Fiscal Management of Aggregate Demand: The Effectiveness of Labor Tax Credits*

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Abstract

We use a quantitative heterogeneous agent model with nominal rigidities and unemployment risk to analyze the effectiveness of several fiscal policies in stabilizing a demand-driven recession. The model delivers empirically realistic distributions of marginal propensities to consume (*mpc*) and labor participation elasticities (*lpe*) and matches the cross-sectional incidence of unemployment risk over the business cycle. We consider three fiscal stabilization packages: (*i*) a transfer to all low-income households, (*ii*) an increase in unemployment benefits to unemployed households, and (*iii*) an increase in labor tax credits to low-income working households. The labor tax credit is the most effective package to attenuate the recession, as it targets both high-*mpc* and high-*lpe* households and thus jointly stimulates labor and consumption. This result holds despite the recession resulting in higher unemployment risk.

Keywords: Heterogeneous Agents, Fiscal Policy, Optimal Taxation, Redistribution, Business Cycle.
JEL: E21, E62, H21, H23, H53.

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1 Introduction

The stabilization of business cycle fluctuations has long been a key discussion in policy debates. Ample research has analyzed the stabilization properties of monetary policy, with the policy rate as its main instrument, and of fiscal policy, with instruments such as government spending, unemployment benefits, and lump-sum checks. Less attention, however, has been devoted to the stabilization properties of labor income taxes.[1] This is somewhat surprising, given the large expansionary effects that empirical work finds after labor tax cuts (Mertens and Ravn 2013; Zidar 2019). In this paper, we aim to fill this gap by analyzing the effectiveness of the cross section of labor taxes in managing aggregate demand during a recession and stabilizing business cycle fluctuations.

To this end, we develop a quantitative Heterogeneous Agents New Keynesian (HANK) model that includes a rich set of fiscal policies, including a cross section of labor taxes. The model features an empirically realistic cross section of marginal propensities to consume (*mpc*) and labor participation elasticities (*lpe*), which makes it suitable to analyze policies on households with heterogeneous responses to taxes. Additionally, the model features a cross section of unemployment risk that varies with the business cycle, reflecting weak labor demand conditions during a recession. We use the model as a laboratory to evaluate different stabilization policies during a demand-driven recession. We find that labor tax cuts concentrated on low-income households are a powerful stabilization policy.

We add three features to an off-the-shelf HANK model: an extensive labor supply decision (Chang and Kim 2007), heterogeneous discount factors (Carroll et al. 2017), and an Okun's law type of relation between output and the probability of being unemployed (Okun 1973). The extensive labor supply assumption implies that *lpe* decline with income, as high-income earners have exceptional labor market opportunities and are thus less likely to exit the labor force. Similarly, high discount factor households accumulate more wealth and thus exhibit lower *mpc*. Additionally, the ad hoc Okun's law enables us to incorporate a cross section of unemployment risk, that is higher for low-income workers as well as more responsive during a recession. As we discuss below, these cross-sectional patterns for *lpe*, *mpc*, and unemployment risk are key to assess the effects of different fiscal policies.

In this environment, we consider a demand-driven recession induced by a decline in households' willingness to consume (Huo and Ríos-Rull 2020; Smets and Wouters 2007). We evaluate three fiscal packages in response to the recession. First, a targeted transfer (TT) package, which temporarily increases transfers to all low-income households regardless of their employment status. Second, an unemployment insurance (UI) package, which temporarily increases unemployment benefits to all unemployed households. And third, a tax credit (TC) package, which temporarily increases labor tax credits for low-

[1] We review the existing literature in Section 1.1.

income employed households—that is, the TC package implements a targeted cut on labor income taxes. We design all three packages so that they amount to the same total spending, financed with a mix of government debt increases and tax adjustments.

While all three fiscal policies mitigate the recession, their effectiveness varies. The TT package mitigates the one-year cumulative output contraction by roughly one-fifth, the UI package mitigates the contraction by one-third, and the TC package mitigates it by almost one-half. It is also useful to report cumulative multipliers at one year—that is, the cumulative output gain relative to no policy per each dollar spent in the package. After one year, the TT package yields a multiplier of 0.37, the UI package's multiplier is 0.60, and the TC multiplier is 0.90. Thus, the TC package is substantially more effective in stabilizing output.

The fiscal packages operate through two margins: a *consumption channel* and a *labor supply channel*. The TT package operates through the *consumption channel* only, by targeting transfers to low-income households with high *mpc*. In fact, the TT package may have a detrimental *labor supply channel* effect, as wealth effects on workers receiving a check may contract labor supply. The UI package also operates through the *consumption channel* only. However, as unemployed workers feature higher *mpc* than working households, the consumption response to the fiscal stimulus is larger than in the TT package. The TC package is the only one to operate through both the *consumption channel* and the *labor supply channel*. The tax cuts target low-income workers who exhibit the larger *lpe*, thus providing strong *labor supply channel* effects. At the same time, these low-income workers have higher *mpc*, thus stimulating *consumption channel* effects. In turn, among the options we consider, the TC package proves to be the most effective in stimulating aggregate demand and reducing the depth of the recession.

The effectiveness of the TC package may raise concerns about the strength of the *labor supply channel* in our model. We argue this is not the case: The model-implied *lpe* distribution is conservative, and the unemployment dynamics are well empirically founded. In particular, the benchmark calibration implies moderate *lpe*: average *lpe* of 0.30, ranging between 0.45 for the bottom quartile and 0.2 for the top quartile. Additionally, we replicate the labor tax cuts experiments of Mertens and Ravn (2013) and Zidar (2019) in our mode and obtain aggregate effects of labor tax cuts smaller than what they empirically estimate. An alternative calibration with average *lpe* of 0.50 brings the model closer to the aggregate evidence on labor tax cuts and generates even larger TC multipliers, well above unity.

Similarly, the calibration features empirically realistic dynamics of unemployment risk over the business cycle. Although in an ad hoc manner, the Okun's law relation in our model captures the business cycle properties of unemployment risk and, in particular, the cross-sectional incidence of unemployment risk over the business cycle (Mueller

2017). Still, we find the TC to be the most effective fiscal policy to stabilize a recession. Thus, we think the strength of the *labor supply channel* is well disciplined by evidence.

Finally, we also compare the three packages with two other stabilization packages often explored in the literature: a one-time lump-sum check to all households, labeled "T package", and an increase in government spending, labeled "G package". The T package has a small capacity to stabilize the recession, as it fails to target low-*mpc* workers. The G package has large effects on output but crowds out private consumption, a shortcoming that the TC package does not have.

Overall, our findings contribute to understanding the effectiveness of fiscal tools in managing aggregate demand during a recession through the lens of a New Keynesian model with heterogeneity, a framework that has been increasingly used for policy analysis. We argue that labor taxes should be included in the toolkit that policymakers have. Unlike other policies typically used, labor tax cuts can stimulate both demand and supply, thus making them an attractive alternative.

1.1 Literature Review

This paper contributes to the rapidly growing literature using HANK models to analyze the effects of fiscal and monetary policies—see Kaplan, Moll, and Violante (2018), Bilbiie (2020), Auclert, Rognlie, and Straub (2023), Bayer, Born, and Luetticke (2023) and Ferriere and Navarro (2024), among many others. Optimal fiscal and monetary policy using quantitative HANK environemn has been considered in Bhandari et al. (2021), Le Grand, Martin-Baillon, and Ragot (2022), McKay and Wolf (2023), all of which discuss the stabilizing properties of fiscal policy. The work in McKay and Reis (2021) analyzes the optimal time-invariant progressivity of the taxes-and-transfers system in the presence of business cycle fluctuations. Bayer et al. (2019) analyzes the business cycle properties of a rich environment with liquid and illiquid assets in which, as in our model, idiosyncratic risk increases in recessions.

Our work is closely related to a literature on automatic stabilizers. Recent quantitative work measuring the effectiveness of fiscal policies as automatic stabilizers includes Oh and Reis (2012), Di Maggio and Kermani (2016), Mitman and Rabinovich (2015), and Mitman and Rabinovich (2021).[2] Our work is closer to McKay and Reis (2016), who also use a HANK model—including an ad hoc unemployment Okun's type of relation, as we do—to measure the effectiveness of commonly used fiscal packages in stabilizing business cycle fluctuations. Our work differs in that we model households' labor supply decisions with an extensive margin, resulting in an empirically realistic *lpe* profile across households,

[2]Empirical work measuring the effectiveness of automatic stabilizers can be found in Auerbach and Feenberg (2000) and Fatás and Mihov (2012).

which we show to be key in assessing the effects of the TC package. Indeed, McKay and Reis (2016) find a very limited effect of labor income taxes in stabilizing business cycle fluctuations.

A recent literature has also used quantitative HANK models to discuss the expansionary effects of unemployment benefits extensions. See Kekre (2022) for a rich model with search frictions on the labor market; Gorn and Trigari (2024) for a tractable model with analytical characterization of the effects of unemployment benefits extensions; Bardoczy and Guerreiro (2023) for a focus on the role of expectations; and Bayer et al. (2023) for an analysis of unemployment benefits policies implemented during the pandemic period.

Two recent papers point out at the importance of labor taxes to stimulate the economy. In a HANK set-up with search-and-matching frictions but exogenous labor supply, Broer et al. (2025) show that a temporary labor subsidy to firms can be more expansionary than a temporary extension of UI benefits. Closer to our paper, Le Grand, Ragot, and Bourany (2024) argue that time-varying flat labor taxes are a powerful instrument to stabilize demand shocks in a standard HANK environment. To the best of our knowledge, our work contributes to the literature by focusing on labor taxes that may vary over the business cycle in a targeted manner. In this sense, our quantitative analysis echoes the analytical work in Bilbiie, Monacelli, and Perotti (2021), who explicitly consider changes in the distribution of taxes in a two-agent New Keynesian environment.

Finally, an additional contribution of our paper is to make progress in reconciling micro estimates of labor elasticities and the larger macro estimates of tax multipliers (Mertens and Ravn 2013; Zidar 2019).

Section 2 describes the model and Section 3 its calibration. Section 4 quantifies the effects of fiscal stabilizers in this environment. Section 5 considers various robustness exercises. Section 6 concludes.

2 Model

In this section, we develop a HANK model to study the effects of various fiscal polices during a recession. We introduce heterogeneity in discount factors and an extensive labor supply decision, to generate heterogeneity in *mpc* and *lpe* in line with the data. We also introduce unemployment risk, with unequal incidence in the distribution. We describe the model environment and equilibrium.

2.1 Environment

Time is discrete and indexed by $t = 0, 1, 2, \ldots, \infty$. The economy is populated by a continuum of households, intermediate-good producers, a final-good producer, a monetary authority, and a fiscal authority. Households supply labor to intermediate-good producers, who sell their goods to final-good producers. Intermediate-good producers are under monopolistic competition and face a cost of adjusting prices as in Rotemberg (1982). For simplicity, we consider deterministic transition dynamics and use time t to denote the aggregate state of the economy.

Households.—Households value consumption and leisure and face idiosyncratic labor income and unemployment risk. Their labor productivity x follows an exogenous stationary Markov process with transition probabilities $\pi_x(x'|x)$. Their employment status η follows an exogenous time-varying Markov process $\pi_{\eta,t}(\eta|\eta_-, x)$. That is, employment status this period depends on past employment status η_-, current productivity x, and the state of the economy captured by t. A household with $\eta = \ell$ faces an indivisible labor supply choice: they can either work $\bar{h}$ hours or zero (Chang and Kim 2007). A household with $\eta = u$ is unemployed and faces no labor supply decision.

Households have differences in their discount factor β, which evolves stochastically following a Markov chain $\pi_\beta(\beta'|\beta)$ (Krusell and Smith 1998). Labor productivity, unemployment, and discount factor shocks are uninsurable: Households can only trade a one-period risk-free bond to self-insure, subject to a nonborrowing limit.

Let $V_t(a, x, \eta, \beta)$ be the maximal attainable value in period t to a household with assets a, idiosyncratic productivity x, unemployment status η and discount factor β. The value when the household is employed, $\eta = \ell$, is given as

$$\begin{aligned} V_t(a, x, \ell, \beta) &= \max_{c,h,a'} \{\log(c) - Bh + \beta \mathbb{E}_t [V_{t+1}(a', x', \eta', \beta')|x, \ell, \beta)]\} \qquad (1) \\ \text{subject to} & \\ c + a' &\leq a + y^\ell + y^k - \mathcal{T}_t(y^\ell, y^k) + T_t + \tilde{d}_t(x), \\ y^\ell &= w_t x h, \quad h \in \{0, \bar{h}\}, \\ y^k &= r_t a, \qquad a' \geq 0, \end{aligned}$$

where c and h denote consumption and hours worked, respectively; w_t denotes wages perceived by households; and r_t denote the real return on households' savings. Households face a distortionary tax $\mathcal{T}_t(y^\ell, y^k, e)$—which depends on labor income $y^\ell = w_t x h$ and capital earnings $y^k = r_t a$—and receive a lump-sum transfer T_t. Finally, $\tilde{d}_t(x)$ represents the dividend payments received from firms in the economy, which we discuss in more detail below.

