}_\ell)\bar{w}\varphi}{1+\bar{\tau}_c}\right]\sum_{t=0}^{\infty}\beta^t\widehat{\tau}_{ct}; \qquad \sum_{t=0}^{\infty}\beta^t\widehat{c}_{\tau,t}^{PE} = \frac{1}{\nu(1+\bar{\tau}_c)}\sum_{t=0}^{\infty}\beta^t\widehat{\tau}_t. \tag{B3}$$

The net effect of Policy 1 on consumption demand is

$$\sum_{t=0}^{\infty}\beta^t\widehat{c}_{\tau_c,\tau,t}^{PE} \equiv \sum_{t=0}^{\infty}\beta^t\left(\widehat{c}_{\tau_c,t}^{PE} + \widehat{c}_{\tau,t}^{PE}\right) = -\frac{(1-\bar{\tau}_\ell)\bar{w}\varphi}{\nu(1+\bar{\tau}_c)^2}\sum_{t=0}^{\infty}\beta^t\widehat{\tau}_{ct} > 0. \tag{B4}$$

Similarly, the net effect of Policy 1 on labor supply is

$$\sum_{t=0}^{\infty}\beta^t\widehat{\ell}_{\tau_c,\tau,t}^{PE} \equiv \sum_{t=0}^{\infty}\beta^t\left(\widehat{\ell}_{\tau_c,t}^{PE} + \widehat{\ell}_{\tau,t}^{PE}\right) = \frac{\varphi}{1+\bar{\tau}_c}\left[\frac{(1-\bar{\tau}_\ell)\bar{w}\varphi}{\gamma\nu(1+\bar{\tau}_c)} - 1\right]\sum_{t=0}^{\infty}\beta^t\widehat{\tau}_{ct} > 0. \tag{B5}$$

Now, compute the cost of Policy 1 for the government. Linearize the government budget constraint (9), normalize $\bar{c} = \bar{\ell} = 1$, and set $\widehat{\pi}_t = \widehat{w}_t = \widehat{r}_t = \widehat{\tau}_{\ell t} = 0$

$$\widehat{\tau}_t + (1+\bar{r})\widehat{b}_{t-1} = \widehat{\tau}_{ct} + \bar{\tau}_c\widehat{c}_t + \bar{\tau}_\ell\bar{w}\widehat{\ell}_t + \widehat{b}_t. \tag{B6}$$

Let $\widehat{s}_t \equiv \widehat{\tau}_{ct} - \widehat{\tau}_t + \bar{\tau}_c \widehat{c}_t + \bar{\tau}_\ell \bar{w} \widehat{\ell}_t$ be primary budget surplus. Compute the present discounted sum of the entire surplus path

$$\sum_{t=0}^{\infty} \beta^t \widehat{s}^{PE}_{\tau_c,\tau,t} = \underbrace{\sum_{t=0}^{\infty} \beta^t \left(\widehat{\tau}_{ct} - \widehat{\tau}_t\right)}_{=0} + \bar{\tau}_c \underbrace{\sum_{t=0}^{\infty} \beta^t \widehat{c}^{PE}_{\tau_c,\tau,t}}_{>0} + \bar{\tau}_\ell \bar{w} \underbrace{\sum_{t=0}^{\infty} \beta^t \widehat{\ell}^{PE}_{\tau_c,\tau,t}}_{>0} > 0. \tag{B7}$$

Policy 1 induces *positive* net present value responses in consumption demand and labor supply while generating a primary budget *surplus*. Next, we show that any alternative policy that decreases the present value of consumption will lead to even larger surplus. Conversely, any alternative policy that reduces the present value of surplus will make the present value of consumption even more positive.

Alternative Policy.—Consider now an alternative policy, call it Policy 2. Pick the same path of consumption tax cuts as Policy 1. Select an alternative path of transfers $\widehat{\boldsymbol{\tau}}^*$

$$\widehat{\tau}^*_t = \widehat{\tau}_{ct} + \delta_t \quad \text{such that} \quad \sum_{t=0}^{\infty} \beta^t \delta_t > 0. \tag{B8}$$

The difference in net present value consumption demand, and labor supply, and primary budget balance between Policies 1 and 2 is respectively

$$\begin{aligned}
\sum_{t=0}^{\infty} \beta^t \left(\widehat{c}^{PE}_{\tau_c,\tau^*,t} - \widehat{c}^{PE}_{\tau_c,\tau,t}\right) &= \frac{1}{\nu(1+\bar{\tau}_c)} \sum_{t=0}^{\infty} \beta^t \delta_t > 0 \\
\sum_{t=0}^{\infty} \beta^t \left(\widehat{\ell}^{PE}_{\tau_c,\tau^*,t} - \widehat{\ell}^{PE}_{\tau_c,\tau,t}\right) &= -\frac{\varphi}{\gamma\nu(1+\bar{\tau}_c)} \sum_{t=0}^{\infty} \beta^t \delta_t < 0 \\
\sum_{t=0}^{\infty} \beta^t \left(\widehat{s}^{PE}_{\tau_c,\tau^*,t} - \widehat{s}^{PE}_{\tau_c,\tau,t}\right) &= -\left[\frac{\nu + \bar{\tau}_c(\nu-1) - \bar{\tau}_c + \bar{\tau}_\ell \bar{w} \varphi \gamma^{-1}}{\nu(1+\bar{\tau}_c)}\right] \sum_{t=0}^{\infty} \beta^t \delta_t < 0,
\end{aligned} \tag{B9}$$

where we use $\nu = 1 + (1-\bar{\tau}_\ell)(1+\bar{\tau}_c)^{-1} \bar{w} \varphi \gamma^{-1} > 1$. Policy 2 reduces primary balance but increases present value consumption even further. One can find $\{\delta_t\}_{t=0}^{\infty}$ such that Policy 2 implies budget balance at all time

$$\delta_t = -\frac{\varphi}{1+\bar{\tau}_c}\left[1 + \frac{(1-\bar{\tau}_\ell)\bar{w}}{\nu(1+\bar{\tau}_c)}\left(\bar{\tau}_c - \frac{\varphi}{\gamma}\right)\right] \times \widehat{\tau}_{ct} > 0. \tag{B10}$$

If (B10) holds, then consumption tax cuts and transfers are budget-equivalent. Thus, Policy 2 generates a positive period-by-period net excess consumption demand. It immediately follows that in general equilibrium $\widehat{\boldsymbol{c}}_{\tau_c,t} > \widehat{\boldsymbol{c}}_{\tau,t}$, and by the market clearing conditions (A14), $\widehat{\boldsymbol{y}}_{\tau_c,t} > \widehat{\boldsymbol{y}}_{\tau,t}$. ■

C Linear Maps in Analytical Models

This section computes the matrices $\mathcal{C}_\tau$ and $\mathcal{C}_{\tau_c}$ in our four analytical models: RANK; TANK; OLG; and tractable HANK. Throughout we normalize $\bar{c} = \bar{\ell} = 1$ without loss of generality.