As is often the case in discrete choice models, we add a preference shock ϵ_h for each possible level of working hours: $h \in \{0, \bar{h}\}$. The preference shock follows a Gumbel distribution with variance ϱ.[3] Let $\mathbb{h}_t^h(a, x, \ell, \beta)$ be the probability of working h hours at time t, and let $c_t^h(a, x, \ell, \beta)$ and $a_t^{h\prime}(a, x, \ell, \beta)$ denote a household's optimal policies conditional

[3] Rust (1997) initially proposed using a Gumbel preference shock in dynamic discrete-choice models. See Ferriere and Navarro (2024) for a more recent application.

on working h hours. Finally, denote $h_t(a,x,\ell,\beta) = \sum_h h\mathbb{h}_t^h(a,x,\ell,\beta)$, $c_t(a,x,\ell,\beta) = \sum_h c_t^h(a,x,\ell,\beta)\mathbb{h}_t^h(a,x,\ell,\beta)$, and $a_t'(a,x,\ell,\beta) = \sum_h a_t^{h\prime}(a,x,\ell,\beta)\mathbb{h}_t^h(a,x,\ell,\beta)$ as the expected policies.

The value when the household is unemployed, $\eta = u$, is given as

$$
\begin{aligned}
V_t(a,x,u,\beta) &= \max_{c,a'} \left\{ \log(c) - B\bar{h} + \beta \mathbb{E}_t \left[V_{t+1}(a',x',\eta',\beta') | x,u,\beta \right] \right\} \qquad (2)\\
&\text{subject to}\\
c + a' &\leq a + y^k - \mathcal{T}_t(0,y^k) + \mathcal{B}_t(w_t x) + T_t + d_t^h(x),\\
y^k &= r_t a, \qquad a' \geq 0.
\end{aligned}
$$

While unemployed, the household faces labor disutility $B\bar{h}$. This assumption, akin to a disutility cost of searching for a job, is irrelevant for business cycle dynamics, as there is no endogenous search decision in the model. The household receives unemployment benefits of the form:

$$
\mathcal{B}_t(w_t x) = \zeta \min(\rho w_t x \bar{h}, \bar{ui}) + \chi w_t x \bar{h}. \qquad (3)
$$

The first part of the unemployment benefit function mimics the standard statutory benefit, with ζ as the eligibility rate for unemployment benefits, ρ as the replacement rate, and $\bar{ui}$ as the maximum benefit level. We assume that unemployment benefits are exempt of taxation.[4] We follow Kekre (2022) and allow for an additional transfer proportional to the labor income received if employed. As discussed in Kekre (2022), modeling non-UI income as a transfer offers a parsimonious way to capture the earnings of other household members without extending the framework to model dual-income households. We calibrate χ to match the ratio of average consumption of households with $\eta = u$ to the average consumption of households with $\eta = \ell$.

As there is no labor choice when unemployed, we denote $c_t^h(a,x,u,\beta) = c_t(a,x,u,\beta)$, and $a'^h_t(a,x,u,\beta) = a_t'(a,x,u,\beta)$ as the consumption and savings policies of unemployed households, and $h_t^h(a,x,u,\beta) = h_t(a,x,u,\beta) = 0$. Finally, let $\mu_t(a,x,\eta,\beta)$ be the measure of households with state (a,x,η,β).

Unemployment Risk.—We model unemployment risk $\pi_{\eta,t}(\cdot)$ as a function that depends on both idiosyncratic productivity, x, and total output, Y_t. That is, we assume $\pi_{\eta,t}(\eta|\eta_-,x) = \pi_\eta(\eta|\eta_-,x,Y_t)$. Guided by empirical evidence presented in Mueller (2017), we make four key assumptions about unemployment risk. First, we assume that, regardless of the state of the economy, low-productivity workers are more likely to become

[4] We assume unemployment benefits are not taxable to simplify the interpretation of our results, with labor tax policies targeted to employed workers, and unemployment-benefit policies targeted to unemployed workers. The function $\mathcal{B}_t(\cdot)$ could thus be interpreted as after-tax unemployment benefits. Similar assumptions are made in Gorn and Trigari (2024).

unemployed—that is, $\partial \pi_\eta(u|\ell_-, x, Y_t)/\partial x < 0 \; \forall Y_t$. Second, we assume that unemployment is more likely during a recession—that is, $\partial \pi_\eta(u|\ell_-, x, Y_t)/\partial Y_t < 0 \; \forall x$. Third, we assume that unemployment duration is independent of the idiosyncratic productivity—that is, $\pi_\eta(\ell|u_-, x, Y_t) = \pi_\eta(\ell|u_-, \tilde{x}, Y_t) \; \forall x, \tilde{x}$. And fourth, we assume that unemployment duration is longer during recessions—that is, $\partial \pi_\eta(\ell|u_-, x, Y_t)/\partial Y_t > 0$. Section 3 discusses how we calibrate $\pi_\eta(\cdot)$ to match the evidence in Mueller (2017). To ease notation, we use $\pi_{\eta,t}(\eta|\eta_-, x) \equiv \pi_\eta(\eta|\eta_-, x, Y_t)$ onwards.

Final-Good Producers.—A competitive representative final-good producer combines a continuum of intermediate goods—indexed by $j \in [0,1]$—to produce the final good Y_t. Production technology is $Y_t = \left(\int_0^1 y_{jt}^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}$, where $\epsilon > 0$ is the elasticity of substitution across intermediate inputs. Profit maximization for the final-good producers reads

$$\max_{\{y_{jt}\}_j} \left\{ P_t Y_t - \int_0^1 P_{jt} y_{jt} dj : \quad Y_t = \left(\int_0^1 y_{jt}^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}} \right\} \tag{4}$$

where P_t and P_{jt} stand for the nominal price of the final good and the intermediate good, respectively. Optimal demand reads

$$y_{jt}^d = \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} Y_t. \tag{5}$$

Intermediate-Good Producers.—The intermediate good is produced with a linear production function in effective labor n_{jt}. Intermediate-good producers set prices subject to a quadratic price adjustment cost. Let $J_t(P_{jt-1})$ be the maximal attainable value at time t to an intermediate-good producer that posted prices P_{jt-1} last period:

$$J_t(P_{jt-1}) = \max_{P_{jt}, y_{jt}, n_{jt}} \left\{ d_{jt} + \frac{1}{1+r_{t+1}} J_{t+1}\left(P_{jt}\right) \right\} \tag{6}$$

subject to

$$\begin{aligned}
d_{jt} &= \frac{P_{jt}}{P_t} y_{jt} - w_t n_{jt} - \Theta_t(P_{jt}, P_{jt-1}) - \Phi \\
y_{jt} &= \left(\frac{P_{jt}}{P_t}\right)^{-\epsilon} Y_t \\
y_{jt} &= n_{jt} \\
\Theta_t(P_{jt}, P_{jt-1}) &= \frac{\Theta}{2}\left(\frac{P_{jt}}{P_{jt-1}} - \bar{\Pi}\right)^2 Y_t
\end{aligned}$$

where w_t is the wage paid to the households and Φ is a fixed operating cost. The cost of adjusting prices is $\Theta_t(\cdot)$, where $\bar{\Pi}$ is the inflation target of the monetary authority. All firms discount flows at the real rate r_t, which is justified by an arbitrage argument in this economy without aggregate uncertainty.

Intermediate-good producers are all identical, so we focus on a symmetric equilibrium with $P_{jt} = P_t \ \forall j, t$. Optimal decisions yield the usual New Keynesian Phillips curve:

$$\left(\Pi_t - \bar{\Pi}\right)\Pi_t + \frac{\epsilon - 1}{\Theta} = \frac{\epsilon}{\Theta} w_t + \frac{1}{1 + r_{t+1}}\left(\Pi_{t+1} - \bar{\Pi}\right)\Pi_{t+1}\frac{Y_{t+1}}{Y_t}, \tag{7}$$

where wages w_t are the marginal cost of production in this economy.

Fiscal Authority.—The government's budget constraint is given by

$$\begin{aligned} G_t + (1 + r_t)D_t + T_t + \int \mathcal{B}_t(w_t x) d\mu_t(a, x, u, \beta) &= \dots \\ D_{t+1} + \int \mathcal{T}_t(w_t x h_t(a, x, \eta, \beta), r_t a) d\mu_t(a, x, \eta, \beta) \end{aligned} \tag{8}$$

where D_t is the government's debt. As we discuss in detail below, the tax function $\mathcal{T}_t(\cdot)$ incorporates a flat component on capital income and a progressive component on labor income.

Monetary Authority.—Monetary policy is fully described by a Taylor rule that sets the short-term nominal interest rate as

$$\ln\left(\frac{1 + i_{t+1}}{1 + \bar{i}}\right) = \phi_\Pi \ln\left(\frac{\Pi_t}{\bar{\Pi}}\right), \tag{9}$$

where $\phi_\Pi > 1$ and $\bar{i}$ is the steady state of the nominal interest rate. Given inflation and the nominal interest rate, the real return r_t is determined by the Fisher equation as

$$1 + r_t = \frac{1 + i_t}{\Pi_t}. \tag{10}$$

We assume that the returns on government bonds and household deposits are determined in real terms. Expressing returns in real or nominal terms is irrelevant in an economy with perfect foresight, except at the first period of the realization of an unexpected shock.

2.2 Equilibrium

We discuss market clearing for labor, assets, and goods markets.

Labor market clearing between households and intermediate-good producers is given as

$$L_t \equiv \int x h_t(a, x, \ell, \beta) d\mu_t(a, x, \ell, \beta) = \int n_{jt} dj \equiv N_t, \tag{11}$$

where L_t is households' effective labor supply, and N_t is the labor demand by intermediate-good producers in a symmetric equilibrium. Market clearing in the assets markets requires that government's debt equates households' savings, that is,

$$D_t = \int a d\mu_t(a, x, \eta, \beta). \tag{12}$$

Market clearing in the goods market reads

$$Y_t = G_t + C_t + \Theta_t + \Phi, \tag{13}$$

where $C_t \equiv \int c_t(a, x, \eta, \beta) d\mu_t(a, x, \eta, \beta)$ is the consumption of all households and Θ_t is the price adjustment costs by intermediate-good producers. Finally, firms' dividends are distributed across all households: $\int \tilde{d}_t(x) d\mu_t(a, x, \eta, \beta) = \int d_{jt} dj$.

Let $\mathbb{A}$ be the space for assets a, $\mathbb{X}$ be the space for productivities x, $\mathbb{E} = \{\ell, u\}$ be the space of employment status, and $\mathbb{B}$ be the space for discount factors β. Define the state space $\mathbb{S} = \mathbb{A} \times \mathbb{X} \times \mathbb{E} \times \mathbb{B}$, with typical element $\boldsymbol{s} \in \mathbb{S}$, and let $\mathcal{S}$ be the Borel σ-algebra induced by $\mathbb{S}$. A formal equilibrium definition for the economy is provided next.

Definition 1 *Given sequences for government policies $\{G_t, T_t, D_t, \mathcal{T}_t(\cdot), \mathcal{B}_t(\cdot)\}_t$, an equilibrium in this economy is given by: sequences of prices $\{r_t, w_t, i_t, \Pi_t\}_t$; sequences of households' values $\{V_t(\boldsymbol{s})\}_t$, policies $\left\{h_t^h(\boldsymbol{s}), c_t^h(\boldsymbol{s}), a'^h_t(\boldsymbol{s})\right\}_{ht}$, and measures $\{\mu_t(\boldsymbol{s})\}_t$; intermediate-good producers' policies $\{n_{jt}\}_{jt}$; such that (i) households' policies solve their problem and achieve values $V_t(\boldsymbol{s})$; (ii) intermediate-goods producers' policies solve their problem; (iii) the government's budget constraint is satisfied; (iv) i_t and r_t satisfy equations (9)-(10); (v) labor, assets, and goods markets clear as in (11)-(13); and (vi) the measure evolves consistently with the households' policies: $\mu_{t+1}(\mathcal{S}_0) = \int Q_t(\boldsymbol{s}, \mathcal{S}_0) d\mu_t(\boldsymbol{s}) \; \forall \mathcal{S}_0 \in \mathcal{S}$, where $Q_t(\cdot)$ is a transition function given as $Q_t(\boldsymbol{s}, \mathcal{S}_0) = \mathbb{I}(a'_t(\boldsymbol{s}) \in \mathcal{S}_0) \sum_{(x', \eta', \beta') \in \mathcal{S}_0} \pi_x(x'|x)$ $\pi_\beta(\beta'|\beta')\pi_{\eta,t}(\eta'|\eta, x)$.*

3 Calibration

In this section, we discuss the model calibration and then compare some key model-implied moments with data. We first discuss the calibration of parameters related to the steady state of the model and then discuss the calibration of parameters related to transitions after shocks. Table 2 summarizes the parameter values. We finish this section discussing how our model compares with evidence on *mpc*, *lpe*, and the aggregate effects of income tax shocks. Appendix A provides the computational details.