C.1 Permanent-Income Consumers

The solution to the household consumption-savings problem is given by the following pair of linearized budget constraint and Euler equation, setting $\widehat{\pi}_t = \widehat{w}_t = \widehat{\ell}_t = \widehat{d}_t = \widehat{i}_t = \widehat{\tau}_{\ell t} = 0$ and $\bar{\tau}_c = 0$

$$\widehat{b}_t = \frac{1}{\beta}\widehat{b}_{t-1} - \widehat{c}_t + \widehat{\tau}_t - \widehat{\tau}_{ct} \tag{C1}$$

$$\widehat{c}_{t+1} = \widehat{c}_t + \gamma\widehat{\tau}_{ct} - \gamma\widehat{\tau}_{ct+1}. \tag{C2}$$

Express the system in matrix form

$$A_1 \begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} = A_0 \begin{bmatrix} \widehat{b}_{t-1} \\ \widehat{c}_t \end{bmatrix} + B_0 \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}, \; A_1 \equiv \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \; A_0 \equiv \begin{bmatrix} 1/\beta & -1 \\ 0 & 1 \end{bmatrix}, \; B_0 \equiv \begin{bmatrix} 1 & -1 & 0 \\ 0 & \gamma & -\gamma \end{bmatrix}. \tag{C3}$$

Since A_1 is invertible, multiply by A_1^{-1} on both sides to simplify the system to

$$\begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} = A \begin{bmatrix} \widehat{b}_{t-1} \\ \widehat{c}_t \end{bmatrix} + B \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}, \; A \equiv A_1^{-1}A_0, \; B \equiv A_1^{-1}B_0. \tag{C4}$$

Apply a Jordan decomposition to matrix $A = D\Lambda D^{-1}$ where Λ is a diagonal matrix with the eigenvalues of A along the diagonal and D is a matrix of eigenvectors of A

$$\begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} = D\Lambda D^{-1} \begin{bmatrix} \widehat{b}_{t-1} \\ \widehat{c}_t \end{bmatrix} + B \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}, \; \Lambda = \begin{bmatrix} 1 & 0 \\ 0 & 1/\beta \end{bmatrix}, \; D = \begin{bmatrix} \frac{\beta}{1-\beta} & 1 \\ 1 & 0 \end{bmatrix}, \; D^{-1} = \begin{bmatrix} 0 & 1 \\ 1 & -\frac{\beta}{1-\beta} \end{bmatrix}. \tag{C5}$$

Multiply by D^{-1} on both sides and decouple the system by defining

$$\begin{bmatrix} \tilde{b}_t \\ \tilde{c}_{t+1} \end{bmatrix} \equiv D^{-1} \begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} \quad \text{and} \quad \tilde{B} \equiv D^{-1}B = \begin{bmatrix} 0 & \gamma & -\gamma \\ 1 & -(\frac{\beta}{1-\beta}\gamma + 1) & \frac{\beta}{1-\beta}\gamma \end{bmatrix}.$$

The system takes the form

$$\begin{bmatrix} \tilde{b}_t \\ \tilde{c}_{t+1} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1/\beta \end{bmatrix} \begin{bmatrix} \tilde{b}_{t-1} \\ \tilde{c}_t \end{bmatrix} + \begin{bmatrix} 0 & \gamma & -\gamma \\ 1 & -(\frac{\beta}{1-\beta}\gamma + 1) & \frac{\beta}{1-\beta}\gamma \end{bmatrix} \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}. \tag{C6}$$

The second row of (C6) reads

$$\tilde{c}_{t+1} = \frac{1}{\beta}\tilde{c}_t + \widehat{\tau}_t - \left(\frac{\beta}{1-\beta}\gamma + 1\right)\widehat{\tau}_{ct} + \frac{\beta}{1-\beta}\gamma\widehat{\tau}_{ct+1}. \tag{C7}$$

Solve for $\tilde{c}_t$, iterate forward, and plug in $\widehat{c}_t = \frac{1-\beta}{\beta}(\widehat{b}_{t-1} - \tilde{c}_t)$

$$\widehat{c}_t = \frac{1-\beta}{\beta}\widehat{b}_{t-1} + (1-\beta)\sum_{s=0}^{\infty}\beta^s\widehat{\tau}_{t+s} - (\beta\gamma + 1 - \beta)\,\widehat{\tau}_{ct} - \beta(1-\beta)\,(1-\gamma)\sum_{s=0}^{\infty}\beta^s\widehat{\tau}_{ct+1+s}. \tag{C8}$$

This expression gives the policy rule for aggregate consumption demand, $\widehat{c}_t$, given an initial level of wealth, $\widehat{b}_{t-1}$, and the paths for the policy shocks, $\widehat{\tau}_t$ and $\widehat{\tau}_{ct}$. Together with the budget constraint (C1), it enables us to calculate the linear maps.

Linear Map for Transfers.—The consumption demand response of permanent-income consumers at any time t to a one-off increase in transfers at time s is given by

$$\mathcal{C}^R_\tau(t,s) = \beta^s(1-\beta) \text{ for all } t, s \geq 0, \tag{C9}$$

or

$$\mathcal{C}^R_\tau = \begin{pmatrix} 1-\beta & \beta(1-\beta) & \beta^2(1-\beta) & \dots \\ 1-\beta & \beta(1-\beta) & \beta^2(1-\beta) & \dots \\ 1-\beta & \beta(1-\beta) & \beta^2(1-\beta) & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}. \tag{C10}$$

If $\bar{\tau}_c > 0$, the linear map writes $\mathcal{C}^R_\tau(t,s) = (1+\bar{\tau}_c)^{-1}\beta^s(1-\beta)$.