3.1 Calibration: Steady State

A period in the model is a quarter. We denote X—suppressing time indexes—as the steady-state value of variable X_t.

Households' Parameters.—We set the level of hours when employed to $\bar{h} = 1/3$. We follow Chang, Kim, and Schorfheide (2013) and set the idiosyncratic labor productivity x shock to follow an AR(1) process in logs: $\log(x') = \rho_x \log(x) + \varepsilon'_x$, where $\varepsilon_x \sim \mathcal{N}(0, \sigma_x)$, with $\sigma_x = 0.287$ and $\rho_x = 0.939$.[5] We calibrate the disutility of working B to match an employment rate of 78% including unemployment, as in Jang, Sunakawa, and Yum (2023). We set the variance of the working preference shock to $\varrho = 0.256$ to match the average *lpe* of 0.30, as we discuss in more detail below. As shown in Table 1, a positive variance ϱ also helps to flatten employment rates per wealth, making the model closer to the data (Ferraro and Valaitis 2024; Jang, Sunakawa, and Yum 2023).

We calibrate heterogeneity in discount factors β to match the households' wealth distribution. We assume β can take three values: $\beta \in \{\beta_{\text{low}}, \beta_{\text{mid}}, \beta_{\text{high}}\}$. We follow Krusell and Smith (1998) and assume a persistence of $\pi_\beta(\beta, \beta) = 0.995$, corresponding to an average duration of 50 years, and, conditional on switching, β can only move to an adjacent value on the grid. Additionally, we assume $\Delta\beta = \beta_{\text{high}} - \beta_{\text{mid}} = \beta_{\text{mid}} - \beta_{\text{low}}$. We set $\beta_{\text{high}} = 0.993$ to match an annualized interest rate of $r = 3.5\%$ and $\Delta^\beta = 0.045$ to match the wealth concentration of the top quartile. As shown in Table 1, the model generates a wealth share of 84% for the top quartile, close to its empirical counterpart in the Survey of Consumer Finances (SCF).

Table 1: Wealth Distribution and Employment by Wealth Quartile

	Wealth quartile			
	1	2	3	4
Share of wealth	0.00	0.03	0.12	0.84
Employment rate	0.87	0.81	0.78	0.70

Notes: Households are sorted by wealth. Employment includes emplyed and unemployed workers.

Unemployment Risk.—We calibrate steady-state unemployment risk as:

$$\pi_\eta(u|\ell, x) = \phi_0 x^{\phi_1},$$

where $\phi_0 > 0$ and $\phi_1 < 0$ are calibrated to match separation rates that decrease by wage group. Using U.S. data for 1980-2012, Mueller (2017) estimates monthly separation rates equal to 0.014 for workers below the median hourly wage and equal to 0.007 for workers above the median hourly wage. We set ϕ_0 and ϕ_1 to match these separation rates by wage groups.

While unemployed, we assume a job-finding rate independent of productivity x, in

[5] These numbers are estimated using the whole sample of Panel Study of Income Dynamics (PSID) ages 18 to 65 from 1979 to 1992.

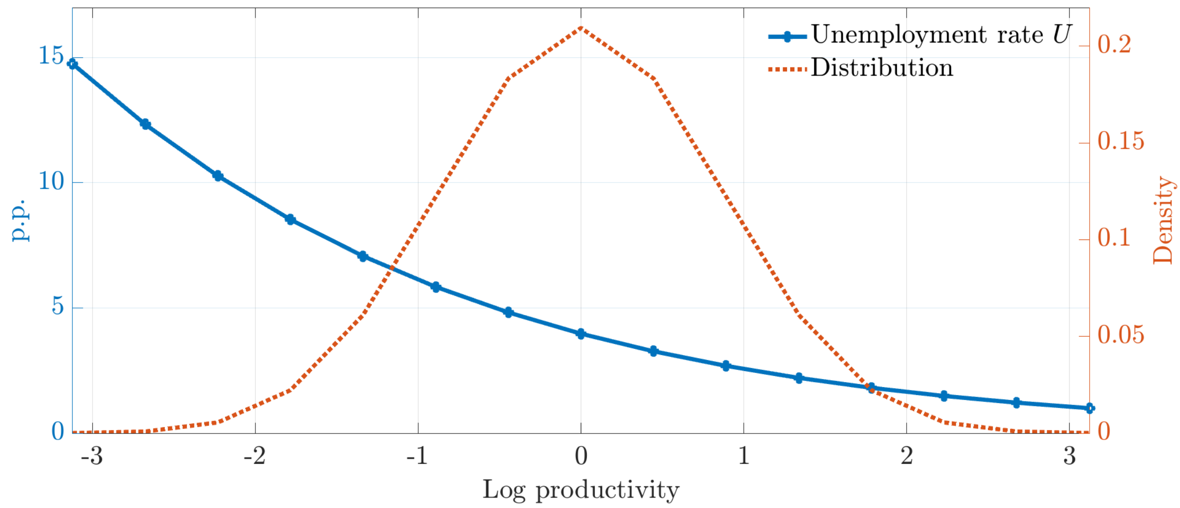

Figure 1: Steady State Cross-Sectional Unemployment Rate

Note: The x-axis reports labor productivity x in logs. The blue line (left y-axis) plots the steady-state unemployment rate by level productivity. The red line (right y-axis) plots the distribution of households.

line with estimates in Mueller (2017):

$$\pi_\eta(\ell|u,x) = \phi_2.$$

Mueller (2017) estimates a monthly finding rate of 0.32, which pins down the value of ϕ_2. This calibration generates a steady-state unemployment rate U equal to 4.3%. Unemployment rates per labor productivity x are reported in Figure 1.

Technology Parameters.—We set $\epsilon = 7$, which is a standard value in the literature. We set $\Theta = 200$ to match a Phillips curve slope, ϵ/Θ, of 0.035, in the midrange of estimates provided in Galí and Gertler (1999). We set the fixed cost of production Φ so that intermediate producers make zero profits in steady state.

Distribution of Profits.—Intermediate-good producers may make profits, which are paid out as dividends. Let $d_t = \int_0^1 d_{jt} dj$ be the dividends paid in period t. We follow Farhi and Werning (2020) and assume these dividends are rebated to households in proportion to their labor productivity—that is, $\tilde{d}_t(x) = \bar{d}_t x$. The value of $\bar{d}_t$ is pinned down such that all profits are distributed: $d_t = \bar{d}_t \mu_x$, where $\mu_x = \mathbb{E}[x]$ is the unconditional mean of idiosyncratic productivity x. This rule realistically implies that profits are more heavily concentrated in high-income households, which are typically wealthier. As such, it limits aggregate consequences of profit redistribution.

Unemployment Benefit.—We follow Kekre (2022) to calibrate the unemployment benefits, and set the fraction of households receiving UI benefits to $\zeta = 0.4$, the replacement rate to $\rho = 0.5$, and the maximum UI benefit $\bar{ui}$ to 60% of mean income. We calibrate the parameter χ to match a 70% ratio of households' average consumption when unemployed relative to average consumption when employed, as discussed in Gorn and Trigari

(2024). Given this calibration of the statutory part of UI benefits, consumption falls by about 10% when a household falls into unemployment, a number in line with empirical estimates provided in Saporta-Eksten (2014) and Ganong and Noel (2019).

Tax Function.—We assume a tax function $\mathcal{T}(wxh, ra)$ with a flat tax on capital income τ_k, and a nonlinear tax rate $\tau_\ell(\cdot)$ on labor income wxh: $\mathcal{T}(wxh, ra) = \tau_k ra + \tau_\ell(wxh)wxh$. The capital tax rate τ_k is set to 35%, following Chen, Imrohoroglu, and Imrohoroglu (2007). This number primarily reflects two flat taxes, on corporate income taxes and property taxes.

For the labor tax, we assume a log-linear tax on labor income y_ℓ as $\tau_\ell(y_\ell) = 1 - \lambda y_\ell^{-\gamma}$. With only two parameters, this tax function features a remarkable fit to the U.S. federal income tax system.[6] The first parameter, γ, measures the progressivity of the taxation scheme. When $\gamma = 0$, the tax rate is constant, while a positive (negative) γ describes a progressive (regressive) taxation scheme. The second parameter, λ, measures the level of taxation. An increase in $1-\lambda$ raises tax rates for all levels of income, while an increase in γ makes tax rates higher for high-income households and lower for low-income households. We set $\gamma = 0.1$, a value in line with tax estimates in the literature. The value of λ is pinned down by the government's budget constraint.

Fiscal and Monetary Authority Parameters: Steady State.—We calibrate transfers T to match a transfers-to-output ratio of 8.2%, the historical average for the post-World War II period, and G to match a spending-to-output ratio of 10%, a number within the range of what is typically used in the literature.[7] Public debt D is set to match a debt-to-output ratio of 100% annually. Finally, we assume an inflation target of $\bar{\Pi} = 1$ and a monetary authority that responds with $\phi_\Pi = 1.5$ to inflation deviations from its target.

3.2 Calibration: Transitions After Shocks

3.2.1 Unemployment Risk over the Business Cycle

We model the business cycle component of the unemployment risk process, $\pi_{\eta,t}(\eta|\eta_-, x)$, to target an empirically realistic Okun's law type of relation between output and unemployment, with a semi-elasticity coefficient of $c^{Ok} = 0.5$. That is, we calibrate $\pi_{\eta,t}(\eta|\eta_-, x)$ such that when output falls by 1% with respect to its steady-state level, unemployment increases by 0.5 percentage point with respect to its steady-state level. The aim is for unemployment to potentially play a nonnegligible role in the model dynamics, and thus target this value for c^{Ok}, which is on the upper end of empirical estimates in the literature (Ball, Leigh, and Loungani 2017).

We assume that separation rates fluctuate with output Y_t as an additive component

[6] See Feldstein (1969), Heathcote, Storesletten, and Violante (2014) and Ferriere et al. (2023), among others.

[7] Typical numbers go from about 6% (Brinca et al. 2016) to 18% (Smets and Wouters 2007).

Table 2: Parameter Calibration

Steady State			
Labor supply	$\bar{h} = 1/3$	$B = 0.654$	$\varrho = 0.256$
Income risk	$\rho_x = 0.939$	$\sigma_x = 0.287$	
Unemployment risk	$\phi_0 = 0.03$	$\phi_1 =$ -0.45	$\phi_2 = 0.69$
Discount factors	$\beta_{\text{high}} = 0.993$	$\Delta_\beta = 0.045$	$\pi_\beta(\beta, \beta) = 0.995$
Taxes	$\tau_k = 0.35$	$\gamma = 0.1$	$\lambda = 0.71$
Other fiscal variables	$T = 0.03$	$G = 0.04$	$D = 1.55$
UI benefits	$\zeta = 0.4$	$\rho = 0.5$	$\bar{ui} = 0.65\mathbb{E}[y]$
Additional UI transfer	$\chi = 0.15$		
Nominal rigidities	$\epsilon = 7$	$\Theta = 200$	
Response to the Cycle			
Monetary and fiscal policy	$\phi_\Pi = 1.5$	$\phi_D = 0.75$	
Unemployment: Job-finding rates	$\bar{\phi}_\ell = 0.6$	$\phi_{\ell,o} = 11.81$	
Unemployment: Separation rates	$\bar{\phi}_u = 0.33$	$\phi_{u,x} = 0$	

relative to its steady-state value:

$$\pi_{\eta,t}(u|\ell, x) = \pi_\eta(u|\ell, x) - \bar{\phi}_u \Delta Y_t x^{-\phi_{u,x}}, \tag{14}$$

where ΔY_t is the log-change of output relative to steady state. The parameter $\bar{\phi}_u$ captures the average response of separation rates to a change in output ΔY_t, while the parameter $\phi_{u,x}$ allows for the separation responses to be heterogeneous depending on the worker's productivity x. A positive value of $\bar{\phi}_u$ means that lower output ΔY_t leads to higher separation rates. A positive value $\phi_{u,x}$ means a lower pass-through of ΔY_t to separations as workers' productivity x increases.

We assume that the job-finding rate fluctuate with output Y_t with a constant elasticity, as

$$\log \pi_{\eta,t}(\ell|u, x) = \log \pi_\eta(\ell|u, x) - \bar{\phi}_\ell \log(1 - \phi_{\ell,o}\Delta Y_t). \tag{15}$$

The values for $\phi_{\ell,o}$ and $\bar{\phi}_\ell$ allow us to target an elasticity of output changes to the finding rate, as well as the effect of an output change on unemployment Note that we assume a homogenous response of finding rates to ΔY_t over idiosyncratic productivity x, consistent with estimates in Mueller (2017).

We then jointly calibrate $\{\bar{\phi}_u,\ \phi_{u,x},\ \bar{\phi}_\ell,\ \phi_{\ell,o}\}$ to match an Okun's coefficient of target, as well as the cross-sectional cyclicality of separations and finding rates as estimated in Mueller (2017). The parameter $\phi_{\ell,o}$, which depends on both the steady-state unem-

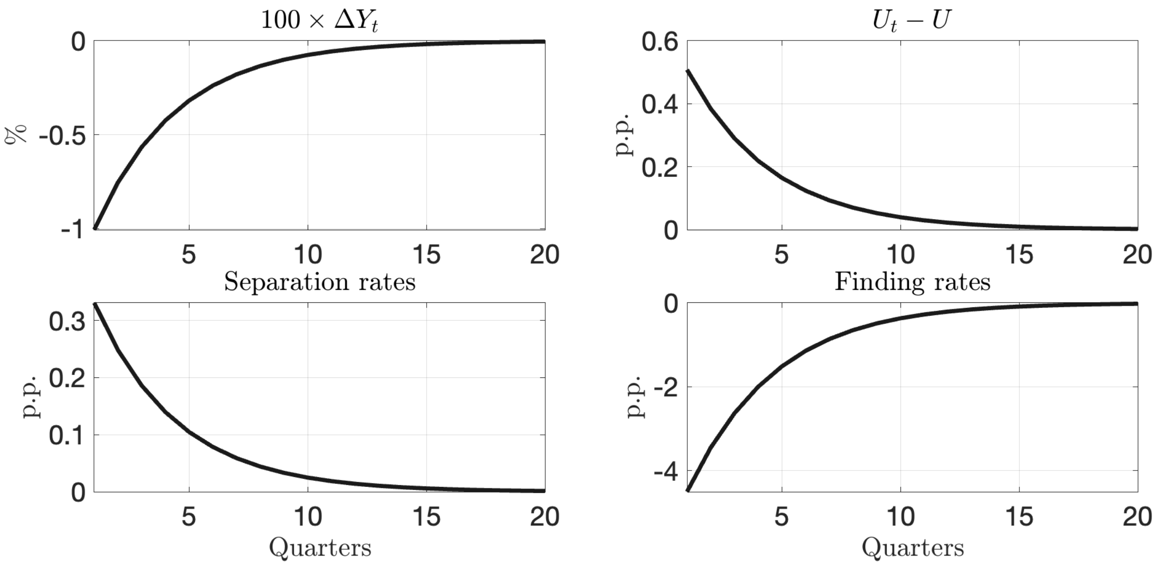

Figure 2: Dynamics of Unemployment After A Recession: Aggregates

Note: The top-right panel reports the response of aggregate unemployment to the output fall depicted in the top left-panel. The bottom left-panel reports the increase in separation rates, while the bottom-right panel reports the decrease in job-finding rates.

ployment and the Okun's coefficient c^{Ok}, expresses a percentage change in output into a percentage change in aggregate unemployment. The parameter $\bar{\phi}_\ell = 0.6$ then delivers an elasticity of finding rates to aggregate unemployment of -0.6, as estimated in Mueller (2017). Regarding separation rates, Mueller (2017) finds that the elasticity of separation rates is larger for high-wage workers. Because high-wage workers have a lower average separation rate, the larger estimated elasticity implies that the change in the *level* of separation rates is rather flat across workers. As such, we set the parameter $\phi_{\ell u,x} = 0$, and $\bar{\phi}_u = 0.33$ to match our target of the Okun's law coefficient.

Figures 2 and 3 report dynamics of unemployment after an output fall of 1%. In line with the targeted Okun's law, unemployment increases by about 0.5 percentage points when output falls by 1%. This increase in unemployment is generated by a strong fall in job-finding rates (bottom-right panel of Figure 2), together with a moderate increase in separation rates (bottom-left panel of Figure 2). Note that, while separation rates and job-finding rates move homogeneously in the distribution in a recession, it does not imply that overall unemployment increases in a homogeneous way in the cross section. Indeed, because steady-state unemployment is larger for low-productivity households, the increase in unemployment is also larger at the bottom of the wage distribution, as shown in Figure 3.

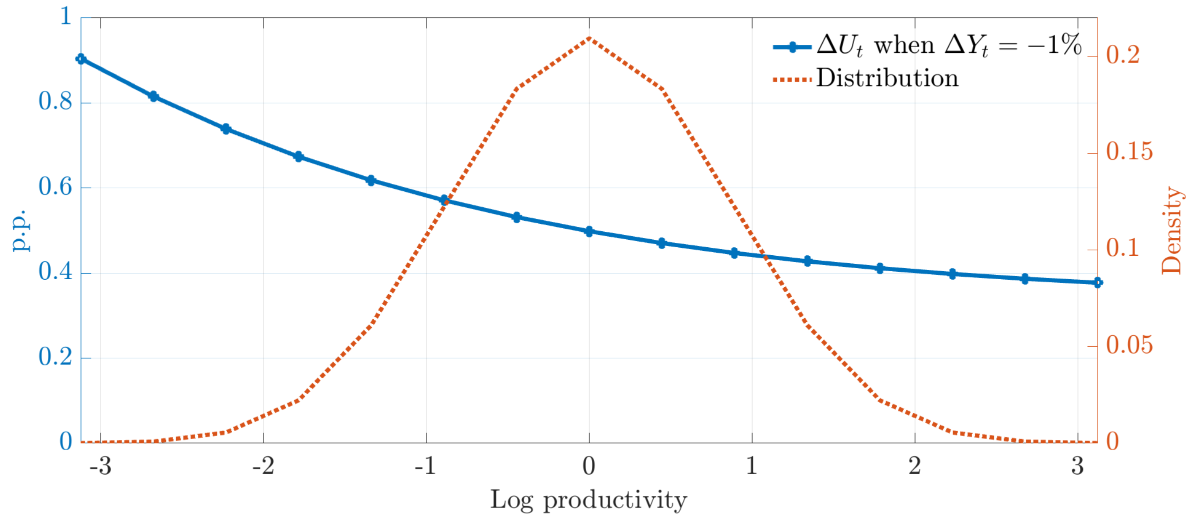

Figure 3: Dynamics of Unemployment After a Recession: Cross Section

Note: The x-axis reports labor productivity x in logs. The blue line (left y-axis) plots the increase in unemployment rates after an output fall of 1% for each productivity x. The red line (right y-axis) plots the distribution of households.

3.2.2 Debt Financing over the Business Cycle

We assume that debt follows a rule in the spirit of Uhlig (2010). In particular,

$$D_{t+1} = (1 - \phi_D)D + \phi_D \left(\hat{G}_t - \tau^k r_t A_t - \mathcal{R}_t^\ell \right) \tag{16}$$

where

$$\hat{G}_t = G_t + T_t + \mathcal{U}_t + (1 + r_t)D_t$$

captures total government expenditures and

$$\mathcal{R}_t^\ell = w_t L_t - \lambda \int (w_t x h_t(a, x, \eta, \beta))^{1-\gamma} d\mu_t(a, x, \eta, \beta)$$

captures the fiscal revenues the government would have raised had they kept labor taxes at their state-state value. When $\phi_D = 0$, debt remains constant, and the government only adjusts the level of the labor tax λ_t to meet its budget constraint. A higher ϕ_D translates into a larger utilization of debt, with a limiting case of $\phi_D = 1$ where labor taxes remain constant at λ. We use $\phi_D = 0.75$ as a benchmark—that is, most business cycle adjustments to the government budgets are done with public debt.

In practice, debt will moderately increase when the economy goes into a recession, because the tax base will contract, and thus $\mathcal{R}_t^\ell$ decreases. However, debt will increase more when the government adopts various fiscal stabilization packages to fight the recession, as we discuss in Section 4.

3.3 Heterogeneity in *lpe* and *mpc*

The calibrated model generates a rich heterogeneity of *mpc* and *lpe* across households, which shapes the effect of the fiscal packages that we explore in Section 4. In turn, we compare the model-implied *mpc* and *lpe* distributions with their empirical counterparts next.

Marginal Propensities to Consume.—We report model-implied *mpc* in Table 3, which we compute in response to an unexpected one-time rebate of $500. The average *mpc* amounts to 0.13 at the quarter level—that is, 0.45 at the annual level; see Crawley and Theloudis (2024) for an overview of the empirical literature estimating *mpc*.[8] The *mpc* declines in wealth, with an *mpc* close to 0.20 for the bottom quartile and falling to 0.03 for the top quartile.

Importantly, *mpc* are also heterogeneous across unemployment status: The average *mpc* is 0.12 for employed households and 0.32 for unemployed households.

Table 3: Marginal Propensities to Consume

	Wealth quartile			
	1	2	3	4
mpc	0.19	0.15	0.07	0.03

Notes: Households are sorted by wealth. The *mpc* are computed at the quarterly level out of a $500 rebate.

Labor Participation Elasticities.—We compute *lpe* using two approaches. First, we compute *lpe* after a transitory increase in tax rates. In particular, we assume a 1% increase in the tax-level parameter λ for four consecutive quarters—to mimic a typical one-year tax code change—which then returns to steady state at a persistence of 0.75, the shock persistence we use in Section 4. We compute the annual response of hours worked and obtain a aggregate *lpe* of 0.30, a standard number in the literature. We also sort households by their annual income and compute *lpe* by income quartile, which we report in the first line of Table 4. The *lpe* decline with income, at 0.44 for the bottom quartile and at 0.22 for the top quartile. This distribution is in line with a large body of evidence showing larger labor supply responsiveness for lower-income earners—and often well above 0.5—as discussed in Blundell (1995), Keane (2011), and Meghir and Phillips (2010) among many others.[9]

As a robustness check, we also measure the *lpe* model using a steady-state simulation and regressing hours worked on after-tax hourly wages, as often done in empirical work (Altonji 1986; Blundell, Duncan, and Meghir 1998; MaCurdy 1981). Most empirical studies use annual data, and thus we simulate a panel of households at a quarterly fre-

[8]The annual mpc^y can be obtained as $mpc^y = 1 - (1 - mpc)^4$. A more accurate annual *mpc* measure can be obtained with non-stochastic simulations, as discussed in Ferriere and Navarro (2024).

[9]See Ferriere and Navarro (2024) for an extensive discussion of this literature.

Table 4: Labor Participation Elasticities

	Income quartile			
	1	2	3	4
lpe [1]	0.44	0.34	0.25	0.22
lpe [2]	0.56	0.59	0.50	0.26

Notes: Households are sorted by income. The *lpe* are computed at the annual frequency. Line [1] reports *lpe* out of a simulated temporary tax change. Line [2] reports *lpe* computed using simulated steady-state data. See text for more details.

quency and then time-aggregate to an annual frequency. We then estimate the following regression:

$$\log h_{in} = b_0 + b_1 \log \tilde{w}_{in} - b_2 \log c_{in} + \varepsilon_{in},$$

where h_{in}, $\tilde{w}_{in}$, and c_{in} denote hours worked, after-tax hourly wage, and consumption of household i in year n.[10] We report the parameter b_1, which is typically referred to as the micro-Frisch labor supply elasticity. While this approach delivers *lpe* that are more sensitive to model details, it is also closer to the empirical literature on labor elasticities.

The model-implied regression-based *lpe* amounts to 0.45, on average, somewhat larger than the 0.30 obtained with the tax shock but still well in line with the micro literature. As in the previous measure, the regression-based *lpe* distribution declines with income, with a bottom-income group elasticity that is also about twice as large as the top-income group elasticity. Overall, both approaches to measure *lpe* deliver empirically realistic elasticities, with moderate heterogeneity across income groups, ranging from 0.26 to 0.59.

3.4 Tax Shocks

The key new policy we analyze in this paper is labor tax cuts. In turn, we compare the model-implied aggregate responses to labor tax cuts with the empirical estimates in Mertens and Ravn (2013) and Zidar (2019). As we argue, the model responses broadly align with evidence. If at all, the model understates the efficacy of labor tax cuts.

Comparison with Mertens and Ravn (2013).—Using U.S. postwar data, Mertens and Ravn (2013) estimate tax multipliers out of changes in personal income tax rates. In their benchmark estimate, they find that a personal income tax cut leads to a multiplier above 2. That is, personal income increases by more than $2 for each $1 of revenue lost by the tax cut.

We replicate the exercise in Mertens and Ravn (2013) in our model. In particular, we assume an unexpected and transitory decline in labor taxes for all workers. We

[10] We drop observations with annual hours equal to 0.

implement the labor tax cut by unexpectedly increasing the tax level parameter λ, which then returns to steady state with a persistence rate of 0.75. We perform our exercise in partial equilibrium and assume that other prices are constant. The model-implied multipliers are moderate, at around 0.6 on impact.

Comparison with Zidar (2019).—Using U.S. cross-state data, Zidar (2019) further investigates the effect of personal income tax changes across different income groups. They find that tax cuts for the bottom 90% of the income distribution leads to higher employment, whereas tax cuts for the top 10% have no significant effect on either employment nor output. Specifically, a tax cut of 1% of output for the bottom 90% income group results in approximately a 3 percentage point increase in employment over a two-year period.