Linear Map for Consumption Tax.—The consumption demand response of permanent-income consumers at time t to a one-off cut in the consumption tax at time s is given by

$$\mathcal{C}^R_{\tau_c}(t,s) = \beta^s(1-\beta)(1-\gamma) + \gamma \times \mathbf{1}_{t=s} \text{ for all } t, s \geq 0, \tag{C11}$$

or

$$\mathcal{C}^R_{\tau_c} = \begin{pmatrix} (1-\beta)(1-\gamma)+\gamma & \beta(1-\beta)(1-\gamma) & \beta^2(1-\beta)(1-\gamma) & \dots \\ (1-\beta)(1-\gamma) & \beta(1-\beta)(1-\gamma)+\gamma & \beta^2(1-\beta)(1-\gamma) & \dots \\ (1-\beta)(1-\gamma) & \beta(1-\beta)(1-\gamma) & \beta^2(1-\beta)(1-\gamma)+\gamma & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}. \tag{C12}$$

If $\bar{\tau}_c > 0$, $\mathcal{C}^R_{\tau_c}(t,s) = (1+\bar{\tau}_c)^{-1}\left[\beta^s(1-\beta)(1-\gamma) + \gamma \times \mathbf{1}_{t=s}\right]$.

C.2 Spenders and Savers

In TANK, spenders' linear maps $\mathcal{C}^H_\tau$ and $\mathcal{C}^H_{\tau_c}$ are fully characterized by their linearized budget constraint, setting $\widehat{w}_t = \widehat{\ell}_t = 0$ and $\bar{\tau}_c = 0$

$$\widehat{c}^H_t = \widehat{\tau}_t - \widehat{\tau}_{ct}. \tag{C13}$$

Take partial derivatives

$$\frac{\partial \widehat{c}^H_t}{\partial \widehat{\tau}_s} = \begin{cases} 1 & \text{if } t = s, \\ 0 & \text{if } t \neq s; \end{cases} \qquad \frac{\partial \widehat{c}^H_t}{-\partial \widehat{\tau}_{cs}} = \begin{cases} 1 & \text{if } t = s, \\ 0 & \text{if } t \neq s. \end{cases} \tag{C14}$$

It follows that

$$\mathcal{C}^H_\tau = \begin{pmatrix} 1 & 0 & 0 & \dots \\ 0 & 1 & 0 & \dots \\ 0 & 0 & 1 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}; \qquad \mathcal{C}^H_{\tau_c} = \begin{pmatrix} 1 & 0 & 0 & \dots \\ 0 & 1 & 0 & \dots \\ 0 & 0 & 1 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}. \tag{C15}$$

If $\bar{\tau}_c > 0$, $\mathcal{C}^H_\tau = \mathcal{C}^H_{\tau_c} = (1+\bar{\tau}_c)^{-1} \times I$. Hand-to-mouth households respond only to contemporaneous policy changes. We conclude that the linear maps for TANK satisfy

$$\mathcal{C}^T_\tau = (1-\lambda) \times \mathcal{C}^R_\tau + \lambda \times \mathcal{C}^H_\tau; \qquad \mathcal{C}^T_{\tau_c} = (1-\lambda) \times \mathcal{C}^R_{\tau_c} + \lambda \times \mathcal{C}^H_{\tau_c}. \tag{C16}$$

C.3 Overlapping Generations

C.3.1 The Model

A continuum of households $i \in [0,1]$ coexist at any point in time, each discounting the future at rate β and surviving from period to period at rate θ. Individual i has preferences

$$E_0 \sum_{t=0}^{\infty} (\beta\theta)^t \left\{ \frac{c_{it}^{1-\frac{1}{\gamma}} - 1}{1-\frac{1}{\gamma}} - \frac{\ell_{it}^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \right\}. \tag{C17}$$

All households supply common work hours to the sticky-wage union, so $\ell_{it} = \ell$. Households purchase fair annuities from competitive life insurance companies. These firms make payments $q_t(b_{it})$ to individuals as long as they are alive, in return for receiving their financial assets when they die. The profit of a specific insurance company contracting with agent i is $-\theta q_t(b_{it}) + (1-\theta)b_{it}$. Free entry implies that insurance firms make zero profit for all t and b

$$q_t(b_{it}) = \frac{1-\theta}{\theta} b_{it}. \tag{C18}$$

As a result, the date-t budget constraint of individual i reads

$$b_{it} = (1-\tau_\ell) w_t \ell_t + \frac{1}{\theta}(1+r_t) b_{it-1} + \tau_t + d_t - (1+\tau_{ct}) c_{it}. \tag{C19}$$

The optimal consumption-saving decision is

$$c_{it}^{-\frac{1}{\gamma}} = \beta \frac{1+\tau_{ct}}{1+\tau_{ct+1}} (1+r_{t+1}) c_{it+1}^{-\frac{1}{\gamma}}. \tag{C20}$$

Combining the budget constraint (C19) and Euler equation (C20) and log-linearizing yields a demand function

$$\begin{aligned} \widehat{c}_{it} = \frac{1-\beta\theta}{1+\bar{\tau}_c} & \left[\frac{\bar{b}}{\bar{y}} \frac{1}{\beta\theta} (\widehat{b}_{it-1} + \widehat{r}_t) + \frac{1}{\bar{y}} \sum_{s=0}^{\infty} (\beta\theta)^s [(1-\tau_\ell) \bar{w} \bar{\ell} (\widehat{w}_{t+s} + \widehat{\ell}_{t+s}) + \bar{\tau} \widehat{\tau}_{t+s} + \bar{d} \widehat{d}_{t+s}] \right] \\ & - \left[\beta\theta\gamma - \frac{1-\beta\theta}{1+\bar{\tau}_c} \frac{\bar{b}}{\bar{y}} \right] \sum_{s=0}^{\infty} (\beta\theta)^s \widehat{r}_{t+1+s} - \gamma \widehat{\tau}_{ct} - (1-\beta\theta)(1-\gamma) \sum_{s=0}^{\infty} (\beta\theta)^s \widehat{\tau}_{ct+s}. \end{aligned} \tag{C21}$$