We replicate the exercise in Zidar (2019) and implement a change in labor taxes to either the bottom 90% of the income distribution or the top 10% of the income distribution. As before, we implement the tax change in partial equilibrium with an unexpected and transitory change in the tax-level parameter λ. The model-implied response broadly aligns with Zidar (2019). The tax cut for the top 10% income group has minimal effects on employment, increasing employment by only 0.16% on impact. In contrast, the tax cut for the bottom 90% income group has a more substantial effect, raising employment by slightly more than 1% on impact. Again, the model-implied responses are more moderate than their empirical counterpart.

One caveat should be raised. While the model-implied level of employment responses are modest relative to evidence, the timing of the response is faster. In particular, the model response peaks on impact, while it takes three quarters in the estimates of Mertens and Ravn (2013) and almost two years in the estimates of Zidar (2019) estimates. This absence of a delayed response is common in models without richer features, such as costly capital adjustments; see Section 4.4 for a further discussion.

Overall, we see our calibration of the *labor supply channel* as conservative. Aggregate *lpe* is 0.3, heterogeneity in *lpe* is moderate, and the macroeconomic effects of tax changes are small compared with their empirical counterparts. Yet, as we show next in Section 4, labor tax cuts are a very effective instrument to stabilize a recession.[11]

4 Quantitative Experiment

We model a demand-driven recession as a sudden decline in households' willingness to consume and first analyze a benchmark case with no policy response. We then intro-

[11]Section 5 presents an alternative calibration with larger and steeper *lpe*, which generate macroeconomic effects of tax cuts closer to estimates found in Mertens and Ravn (2013) and Zidar (2019). In this calibration, which remains broadly aligned with the data, the effectiveness of temporary tax credits is even further enhanced.

duce the three fiscal stabilization packages: a TT package, which temporarily increases transfers for all low-income households; a UI package, which temporarily increases UI benefits for all unemployed households; and a TC package, which temporarily increases tax credit for low-income working households. We conclude this section with a discussion on various properties of the stabilization packages.

While we set all the packages to have the same fiscal cost, they differ drastically in their effectiveness to stimulate aggregate demand and stabilize the economy. We discuss this finding next.

4.1 Recession

We engineer a demand-driven recession with a multiplicative preference shock, ω_t, so that the per-period utility function is $\omega\{\ln(c) - Bh\}$. We assume that $\omega = 1$ in steady state and that ω_t unexpectedly falls in $t = 0$ and reverts to its steady-state value with a quarterly persistence of $\rho_\omega = 0.75$. We calibrate the initial fall to generate an output contraction of about 12 basis points on impact.[12] We assume the economy was at steady state before the preference shock and that there is perfect foresight after the shock.

Figure 4 presents impulse responses of macroeconomic variables after the preference shock. Output contracts by 0.12% on impact, with moderate persistence: After 10 quarters, output has almost fully returned to steady state. Consumption follows a similar path: It contracts by about 0.15% on impact, and recovers at a similar rate as output. Unemployment increases by about 5 basis points, consistent with an Okun's coefficient of 0.5. As is typical with an aggregate demand shock, wages and inflation drop. On the fiscal side, public debt increases moderately, as the tax base of the labor income tax decreases in a recession.

4.2 Fiscal Packages

We explore the aggregate response of the economy to three alternative fiscal stabilization packages. All packages amount to a total spending equivalent to giving a one-time check of $200 to each household. We describe the implementation of each program, as well as each program's effects on output, consumption, and prices.

The TT Package. The first fiscal stabilization package implements a temporary transfer to all low-income households.

We build on Ferriere et al. (2023) and model transfers that phase out with income through the means of a logistic function. In particular, for a given income y, the tempo-

[12] Section 5.1 shows that our main findings hold when using larger shocks.

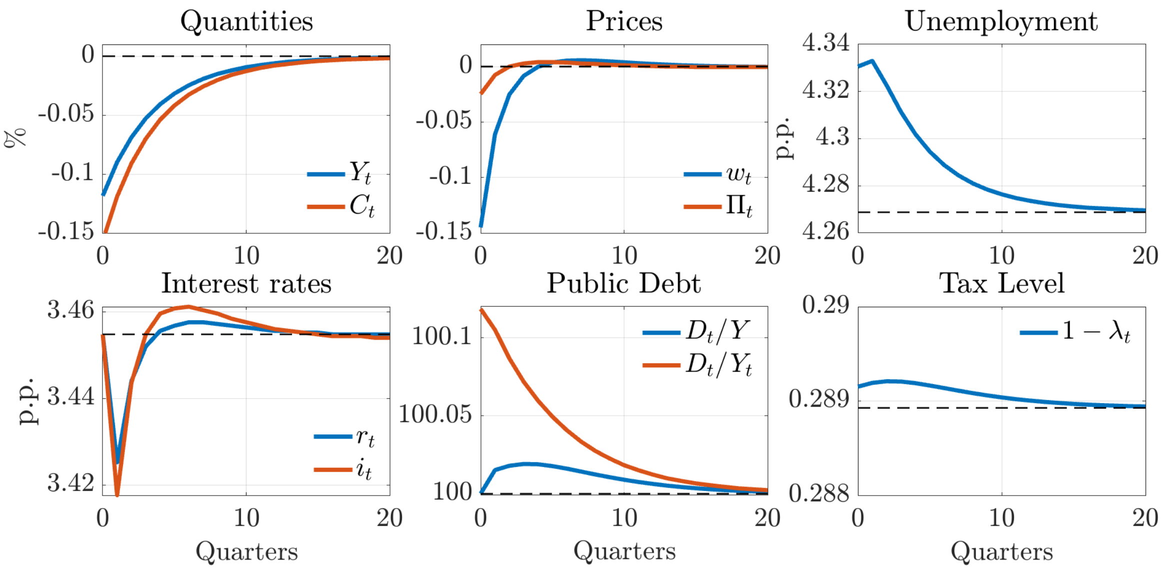

Figure 4: Impulse Responses to a Negative Demand Shock

Note: Impulse responses of a demand-driven recession engineered as a temporary shock to instantaneous utility. The x-axes report quarters.

rary transfer is defined as

$$\hat{T}_t(y) = m_t \frac{2\exp(-\xi y/\bar{y})}{1 + \exp(-\xi y/\bar{y})},$$

where m_t is the amount of transfers received at no income, $y = 0$, and ξ is the phaseout rate, capturing the speed at which transfers phase out with income relative to steady-state mean income level $\bar{y}$.

These types of checks have been implemented in recent recessions, such as during the 2008 crisis (Parker et al. 2013). In that example, the dollar amount of the checks was determined by the level of income reported by each household to the IRS during the previous fiscal year. As such, apart from their wealth effect, the checks did not feature any direct distortionary effect on household behaviors. To mimic this design, we assume that the transfer received by a household with states (x, η, β) depends on a measure $\tilde{y}(x, \eta, \beta)$ defined as the mean steady-state pretax income of a household with productivity x, employment status η and discount factor β, which is a good proxy for assets:

$$\tilde{y}(x, \eta, \beta) = \int \{ wxh(a, x, \eta, \beta) + ra\} d\mu(a, x, \eta, \beta).$$

Such a design ensures that the transfer does not directly distort labor or savings decisions, as the amount of transfer received by a household only depends on its exogenous states.

To give this package an automatic stabilizer flavor, we assume that transfers decline over time at the same rate as the economy returns to steady state. That is, we fix an initial transfer m_0 and assume that $m_t = \rho_\omega m_{t-1}$, where $\rho_\omega = 0.75$. We compute m_0 such that the total cost of this program equates a one-time check of \$200 to each household. The transfer is designed to phaseout rather quickly over income, with a phase-out rate of $\xi = 12$. Overall, the package features a transfer of about \$900 at $\tilde{y} = 0$, and is well targeted at the bottom of the income distribution with only 20% of households receiving more than \$50 in the first quarter of the recession.

The UI Package. The second fiscal stabilization package implements a temporary transfer to unemployed households:

$$\hat{T}_t(\eta) = m_t \quad \text{if} \quad \eta = u.$$

We assume that the transfer phases out with a persistence of $\rho_\omega = 0.75$ as in the previous package, and set the initial transfer level m_0 such that the cost of the UI package equates the cost of giving one check of \$200 to each household, as with the TT package. This procedure yields a transfer of about \$1,100 to all unemployed households in the first period.

The TC Package. The third fiscal stabilization package implements a temporary transfer to working-poor households. As before, we model the targeted feature of the transfer using a logistic function. We make three assumptions which differentiate the TC package from the TT package. First, the transfer depends on current income. Second, the transfer depends on labor income only. And third, the transfer can only be received if labor income is positive:

$$\hat{T}_t(y_\ell) = m_t \frac{2\exp(-\xi y_\ell/\bar{y})}{1 + \exp(-\xi y_\ell/\bar{y})} \quad \text{if } \eta = e \text{ and } y_\ell > 0.$$

The transfer is akin to a refundable labor tax credit, and, as such, implements a temporary labor tax cut targeted to low-income working households.

As before, we assume that m_t declines over time with a persistence of $\rho_\omega = 0.75$ and set m_0 to equate the total package cost to the cost of giving one check of \$200 to each household. We also assume a slower phaseout rate at $\xi = 6$, which maximizes the efficiency of this instrument. This procedure yields a maximum transfer of \$800 for the poorest working household in the first quarter of the recession.

4.3 Comparing Fiscal Packages' Effectiveness

Figure 5 reports impulse response functions after the preference shock for the benchmark case with no fiscal policy intervention, as well as for each of the three fiscal packages discussed above.

The TT package stabilizes the economy and reduces the initial output contraction by about 20%—from -0.12% in the benchmark with no fiscal intervention to -0.096% under the TT package. Consumption also declines by less than in the benchmark, and the unemployment increase is more muted. The TT package, however, has strong inflationary effects.

The UI package appears more effective than the TT package in stabilizing the economy, with a reduction of the initial output contraction of 32%. It is also associated with a lower increase in wages and inflation than the TT package. The increased effectiveness of the UI package over the TT package is due to the *consumption channel*: Transfers are targeted to unemployed workers, who have a higher *mpc*, and thus deliver a stronger aggregate demand response.

The TC package is the most effective fiscal package we consider, with a reduction of the initial output contraction of 48%. The TC package also generates the stronger recovery in consumption across all packages despite having significantly smaller effects on inflation. The reason for the TC efficacy is that it stimulates both consumption and labor supply. The tax cuts target low-income households who exhibit the higher *mpc*, thus stimulating aggregate demand through *consumption channel* effects. At the same time, these low-income households have larger *lpe*, thus providing strong *labor supply channel* effects, which result in more muted wages and lower inflation. In contrast, the TT and UI packages stimulate output through the *consumption channel*, but these transfers actually disincentivize labor, thus resulting in higher wages and inflation. In turn, among the options we consider, the TC package proves to be the most effective in stimulating aggregate demand and reducing the depth of the recession.

Fiscal Packages Multipliers. To evaluate the packages' efficacy over time, Figure 6 reports cumulative multipliers for each package. In particular, we compute the cumulative multiplier of a fiscal package as the sum of output gains relative to the benchmark with no fiscal intervention, divided by the fiscal cost of the package. That is, the fiscal package multiplier h after the shock, M_h, is given as

$$M_h = \frac{\sum_{t=0}^{h}(Y_t^f - Y_t^b)}{\sum_{t=0}^{h}\hat{T}_t},$$

where Y_t^f denotes the path of output for a given fiscal package, Y_t^b denotes the path for output under no fiscal package, and $\hat{T}_t$ denotes the fiscal cost of the fiscal package each period. Figure 6 reports the cumulative multipliers for output and consumption.

The efficacy of the TC package is particularly visible when computing cumulative multipliers. The multiplier is 0.90 at four quarters for the TC package, while it is only 0.6 for the UI package and 0.37 for the TT package. That is, for each dollar of fiscal

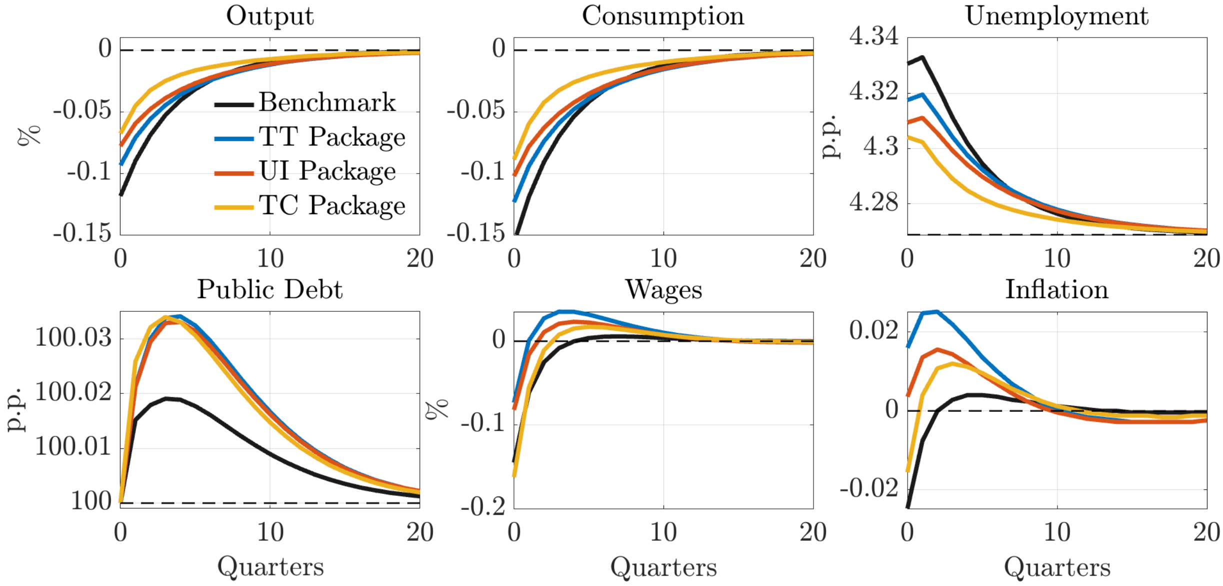

Figure 5: Impulse Responses for Three Stabilization Packages

Note: Impulse responses of a demand-driven recession. The benchmark depicts the case with no fiscal stabilization package; the TT package implements targeted transfers to low-income households; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. The x-axes report quarters.

revenues spent, the TC package delivers the larger increase in output.

Decomposition. As discussed above, all fiscal packages operate through a *consumption channel* and a *labor supply channel*. To quantify each channel, we isolate a demand-side and a supply-side response to each fiscal package by fixing equilibrium objects other than the fiscal package itself to the benchmark case with no fiscal intervention. In particular, from the household's perspective, the effect of shocks and policies only matters through the equilibrium sequences of wages w_t, interest rates r_t, dividends d_t, labor taxes captured by λ_t, and the unemployment status distribution $\pi_{\eta,t}(\cdot)$, as well as the fiscal policy itself $\hat{T}_t(\cdot)$. Let $\{p_t\}_t = \{w_t,\ r_t,\ d_t,\ \lambda_t,\ \pi_{\eta,t}(\cdot)\}_t$ collect the sequences other than the fiscal policy. Note that we can compute households' consumption and labor supply policies, $\{\hat{c}_t, \hat{h}_t\}_t$, given sequences $\left\{p_t, \hat{T}_t(\cdot)\right\}_t$. Then, to isolate the demand-side and the supply-side responses of a fiscal package $\hat{T}_t(\cdot)$, we compute households' policies under the sequences $\left\{p_t^b, \hat{T}(\cdot)_t\right\}_t$, where p_t^b denotes the sequences under the benchmark case with no fiscal policy. We then use these sequences to compute a counterfactual supply-side output $\{\hat{Y}_t^s\}_t$ and demand-side output $\{\hat{Y}_t^d\}$ as follows:

$$\hat{Y}_t^s = \int x\hat{h}_t(a, x, \eta, \beta) d\hat{\mu}_t(a, x, \eta, \beta)$$

$$\hat{Y}_t^d = \int \hat{c}_t(a, x, \eta, \beta) d\hat{\mu}_t(a, x, \eta, \beta) + G_t + \Theta_t^b + \Phi,$$

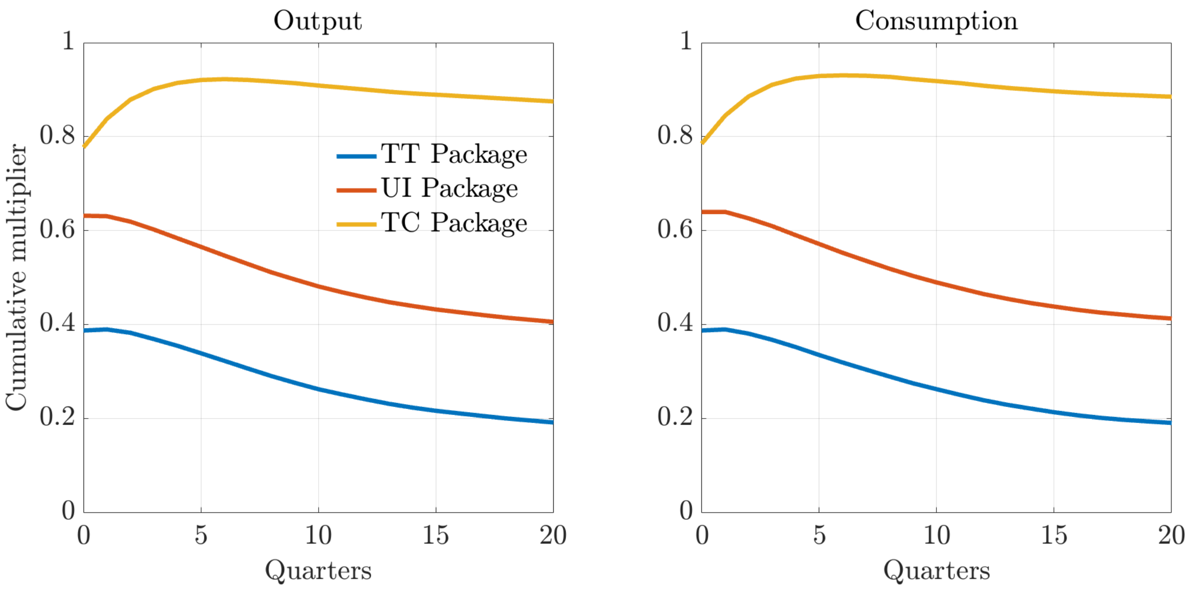

Figure 6: Cumulative Multipliers for Three Stabilization Packages

Note: Cumulative output and consumption multipliers. The TT package implements targeted transfers to low-income households; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. The x-axes report quarters.

where $\{\Theta_t^b\}$ denotes the output cost of adjusting prices under the benchmark case. Figure 7 plots the demand-side and supply-side responses, $\hat{Y}_t^s$ and $\hat{Y}_t^d$, for each fiscal package we analyze.

The left panel in Figure 7 plots supply-side output $\hat{Y}_t^s$ for the three experiments. The *labor supply channel* is (small but) negative for the TT and the UI packages, as supply-side output in these cases is lower than in the benchmark case. That is, the fiscal package itself reduces labor supply. For the TT case, transfers to low-income households are associated with positive wealth effects, which lowers labor supply. For the UI case, there is no direct effect on labor supply, as the recipients of the transfers are unemployed and we abstract from search efforts. Yet, larger future UI benefits reduce precautionary motives for currently employed workers, and, as saving is less desirable, their labor supply declines. In contrast, the *labor supply channel* is very large for the TC package, as supply-side output in this case is well above the benchmark case. As discussed above, the large supply-side output response is because tax credits incentivize labor supply of low-income working households, who feature high *lpe*. Importantly, this large *labor supply channel* of the TC package occurs despite the larger unemployment risk associated with the recession.

The right panel in Figure 7 plots demand-side output for the three experiments. As expected, the *consumption channel* is positive in all three experiments. That is, all fiscal packages lead to higher consumption. The UI package leads to a higher consumption response than the TT package because the *mpc* of unemployed households are larger. Interestingly, the *consumption channel* is the largest for the TC package, even in isolation of other general equilibrium responses. A tax credit that increases labor supply leads

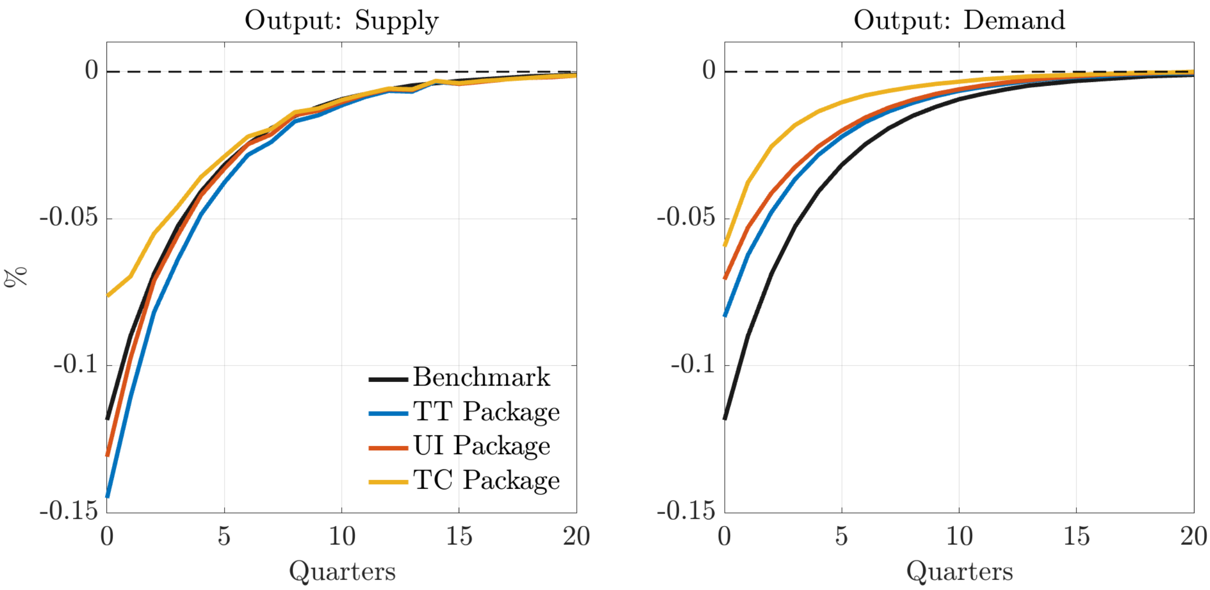

Figure 7: Decompositions

Note: Impulse responses of a demand-driven recession. The left panel reports supply-side output, while the right panel reports demand-side output. The benchmark depicts the case with no fiscal stabilization package; the TT package implements targeted transfers to low-income households; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. The x-axes report quarters.

to higher labor income and, therefore, to higher consumption. Thus, the magnitude of the *consumption channel* hinges on, both, the high *lpe* and the high *mpc* of low-income working households.[13]

The UI package has only a small disincentivizing effect on labor supply, as shown in the left panel of Figure 7. Two features of our model explain this result. First, we abstract from job search efforts while unemployed. Second, unemployment benefits are received only by those without work opportunities ($\eta = u$). As a result, more generous unemployment benefits have a limited impact on labor supply—beyond the wealth effects discussed earlier. Removing these features would likely amplify the disincentivizing effect of the UI package on labor supply, leading to a more contractionary supply-side response.

On the other hand, the model abstracts from heterogeneity in UI benefit recipiency (i.e., distinguishing between recipients and non-recipients) and instead targets an average recipiency rate. This likely underestimates the consumption response of unemployed households with low wealth.[14] A more detailed modeling of the cross-section of recipiency rates would likely result in a stronger demand-side response to the UI package.

To sum up, our results suggest that labor tax cuts (or larger tax credits) are an effective fiscal instrument in managing aggregate demand during a recession. We obtain

[13]See Ferriere and Navarro (2024) for an analytical characterization of this interaction in the context of government spending shocks.

[14]See, for instance, Ganong and Noel (2019) for an empirical discussion of consumption patterns among UI recipients and non-recipients, and Kekre (2022) and Broer et al. (2025) for a quantitative analysis of transfers targeted specifically to non-recipient unemployed households.

these results using an off-the-shelf HANK model, an increasingly common environment for policy questions. These findings are noteworthy for two reasons. First, the TC package stabilizes the economy despite unemployment risk being more prevalent during a recession, particularly at the bottom of the income distribution. Second, we use a relatively conservative calibration of *lpe*, as discussed in Section 3.4. In Section 5.3, we show that the TC multiplier is well above unity when we target a steeper profile of *lpe* across households—even as the steeper *lpe* remain well within empirical estimates.

4.4 Discussion

We conclude this section with a discussion on various properties of the stabilization packages. Section 4.4.1 discusses the importance of public debt financing of the packages, what we refer to as the intertemporal and intratemporal dimensions packages. Section 4.4.2 compares distributional effects of the three stabilization packages. Section 4.4.3 discusses the insurance channel of the UI package. Finally, Section 4.4.4 discusses the implementability of the TC package.

4.4.1 Stabilization Through Higher Labor Tax Progressivity

The labor tax cuts implemented in TC package have an *intertemporal* component, as the loss of fiscal revenue is initially financed with debt but repaid with higher taxes in the future. The labor tax cuts also have an *intratemporal* component, as labor tax credits are targeted towards low-income households and financed by future taxes on all households, which redistributes the tax burden from the bottom toward the top of the distribution. In this section, we aim to disentangle the stabilization effectiveness of the *intertemporal* and *intratemporal* components of the TC package.