Aggregating over all households, we obtain an aggregate budget constraint

$$\bar{b}\widehat{b}_t = (1-\tau_\ell)\bar{w}\bar{\ell}(\widehat{w}_t + \widehat{\ell}_t) + \bar{\tau}\widehat{\tau}_t + \bar{d}\widehat{d}_t + \frac{1}{\beta}\bar{b}(\widehat{b}_{t-1} + \widehat{r}_t) - (1+\bar{\tau}_c)\bar{c}(\widehat{c}_t + \widehat{\tau}_{ct}), \tag{C22}$$

together with an aggregate Euler equation

$$\begin{aligned} [1-\theta(1-\beta\theta)]\widehat{c}_t = \beta\theta\widehat{c}_{t+1} + \frac{1-\beta\theta}{1+\bar{\tau}_c} \frac{\bar{b}}{\bar{y}} \frac{1}{\beta} (1-\theta) \left(\widehat{b}_{t-1} + \widehat{r}_t \right) \\ + \frac{1-\beta\theta}{1+\bar{\tau}_c} \frac{1}{\bar{y}} (1-\theta) \left[(1-\tau_\ell)\bar{w}\bar{\ell}(\widehat{w}_t + \widehat{\ell}_t) + \bar{\tau}\widehat{\tau}_t + \bar{d}\widehat{d}_t \right] - \left[\beta\theta\gamma - \frac{1-\beta\theta}{1+\bar{\tau}_c} \frac{\bar{b}}{\bar{y}} (1-\theta) \right] \widehat{r}_{t+1} \\ - [\beta\theta\gamma + (1-\beta\theta)(1-\theta)] \widehat{\tau}_{ct} + \beta\theta\gamma\widehat{\tau}_{ct+1}. \end{aligned} \tag{C23}$$

C.3.2 Linear Maps

Equations (C22) and (C23) fully characterize the linear maps $\mathcal{C}_{\tau}^{OLG}$ and $\mathcal{C}_{\tau_c}^{OLG}$. Set $\widehat{\pi}_t = \widehat{w}_t = \widehat{\ell}_t = \widehat{d}_t = \widehat{i}_t = 0$ and $\bar{\tau}_c = 0$

$$\widehat{b}_t = \frac{1}{\beta}\widehat{b}_{t-1} - \widehat{c}_t + \widehat{\tau}_t - \widehat{\tau}_{ct} \tag{C24}$$

$$\begin{aligned} \beta\theta\widehat{c}_{t+1} = &-(1-\beta\theta)(1-\theta)\frac{1}{\beta}\widehat{b}_{t-1} + [1-\theta(1-\beta\theta)]\widehat{c}_t + (1-\beta\theta)(1-\theta)\widehat{\tau}_t \\ &+ [\beta\theta\gamma + (1-\beta\theta)(1-\theta)]\,\widehat{\tau}_{ct} - \beta\theta\gamma\widehat{\tau}_{ct+1}. \end{aligned} \tag{C25}$$

Express the system in matrix form

$$\begin{aligned} &A_1 \begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} = A_0 \begin{bmatrix} \widehat{b}_{t-1} \\ \widehat{c}_t \end{bmatrix} + B_0 \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}, \quad A_0 \equiv \begin{bmatrix} 1/\beta & -1 \\ -(1-\beta\theta)(1-\theta)\frac{1}{\beta} & 1-\theta(1-\beta\theta) \end{bmatrix}, \\ &A_1 \equiv \begin{bmatrix} 1 & 0 \\ 0 & \beta\theta \end{bmatrix}, \quad B_0 \equiv \begin{bmatrix} 1 & -1 & 0 \\ -(1-\beta\theta)(1-\theta) & \beta\theta\gamma + (1-\beta\theta)(1-\theta) & -\beta\theta\gamma \end{bmatrix}. \end{aligned} \tag{C26}$$

Since A_1 is invertible, multiply by A_1^{-1} on both sides to simplify the system to

$$\begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} = A \begin{bmatrix} \widehat{b}_{t-1} \\ \widehat{c}_t \end{bmatrix} + B \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}, \; A \equiv A_1^{-1}A_0, \; B \equiv A_1^{-1}B_0. \tag{C27}$$

As before, apply a Jordan decomposition to matrix $A = D\Lambda D^{-1}$, multiply by D^{-1} on both sides, and define

$$\begin{bmatrix} \tilde{b}_t \\ \tilde{c}_{t+1} \end{bmatrix} \equiv D^{-1} \begin{bmatrix} \widehat{b}_t \\ \widehat{c}_{t+1} \end{bmatrix} \quad \text{and} \quad \tilde{B} \equiv D^{-1}B.$$

The resulting system takes the form

$$\begin{bmatrix} \tilde{b}_t \\ \tilde{c}_{t+1} \end{bmatrix} = \begin{bmatrix} \theta & 0 \\ 0 & \frac{1}{\beta\theta} \end{bmatrix} \begin{bmatrix} \tilde{b}_{t-1} \\ \tilde{c}_t \end{bmatrix} + \begin{bmatrix} \frac{\theta(1-\beta\theta)(1-\theta)}{1-\beta\theta^2} & \frac{(1-\beta\theta)\theta(\gamma-1+\theta)}{1-\beta\theta^2} & -\frac{\gamma\theta(1-\beta\theta)}{1-\beta\theta^2} \\ -\frac{(1-\beta\theta)(1-\theta)}{\beta\theta(1-\beta\theta^2)} & \frac{(1-\theta)(\beta\gamma\theta+1-\beta\theta)}{\beta\theta(1-\beta\theta^2)} & -\frac{\gamma(1-\theta)}{1-\beta\theta^2} \end{bmatrix} \begin{bmatrix} \widehat{\tau}_t \\ \widehat{\tau}_{ct} \\ \widehat{\tau}_{ct+1} \end{bmatrix}. \tag{C28}$$

The second row of (C28) reads

$$\tilde{c}_{t+1} = \frac{1}{\beta\theta}\tilde{c}_t - \frac{(1-\beta\theta)(1-\theta)}{\beta\theta(1-\beta\theta^2)}\widehat{\tau}_t + \frac{(1-\theta)(\beta\gamma\theta+1-\beta\theta)}{\beta\theta(1-\beta\theta^2)}\widehat{\tau}_{ct} - \frac{\gamma(1-\theta)}{1-\beta\theta^2}\widehat{\tau}_{ct+1}. \tag{C29}$$

Solve for $\tilde{c}_t$, iterate forward, and plug in $\widehat{c}_t = \frac{1-\beta\theta}{\beta}\widehat{b}_{t-1} + \frac{1-\beta\theta^2}{1-\theta}\tilde{c}_t$

$$\begin{aligned} \widehat{c}_t = &\frac{1-\beta\theta}{\beta}\widehat{b}_{t-1} + (1-\beta\theta)\sum_{s=0}^{\infty}(\beta\theta)^s\widehat{\tau}_{t+s} - (\beta\theta\gamma + 1 - \beta\theta)\widehat{\tau}_{ct} \\ &-\beta\theta(1-\beta\theta)(1-\gamma)\sum_{s=0}^{\infty}(\beta\theta)^s\widehat{\tau}_{ct+1+s}. \end{aligned} \tag{C30}$$

This expression gives the policy rule for aggregate consumption demand, $\widehat{c}_t$, given an initial level of wealth, $\widehat{b}_{t-1}$, and the paths for the policy shocks, $\widehat{\tau}_t$ and $\widehat{\tau}_{ct}$. Together with the budget constraint (C24), it enables us to calculate the linear maps.