To do so, we conduct a new experiment in which public debt remains constant after the shock—that is, we set the debt adjustment parameter to $\phi_D = 0$. In turn, the larger tax credits at the bottom of the distribution are entirely financed with a contemporaneous uniform increase in the level of labor taxes—that is, adjusting the tax-level parameter λ_t. For completeness, we also analyze the stabilization properties of the UI package under this constant-debt scenario. Figure 8 reports responses of quantities, prices, and fiscal variables, while Figure 9 reports cumulative multipliers.

There are two main results of this exercise. First, multipliers are lower, especially on impact, when public debt is not used to finance the fiscal packages. This finding is not surprising, as public debt can dampen the crowding-out effect of distortionary taxes, especially in an economy with non-Ricardian agents (Heathcote 2005).

Second, and more interestingly, the TC multiplier remains high, at almost 0.8 after four quarters. Notice that, when public debt is not used, the TC package is akin to a budget-neutral temporary increase in labor income tax progressivity, with a decline in tax

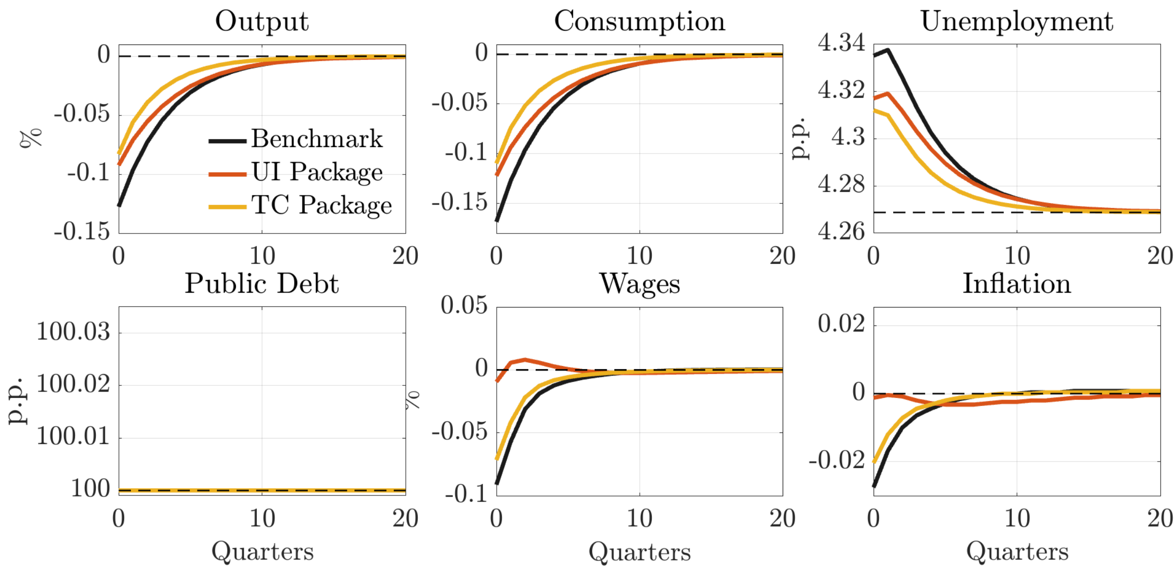

Figure 8: Impulse Responses with Constant Debt

Note: Impulse responses of a demand-driven recession. The benchmark depicts the case with no fiscal stabilization package; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. Public debt remains constant: $\phi_D = 0$. The x-axes report quarters.

payments for low-income households and an increase in tax payments for higher-income households. Thus, this exercise shows that a temporary increase in labor tax progressivity is a quantitatively efficient policy to boost output and stabilize a recession.

4.4.2 Tax Credit Package: Who Benefits More?

As discussed above, the TC package is an effective policy because it stimulates demand through a *consumption channel* as well as supply through a *labor supply channel*. However, because it targets working households only, the TC package may fall short in redistributing toward unemployed households, who are likely among the poorest households in the economy.

Figure 10 plots, for several income groups, the gain in consumption relative to the benchmark case. With the UI and TT packages, consumption increases mostly for the poorest income group (below the fifth percentile), reflecting that transfers are targeted to these groups. In contrast, with the TC package, the consumption increase is more spread out across income groups, reflecting that tax credits benefits only those who work. In particular, consumption for households between the 5th and the 25th percentiles increases more in the TC package than in the TT package or the UI package.

These results provide an interesting tradeoff for policy design. While labor-tax credits stimulate both demand and supply, they support the working poor but may fail to redistribute towards those who need it the most.

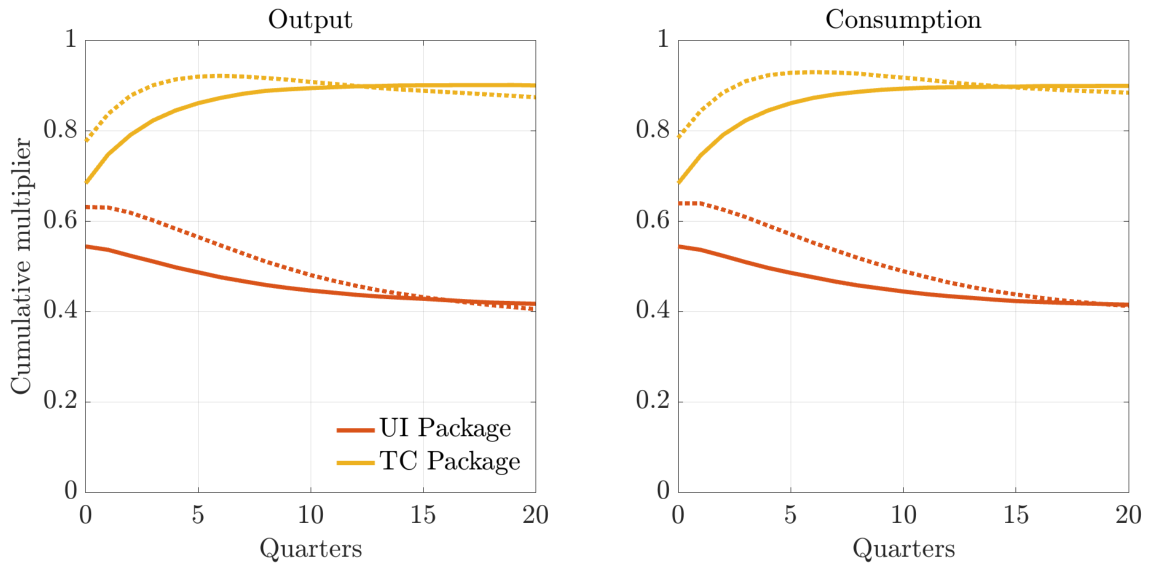

Figure 9: Cumulative Multipliers with Constant Debt

Note: Cumulative output and consumption multipliers. The UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. Solid lines report the case of constant public debt: $\phi_D = 0$; dashed lines report the baseline case with standard debt adjustment $\Phi_D = 0.75$. The x-axes report quarters.

4.4.3 The Insurance Channel of the Unemployment Insurance Package

The effectiveness of the UI package partially derives from an *insurance channel.* Since the UI package is persistent, individuals anticipate receiving larger benefits in an eventual future unemployment spell, which may lead them to save less and consume more today. That is, even currently employed workers–who do not immediately receive UI benefits–may adjust their behavior by consuming more and save less, effectively leveraging on the enhanced state-contingent insurance of the UI package. In their recent work, Bayer et al. (2023) argue that this *insurance channel* can be quantitatively significant.

We conduct a decomposition exercise to isolate the *insurance channel* of the UI package. Specifically, we compute household consumption, labor supply, and savings responses in a counterfactual economy where: *(i)* the UI package is implemented, but *(ii)* prices, taxes, and unemployment risk remain as in the benchmark case, and *(iii)* the measure of households in each period is as in the benchmark as well. This ensures that employed workers ($\eta = \ell$) face the same sequences of prices and unemployment risk as in benchmark case. Additionally, by holding the household distribution as in the benchmark case, we ensure that the wealth distribution is not affected by past UI payments. Thus, the differences in responses of employed households ($\eta = \ell$) relative to the benchmark purely reflect the *insurance channel.*

Figure 11 shows the impact of the UI package by comparing the counterfactual economy to the benchmark case for consumption, labor supply, and savings, aggregated across two groups: all households ($\eta = \ell, u$) and only those who can work ($\eta = \ell$).

The *insurance channel* is quantitatively significant. In this counterfactual, the UI

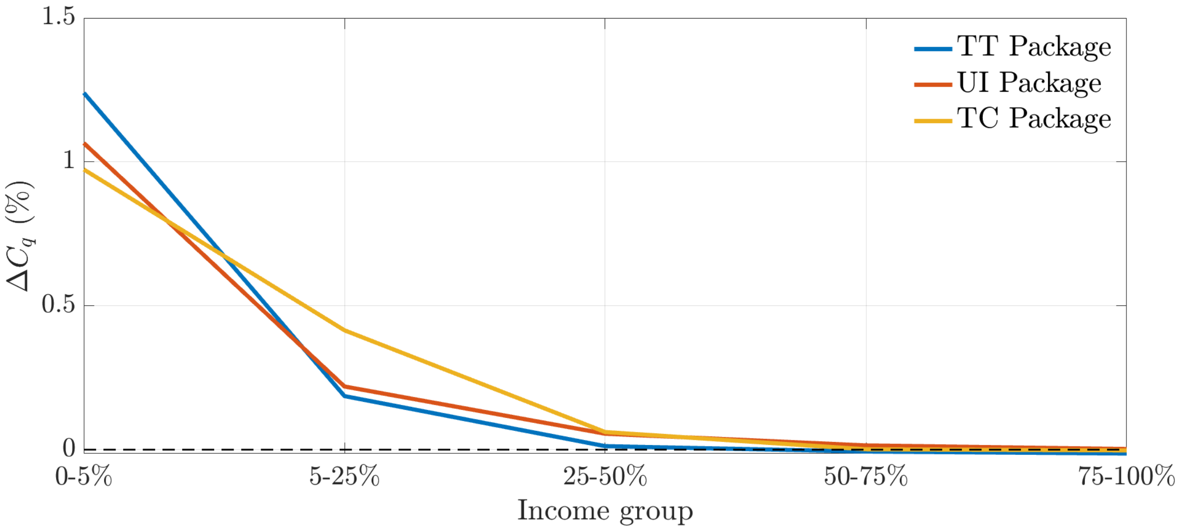

Figure 10: Distribution of Consumption Changes

Note: Distribution of consumption changes, by income group, for each fiscal package. Consumption changes are computed relative to the benchmark case with no fiscal stabilization package in the first quarter of the recession. The TT package implements targeted transfers to low-income households; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households.

package raises consumption by about 0.06% on impact, with roughly one-third of the increase coming from the *insurance channel* effect on $\eta = \ell$ workers. Labor supply decreases, entirely driven by insurance in this setup with no endogenous job search while unemployed. Interestingly, while total savings rise, savings among those who can work actually decline.

Overall, the *insurance channel* of the UI package shapes its stabilization properties, especially in boosting consumption. Despite this, the TC package remains more effective to stabilize the economy.

4.4.4 Implementation and Timing of a Tax Credit Package

Implementing changes in income taxes can be an arduous task, with multiple rounds of discussions among several branches of government. As such, changing income taxes at a business cycle frequency may seem unfeasible. Additionally, full awareness of the tax change may develop slowly, especially if tax credits are refunded towards the end of the fiscal year.

That being said, a feasible alternative would be to implement legislations such that labor taxes respond systematically to the state of the economy. A current example of such legislation is unemployment benefits, whose generosity and duration respond to the total unemployment level.[15] Implementing this systematic component on taxes with a simpler structure—such as payroll taxes, which are collected by firms on a monthly basis—could

[15] A similar proposal can be found in Sahm (2019), who proposes paychecks to be automatically distributed to households as a function of the state of the economy.