Linear Map for Transfers.—The aggregate consumption demand response of the OLG economy at time t to a one-off increase in transfers at time s is given by

$$\mathcal{C}_{\tau}^{OLG}(t,s) = (1-\beta\theta)\Big(\mathbf{1}_{t<s} \times (\beta\theta)^{s-t}\Psi_t + \mathbf{1}_{t\geq s} \times \theta^{t-s}\Psi_s\Big) \text{ for all } t,s \geq 0$$
$$\text{where } \Psi_t \equiv 1-(1-\beta\theta)\sum_{s=0}^{t-1}\theta^{t-s}\Psi_s = 1-\theta+\beta\theta^2\Psi_{t-1},\ \Psi_0 = 1. \tag{C31}$$

That is,

$$\mathcal{C}_{\tau}^{OLG} = (1-\beta\theta) \times \begin{pmatrix} \Psi_0 & \beta\theta & (\beta\theta)^2 & \dots \\ \theta & \Psi_1 & \beta\theta\Psi_1 & \dots \\ \theta^2 & \theta\Psi_1 & \Psi_2 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}. \tag{C32}$$

Linear Map for Consumption Tax.—The aggregate consumption demand response of the OLG economy at time t to a one-off decrease in the consumption tax at time s is given by

$$\begin{aligned} \mathcal{C}_{\tau_c}^{OLG}(t,s) &= (1-\beta\theta)(1-\gamma)\Big(\mathbf{1}_{t<s} \times (\beta\theta)^{s-t}\Psi_t + \mathbf{1}_{t\geq s} \times \theta^{t-s}\Psi_s\Big) + \gamma \times I \\ &= (1-\gamma) \times \mathcal{C}_{\tau}^{OLG}(t,s) + \gamma \times \mathbf{1}_{t=s} \text{ for all } t,s \geq 0. \end{aligned} \tag{C33}$$

That is,

$$\mathcal{C}_{\tau_c}^{OLG} = (1-\beta\theta)(1-\gamma) \times \begin{pmatrix} \Psi_0 & \beta\theta & (\beta\theta)^2 & \dots \\ \theta & \Psi_1 & \beta\theta\Psi_1 & \dots \\ \theta^2 & \theta\Psi_1 & \Psi_2 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} + \gamma \times \begin{pmatrix} 1 & 0 & 0 & \dots \\ 0 & 1 & 0 & \dots \\ 0 & 0 & 1 & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}. \tag{C34}$$

C.4 Tractable Heterogeneous-Agent Model

Previous sections describe how never constrained, permanent-income consumers and always constrained, hand-to-mouth consumers respond to transfers and consumption tax cuts. This section studies the case of an intermediate household, which is currently unconstrained (ie has positive asset holdings and behaves according to its Euler equation) but faces the risk of becoming constrained in the future. We draw on the tractable HANK framework proposed by Bilbiie (2021).

C.4.1 The Consumption-Savings Problem

A household is currently of type saver S. Each period, the household remains saver with probability θ and becomes spender H with probability $1-\theta$. If it turns spender, the household consumes all its bonds and then lives hand to mouth, ie it never saves again. Let $V^S(b_{t-1}^S)$ be the value function of a household with asset holdings b_{t-1}^S. The agent solves

$$V^S(b_{t-1}^S) = \max_{c_t^S, b_t^S} u(c_t^S) + \beta E_t\left[\theta V^S(b_t^S) + (1-\theta)V^H(b_t^S)\right] \tag{C35}$$

$$\text{subject to} \quad (1+\tau_{ct})c_t^S + b_t^S = (1-\tau_{\ell t})w_t\ell_t + (1+r_t)b_{t-1}^S + \tau_t + d_t, \tag{C36}$$

where a spender's value function is $V^H(b^S_{t-1}) = u(c^H_t)$ and budget constraint is

$$(1+\tau_{ct})c^H_t = (1-\tau_{\ell t})w_t\ell_t + (1+r_t)b^S_{t-1} + \tau_t. \tag{C37}$$

Optimization yields the following Euler equation

$$u'(c^S_t) = \beta(1+r_{t+1})\frac{1+\tau_{ct}}{1+\tau_{ct+1}}E_t\left[\theta u'(c^S_{t+1}) + (1-\theta)u'(c^H_{t+1})\right]. \tag{C38}$$

The presence of the term $(1-\theta)u'(c^H_{t+1})$ in (C38) indicates that the household engages in precautionary savings by demanding more bonds, thereby consuming less, than a permanent-income consumer would do. This is because the household self-insures against the possibility of becoming hand-to-mouth in the future. Equations (C36), (C37), and (C38) characterize the partial-equilibrium consumption-savings behavior of the household, holding constant its labor supply.

C.4.2 Linear Maps

Normalize $\bar{c}^S = \bar{c}^H = 1$. The linearized system reads, setting $\widehat{d}_t = \widehat{i}_t = \widehat{\ell}_t = \widehat{\pi}_t = \widehat{w}_t = 0$

$$\widehat{b}^S_t = \frac{1}{\beta}\widehat{b}^S_{t-1} - \widehat{c}^S_t + \widehat{\tau}_t - \widehat{\tau}_{ct} \tag{C39}$$

$$\theta\widehat{c}^S_{t+1} + (1-\theta)\widehat{c}^H_{t+1} = \widehat{c}^S_t - \gamma\widehat{\tau}_{ct+1} + \gamma\widehat{\tau}_{ct} \tag{C40}$$

$$\widehat{c}^H_{t+1} = \frac{1}{\beta}\widehat{b}^S_t + \widehat{\tau}_{t+1} - \widehat{\tau}_{ct+1}. \tag{C41}$$

Plug (C41) into (C40)

$$\widehat{b}^S_t = \frac{1}{\beta}\widehat{b}^S_{t-1} - \widehat{c}^S_t + \widehat{\tau}_t - \widehat{\tau}_{ct} \tag{C42}$$

$$(1-\theta)\frac{1}{\beta}\widehat{b}^S_t + \theta\widehat{c}^S_{t+1} = \widehat{c}^S_t - (1-\theta)\widehat{\tau}_{t+1} + \gamma\widehat{\tau}_{ct} + (1-\theta-\gamma)\widehat{\tau}_{ct+1}. \tag{C43}$$

Express the system in matrix form

$$A_1\begin{bmatrix}\widehat{b}^S_t\\ \widehat{c}^S_{t+1}\end{bmatrix} = A_0\begin{bmatrix}\widehat{b}^S_{t-1}\\ \widehat{c}^S_t\end{bmatrix} + B_0\begin{bmatrix}\widehat{\tau}_t\\ \widehat{\tau}_{t+1}\\ \widehat{\tau}_{ct}\\ \widehat{\tau}_{ct+1}\end{bmatrix},$$
$$A_1 \equiv \begin{bmatrix}1 & 0\\ \frac{1-\theta}{\beta} & \theta\end{bmatrix},\quad A_0 \equiv \begin{bmatrix}1/\beta & -1\\ 0 & 1\end{bmatrix},\quad B_0 \equiv \begin{bmatrix}1 & 0 & -1 & 0\\ 0 & -(1-\theta) & \gamma & 1-\theta-\gamma\end{bmatrix}. \tag{C44}$$

Since A_1 is invertible, multiply by A_1^{-1} on both sides to simplify the system to

$$\begin{bmatrix}\widehat{b}^S_t\\ \widehat{c}^S_{t+1}\end{bmatrix} = A\begin{bmatrix}\widehat{b}^S_{t-1}\\ \widehat{c}^S_t\end{bmatrix} + B\begin{bmatrix}\widehat{\tau}_t\\ \widehat{\tau}_{t+1}\\ \widehat{\tau}_{ct}\\ \widehat{\tau}_{ct+1}\end{bmatrix},\ A \equiv A_1^{-1}A_0,\ B \equiv A_1^{-1}B_0. \tag{C45}$$

As before, apply a Jordan decomposition to matrix $A = D\Lambda D^{-1}$, multiply by D^{-1} on both sides, and define

$$\begin{bmatrix} \tilde{b}_t^S \\ \tilde{c}_{t+1}^S \end{bmatrix} \equiv D^{-1} \begin{bmatrix} \widehat{b}_t^S \\ \widehat{c}_{t+1}^S \end{bmatrix} \quad \text{and} \quad \tilde{B} \equiv D^{-1}B.$$

The second row of the resulting system reads

$$\tilde{c}_{t+1}^S = \frac{1}{\Psi\theta}\tilde{c}_t - \frac{1-\theta}{\Psi\theta\chi}\widehat{\tau}_t - \frac{(1-\theta)^2}{\omega\theta\chi}\widehat{\tau}_{t+1} + \frac{1+\beta\gamma-\theta(1+\Psi\gamma)}{\Psi\theta\chi}\widehat{\tau}_{ct} + \frac{(1-\theta)(1-\gamma-\theta)}{\omega\theta\chi}\widehat{\tau}_{ct+1}, \tag{C46}$$

where we define the following parameters to lighten notation

$$\omega \equiv \frac{2(1-\theta)}{1+\beta+\chi-2\theta}; \quad \Psi \equiv \frac{2\beta}{1+\beta+\chi}; \quad \chi \equiv \sqrt{(1-\beta)^2+4\beta(1-\theta)}.$$

Solve for $\tilde{c}_t^S$, iterate forward and plug in $\widehat{c}_t^S = \frac{\omega}{\beta}\widehat{b}_{t-1}^S + \frac{\omega\chi}{1-\theta}\tilde{c}_t^S$

$$\widehat{c}_t^S = \frac{\omega}{\beta}\widehat{b}_{t-1}^S + \sum_{t=0}^{\infty}(\Psi\theta)^s\left[\omega(\widehat{\tau}_{t+s}-\widehat{\tau}_{ct+s}) + \Psi(1-\theta)(\widehat{\tau}_{t+1+s}-\widehat{\tau}_{ct+1+s}) - \Psi\gamma(\widehat{\tau}_{ct+s}-\widehat{\tau}_{ct+1+s})\right]. \tag{C47}$$

This expression gives the policy rule for a saver's consumption demand, $\widehat{c}_t^S$, given an initial level of wealth, $\widehat{b}_{t-1}^S$, and the paths for the policy shocks, $\widehat{\tau}_t$ and $\widehat{\tau}_{ct}$. The last term of (C47) captures the difference between the transfer and tax two policies.

Linear Map for Transfers.—The period t consumption demand response of an individual saver household facing a risk of becoming spender in the future to a one-off increase in transfers at time s is given by

$$\begin{aligned} \frac{\partial\widehat{c}_t^S}{\partial\widehat{\tau}_s} &= \mathbf{1}_{t<s} \times \Psi^{s-t}\theta^{s-1-t}\beta\frac{\omega}{\Psi}\left[1-\omega\sum_{k=0}^{t-1}\left(\frac{\Psi\theta}{\beta}\right)^{k+1}(1-\omega)^k\right] \\ &\quad + \mathbf{1}_{t\geq s} \times \beta^{-(t-s)}(1-\omega)^{t-s}\frac{\partial\widehat{c}_s^S}{\partial\widehat{\tau}_s} \quad \text{for all } t, s, \end{aligned} \tag{C48}$$

where the elements on the diagonal (ie the contemporaneous MPCs) satisfy

$$\frac{\partial\widehat{c}_s^S}{\partial\widehat{\tau}_s} = \left[1-\omega\sum_{k=0}^{s-1}\left(\frac{\Psi\theta}{\beta}\right)^k(1-\omega)^k\right]\omega \ \text{ for all } s \geq 0; \quad \frac{\partial\widehat{c}_0^S}{\partial\widehat{\tau}_0} = \omega. \tag{C49}$$

Linear Map for Consumption Tax.—The consumption demand response of an individual saver to changes in consumption taxes is given by

$$\begin{aligned} \frac{\partial\widehat{c}_t^S}{-\partial\widehat{\tau}_{cs}} &= \mathbf{1}_{t<s} \times \Psi^{s-t}\theta^{s-1-t}\left[\beta\frac{\omega}{\Psi}-\gamma(1-\Psi\theta)\right]\left[1-\omega\sum_{k=0}^{t-1}\left(\frac{\Psi\theta}{\beta}\right)^{k+1}(1-\omega)^k\right] \\ &\quad + \mathbf{1}_{t=s} \times \frac{\partial\widehat{c}_s^S}{-\partial\widehat{\tau}_{cs}} + \mathbf{1}_{t>s} \times \left[\beta^{-(t-s)}(1-\omega)^{t-s}\frac{\partial\widehat{c}_s^S}{-\partial\widehat{\tau}_{cs}} + \beta^{-(t-s)}(1-\omega)^{t-s-1}\Psi\gamma\right], \end{aligned} \tag{C50}$$

where the elements on the diagonal satisfy

$$\frac{\partial\widehat{c}_s^S}{-\partial\widehat{\tau}_{cs}} = \left[1-\left(\omega-\frac{\Psi}{\beta}\gamma(1-\Psi\theta)\right)\sum_{k=0}^{s-1}\left(\frac{\Psi\theta}{\beta}\right)^k(1-\omega)^k\right]\omega + \Psi\gamma \text{ for all } s. \tag{C51}$$

D Supplementary Results

D.1 Property of the Linear Maps

In their Proposition 1, Auclert, Rognlie, and Straub (2023) derive an important property of the linear map for transfers: all columns of $\mathcal{C}_\tau$ sum to one in present value. We confirm this result and show it also applies to the linear map for consumption taxes $\mathcal{C}_{\tau_c}$. Aggregate the household budget constraint (2) and set $\widehat{\pi}_t = \widehat{w}_t = \widehat{\ell}_t = \widehat{d}_t = 0$

$$(1+\bar{\tau}_c)\widehat{c}_t + \widehat{\tau}_{ct} + \widehat{b}_t = \frac{1}{\beta}\widehat{b}_{t-1} + \widehat{\tau}_t. \tag{D52}$$

Solve the equation forward

$$\sum_{t=0}^{\infty} \beta^t \widehat{c}_t = \frac{1}{\beta(1+\bar{\tau}_c)}\widehat{b}_{t-1} + \frac{1}{1+\bar{\tau}_c}\sum_{t=0}^{\infty}\beta^t\left(\widehat{\tau}_t - \widehat{\tau}_{ct}\right). \tag{D53}$$

Take partial derivatives with respect to transfers $\widehat{\tau}_s$ and consumption taxes $\widehat{\tau}_{cs}$

$$\begin{aligned} \sum_{t=0}^{\infty}\beta^t \mathcal{C}_\tau(t,s) &= \sum_{t=0}^{\infty}\beta^t \frac{\partial \widehat{c}_t}{\partial \widehat{\tau}_s} = \frac{\beta^s}{1+\bar{\tau}_c} \\ \sum_{t=0}^{\infty}\beta^t \mathcal{C}_{\tau_c}(t,s) &= \sum_{t=0}^{\infty}\beta^t \frac{\partial \widehat{c}_t}{-\partial \widehat{\tau}_{cs}} = \frac{\beta^s}{1+\bar{\tau}_c}. \end{aligned} \tag{D54}$$

If $\bar{\tau}_c = 0$, the columns of $\mathcal{C}_\tau$ and $\mathcal{C}_{\tau_c}$ sum to one in present value.

D.2 Comparing Linear Maps in Analytical Models

In Section 2.2, we discuss the first-period impact response of consumption demand to transfers, $\mathcal{C}_\tau(0,0)$, and consumption tax cuts, $\mathcal{C}_{\tau_c}(0,0)$. This section generalizes the results to all elements on the diagonal. In addition, we compare the present-value cumulative responses to each policy.

Permanent-Income Consumers.—Evaluate the elements on the main diagonal of each map in (11) and (12)

$$\mathcal{C}^R_{\tau_c}(s,s) - \mathcal{C}^R_\tau(s,s) \;= \gamma\left[1-\beta^s(1-\beta)\right] \;> 0 \text{ for all } s. \tag{D55}$$

The contemporaneous response of aggregate consumption demand is larger under the consumption tax policy than under the transfer policy. Now, compare the present discounted sum of the elements of each column between the two maps

$$\begin{aligned} \sum_{t=0}^{H}\beta^t\left[\mathcal{C}^R_{\tau_c}(t,s) - \mathcal{C}^R_\tau(t,s)\right] &= \beta^s\gamma + \sum_{t=0}^{H}\beta^{t+s}(1-\beta)(1-\gamma) - \sum_{t=0}^{H}\beta^{t+s}(1-\beta) \\ &= \gamma\beta^{H+s+1} \;> 0 \text{ for all } H. \end{aligned} \tag{D56}$$

At any finite horizon, the present-value cumulative aggregate consumption demand response is larger under the consumption tax policy than under the transfer policy. Thus in RANK, $\mathcal{C}^R_{\tau_c}(s,s) > \mathcal{C}^R_\tau(s,s)$ and $\sum_{t=0}^{H}\beta^t\mathcal{C}^R_{\tau_c}(t,s) > \sum_{t=0}^{H}\beta^t\mathcal{C}^R_\tau(t,s)$ for all t, s, and H.

Spenders and Savers.—From (15), we see that spenders' responses to transfers and taxes are identical. Recall that in TANK

$$\mathcal{C}_{\tau}^{T} = (1-\lambda) \times \mathcal{C}_{\tau}^{R} + \lambda \times \mathcal{C}_{\tau}^{H}; \quad \mathcal{C}_{\tau_c}^{T} = (1-\lambda) \times \mathcal{C}_{\tau_c}^{R} + \lambda \times \mathcal{C}_{\tau_c}^{H}. \tag{D57}$$

It follows that $\mathcal{C}_{\tau_c}^{T}(s,s) > \mathcal{C}_{\tau}^{T}(s,s)$ and $\sum_{t=0}^{H} \beta^t \mathcal{C}_{\tau_c}^{T}(t,s) > \sum_{t=0}^{H} \beta^t \mathcal{C}_{\tau}^{T}(t,s)$ for all t, s, and H.

Overlapping Generations.—Evaluate the elements on the main diagonal of each map in (16) and (17), using the fact that $\mathcal{C}_{\tau}^{OLG}(s,s) = \Psi_s < 1$ for all s

$$\mathcal{C}_{\tau_c}^{OLG}(s,s) - \mathcal{C}_{\tau}^{OLG}(s,s) = \gamma \left[1 - \mathcal{C}_{\tau}^{OLG}(s,s)\right] > 0 \text{ for all } s. \tag{D58}$$

The contemporaneous response of aggregate consumption demand is larger under the consumption tax policy than under the transfer policy. Now, compare the present discounted sum of each column

$$\begin{aligned}\sum_{t=0}^{H} \beta^t \left[\mathcal{C}_{\tau_c}^{OLG}(t,s) - \mathcal{C}_{\tau}^{OLG}(t,s)\right] &= \beta^s \gamma - \gamma(1-\beta\theta) \left(\sum_{t=0}^{s-1} \beta^t (\beta\theta)^{s-t} \Psi_t + \sum_{t=s}^{H} \beta^t \theta^{t-s} \Psi_s\right) \\ &= \beta^s \gamma \left(\underbrace{1 - (1-\beta\theta) \sum_{t=0}^{s-1} \theta^{s-t} \Psi_t}_{=\Psi_s} - (1-\beta\theta)\Psi_s \sum_{t=0}^{H-s} (\beta\theta)^t \right) \\ &= \beta^s \gamma \Psi_s (\beta\theta)^{H-s+1} > 0 \text{ for all } H.\end{aligned} \tag{D59}$$

At any finite horizon, the cumulative response of aggregate consumption demand is larger under the consumption tax policy than under the transfer policy. Thus in OLG, $\mathcal{C}_{\tau_c}^{OLG}(s,s) > \mathcal{C}_{\tau}^{OLG}(s,s)$ and $\sum_{t=0}^{H} \beta^t \mathcal{C}_{\tau_c}^{OLG}(t,s) > \sum_{t=0}^{H} \beta^t \mathcal{C}_{\tau}^{OLG}(t,s)$ for all t, s, and H.

Heterogeneous Households.—The linear maps of an individual saver facing a risk θ of becoming spender next period are given by (C48) and (C50). Recall, $\chi = \sqrt{(1-\beta)^2 + 4\beta(1-\theta)}$, $\Psi = \frac{2\beta}{1+\beta+\chi}$, and $\omega = \frac{2(1-\theta)}{1+\beta+\chi-2\theta}$. Therefore

$$0 < 1-\beta < \chi < 1+\beta; \quad 0 < \frac{\beta}{1+\beta} < \Psi < \beta; \quad 1-\beta < \omega < 1,$$

where the inequality $\omega > 1-\beta$ comes from the fact that $\frac{\partial \omega(\theta)}{\partial \theta} = -\frac{4(1-\theta)(\beta\chi^{-1}+1)}{(1+\beta+\chi-2\theta)^2} - \frac{2}{1+\beta+\chi-2\theta} < 0$ for $\theta \in (0,1)$ and $\lim_{\theta \to 1} \omega(\theta) = 1-\beta$. Use these relations to compare the entries on the main diagonal of each map in (C49) and (C51)

$$\frac{\partial \widehat{c}_s^S}{-\partial \widehat{\tau}_{cs}} - \frac{\partial \widehat{c}_s^S}{\partial \widehat{\tau}_s} = \Psi\gamma + \omega\gamma(1-\Psi\theta) \sum_{k=0}^{s-1} \left(\frac{\Psi}{\beta}\right)^{k+1} \theta^k (1-\omega)^k > 0 \text{ for all } s. \tag{D60}$$

The contemporaneous response of a saver's consumption demand is larger under the consumption tax policy than under the transfer policy. Now, compute the present discounted sum of each column of each map

$$\sum_{t=0}^{H} \beta^t \frac{\partial \widehat{c}_t^S}{\partial \widehat{\tau}_s} = \beta^s \left\{ 1 - (1-\omega)^{H-s+1} \left[1 - \omega \sum_{k=0}^{s-1} \left(\frac{\Psi\theta}{\beta}(1-\omega) \right)^k \right] \right\} \tag{D61}$$

$$\sum_{t=0}^{H} \beta^t \frac{\partial \widehat{c}_t^S}{-\partial \widehat{\tau}_{cs}} = \beta^s \left\{ 1 - (1-\omega)^{H-s+1} \left[1 - \left(\omega - \frac{\Psi}{\beta}\gamma(1-\Psi\theta) \right) \sum_{k=0}^{s-1} \left(\frac{\Psi\theta}{\beta}(1-\omega) \right)^k - \frac{\Psi\gamma}{1-\omega} \right] \right\}.$$

Take the difference

$$\begin{aligned} \sum_{t=0}^{H} \beta^t \left[\frac{\partial \widehat{c}_t^S}{-\partial \widehat{\tau}_{cs}} - \frac{\partial \widehat{c}_t^S}{\partial \widehat{\tau}_s} \right] &= \Psi\gamma(1-\omega)^{H-s+1} \left[\frac{\beta^s}{1-\omega} - (1-\Psi\theta) \frac{\beta^s - (\Psi\theta)^s(1-\omega)^s}{\beta - \Psi\theta(1-\omega)} \right] \\ &> \Psi\gamma(1-\omega)^{H-s+1} \left[\frac{\beta^s}{1-\omega} - (1-\Psi\theta) \frac{\beta^s - 0}{\beta - \Psi\theta(1-\omega)} \right] \\ &= \Psi\gamma(1-\omega)^{H-s+1} \beta^s \frac{\beta - (1-\omega)}{(1-\omega)[\beta - \Psi\theta(1-\omega)]} > 0 \text{ for all } H. \end{aligned} \tag{D62}$$

At any finite horizon, the cumulative response of an individual saver's consumption demand is larger under the consumption tax policy than under the transfer policy. We conclude that in all models, $\mathcal{C}_{\tau_c}(s,s) > \mathcal{C}_{\tau}(s,s)$ and $\sum_{t=0}^{H} \beta^t \mathcal{C}_{\tau_c}(t,s) > \sum_{t=0}^{H} \beta^t \mathcal{C}_{\tau}(t,s)$ for all t, s, and H.