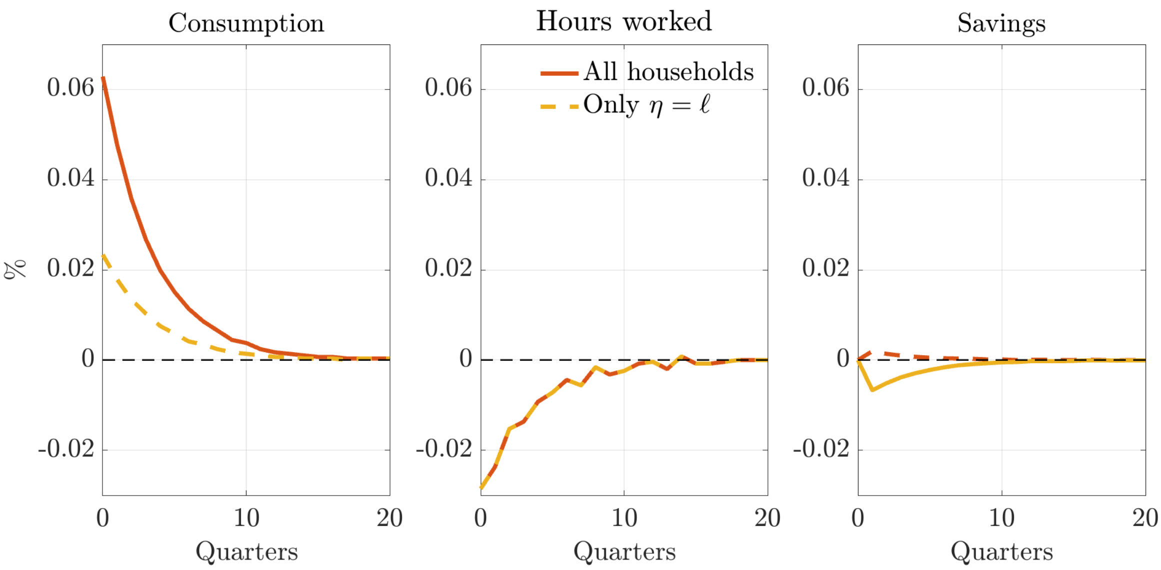

Figure 11: Insurance Channel of the UI Package

Note: Figure 11 presents differences in impulse response function of consumption, labor supply, and savings, between a counterfactual economy—implementing the UI package but keeping prices, taxes, unemployment risk and the measure of households as in the no-stabilization benchmark—and the no-stabilization benchmark. Responses are aggregated at two levels: across the entire population, with $\eta = \ell, u$, and only across households who can work ($\eta = \ell$). The *insurance channel* of the UI Package is given by the differential responses of households who can work. The x-axes report quarters.

be further convenient, as workers would perceive their additional income as they receive their paychecks.

An additional concern with labor tax cuts centers on the time it may take for the policy to have an effect. While our model implies an immediate peak effect of labor tax cuts, the empirical work in Mertens and Ravn (2013) and Zidar (2019) suggests that effects are more backloaded. Delayed responses may be attributable to the delayed awareness about the tax changes, or because of further labor and capital adjustment frictions we currently don't have in our model. Addressing this issue would necessitate a richer model of the labor market, capital accumulation, and of formation of expectations.

Beyond implementation and timing considerations, our findings suggest that labor tax cuts are a potent policy that deserves more attention in policy debates.

5 Robustness

This section presents several robustness exercises. Section 5.1 considers deeper recessions. Section 5.2 analyzes other standard fiscal stabilization packages frequently implemented or discussed in the literature. Section 5.3 presents an alternative calibration with larger *lpe*. Section 5.4 considers alternative monetary policy rules. Finally, Section 5.5 discusses the effects of considering sticky wages in our environment.

5.1 Deeper Recession

Section 4 considers and arguably mild recession, with GDP contracting by just 0.12% in the first quarter. One might expect the effectiveness of the TC package to weaken in a deeper downturn with higher unemployment. We find this is not the case: even in a deeper recession, the TC package remains the most effective stabilization tool among those we consider.

In particular, we increase the size of the preference shock ω_t so that total output loss in the benchmark case (with no fiscal intervention) is 1% of GDP, relative to 0.125% in the case we considered in Section 4.1.[16] We also rescale the size of the fiscal packages. While the fiscal cost of the packages in Section 4.2 was equivalent to a one-time $200 check to each household, in this section we consider a package size equivalent to a one-time $1,500 check to each household. In particular, during the first quarter after the shock, the TT package implies a $2,200 check for the poorest 15% of households, the UI package implies an $8,500 check for unemployed households, and the TC package implies an average transfer of $2,200 for the poorest 15% of working households.[17] As in Section 4.2, the fiscal package benefits return to their steady-state values with the same persistence of the preference shock, $\rho_\omega = 0.75$.

Figure 12 plots the impulse response functions after the larger shock, for the benchmark case as well as for each fiscal package. Figure 13 plots the multipliers of each fiscal package. As these figures show, while the model is nonlinear, results roughly scale up linearly for the shock sizes we consider.

Importantly, the TC remains the most effective package in the deeper recession case, delivering stronger gains in output and consumption, together with more muted effects on inflation. Fiscal package multipliers are virtually the same as in Section 4.3, as output gains and fiscal costs increased in similar proportions.

5.2 Other Fiscal Packages

Transfers and Public Spending. To put our results into perspective, we compare the three fiscal packages we analyzed with two other packages frequently discussed in policy debates. First, we consider a one-time lump-sum transfer of $200 given to each households, which we refer to as the T package. Second, we consider an increase in government spending, of the same amount of the other packages, which returns to steady-state at a persistence of $\rho_\omega = 0.75$, which we refer to as the G package. The left panel of Figure 14 reports output multipliers for these two cases, together with the TC package

[16] We measure annual output loss as $\sum_t \frac{Y_t^b - Y}{4Y}$, where Y_t^b is output in the benchmark case and Y is steady-state output. Because a model period is a quarter, we rescale by four to get annual numbers.

[17] We model the fiscal packages in the same manner as we did in Section 4, including the phaseout rates ξ, and increase the level of the transfers by increasing m_t.

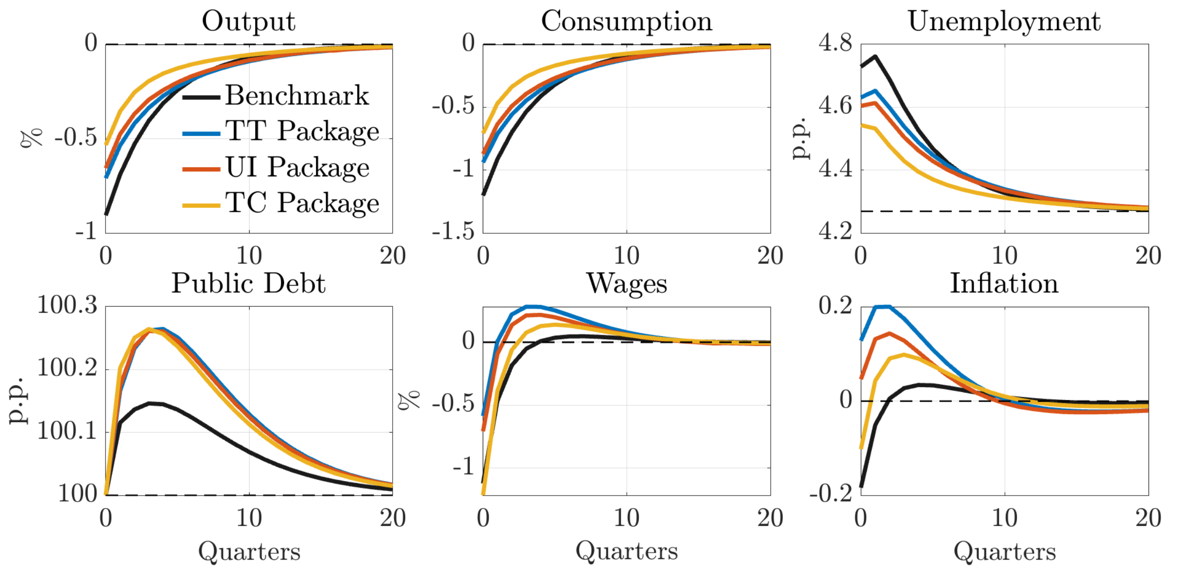

Figure 12: Impulse Responses during a Deeper Recession

Note: Impulse responses of a deeper demand-driven recession. The benchmark depicts the case with no fiscal stabilization package; the TT package implements targeted transfers to low-income households; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. The x-axes report quarters. The initial shock is selected to generate an annual output loss of 1% in the benchmark case.

multiplier to ease comparison.

The T package is not very effective in stimulating output—despite an average quarterly *mpc* of 0.13 in our calibration—with an output multiplier barely around 0.1. The reason is that the T package fails to target low-income/high-*mpc* households, thus reducing the effectiveness of the fiscal package. In contrast, the G package does stimulate the economy, with a output multiplier even larger than the TC package one on impact. Yet, this output expansion comes together with a large crowding-out of private consumption. In our calibration, the consumption multiplier is negative at all horizons in the case of the G package.

UI Extension. We also compare our UI package with another commonly used fiscal stimulus package: an extension of UI benefits, which we refer to as "UI extension package". We model the UI extension as an increase in ζ, the fraction of unemployed households who receive unemployment benefits. We assume ζ increases after the shock, and returns to its steady-state value at a persistence of $\rho_\omega = 0.75$. We find the initial increase in ζ so that the total fiscal cost of the package equates the cost of the other analyzed packages. The right panel of Figure 14 plots cumulative output multipliers for the UI extension package and compares it to the UI package. A fiscal stimulus package in the form of a UI extension delivers multipliers slightly smaller than the UI package but of a comparable magnitude. Transfers are equal across all unemployed in the UI package, while they are increasing in productivity for the UI extension. Lower-productivity households also feature higher *mpc*, which explains why the UI package is more expan-

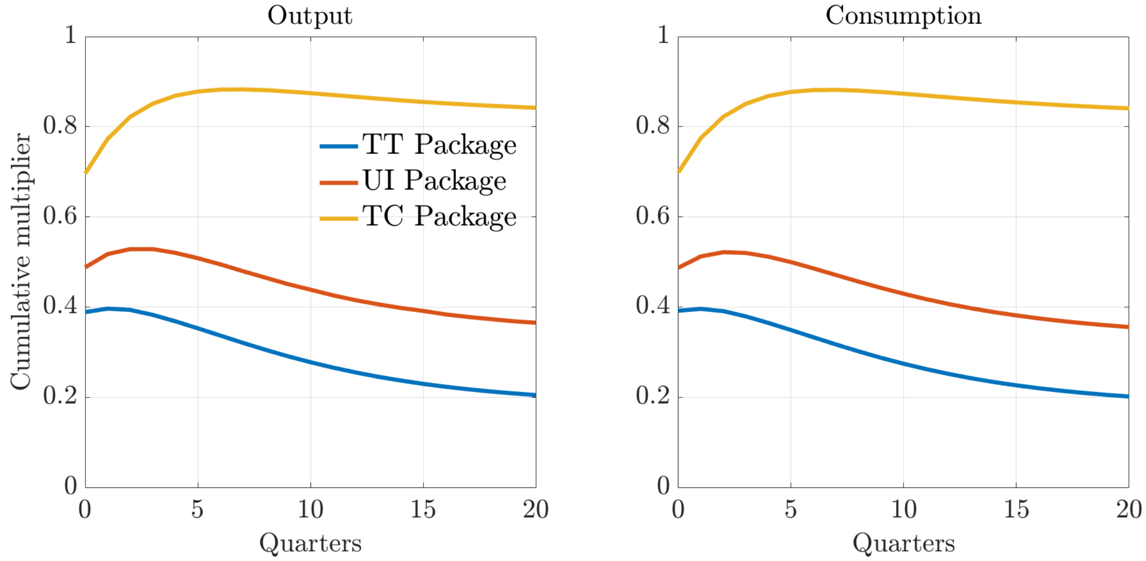

Figure 13: Cumulative Multipliers during a Deeper Recession

Note: Cumulative output and consumption multipliers in a deeper recession. The TT package implements targeted transfers to low-income households; the UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. The x-axes report quarters. The initial shock is selected to generate an annual output loss of 1% in the Benchmark case.

sionary. Yet, the quantification of the UI extension remains imprecise in the model, as we abstract from heterogeneity between recipients and non-recipients of the UI benefits and do not allow for endogenous job search when unemployed.

5.3 Alternative Calibration: Higher *lpe*

In this section, we investigate an alternative calibration, which targets larger average *lpe*. We do so because the average *lpe* is a key model-implied moment to evaluate the TC package, but there is disagreement in the literature on what the *lpe* value should be.[18] In particular, we target an average *lpe* of 0.45 in this section, larger than the average *lpe* of 0.30 discussed in Section 3.3. We obtain the larger *lpe* by adjusting the variance of the Gumbel shock ϱ—associated with the households' labor supply discrete choice. We recalibrate all other parameters to target the same remaining moments as before.

The higher-*lpe* calibration results in a steeper profile of *lpe* across households, ranging from 0.94 for the bottom income quartile to 0.25 for the top income quartile. Additionally, the higher-*lpe* calibration features a larger *mpc*, at 0.19 at the quarterly level compared with 0.13 in the previous calibration. In turn, the higher-*lpe* calibration is more aligned with the evidence on tax shocks discussed in Section 3.4. For instance, when replicating the exercise in Mertens and Ravn (2013), we obtain a tax multiplier close to 1 in the high-*lpe* calibration, larger than the 0.6 obtained with the previous calibration and closer to the tax multiplier range of 2-2.5 estimated in Mertens and Ravn (2013). Similarly,

[18]Two outstanding recent surveys of the literature are Meghir and Phillips (2010) and Keane (2011).

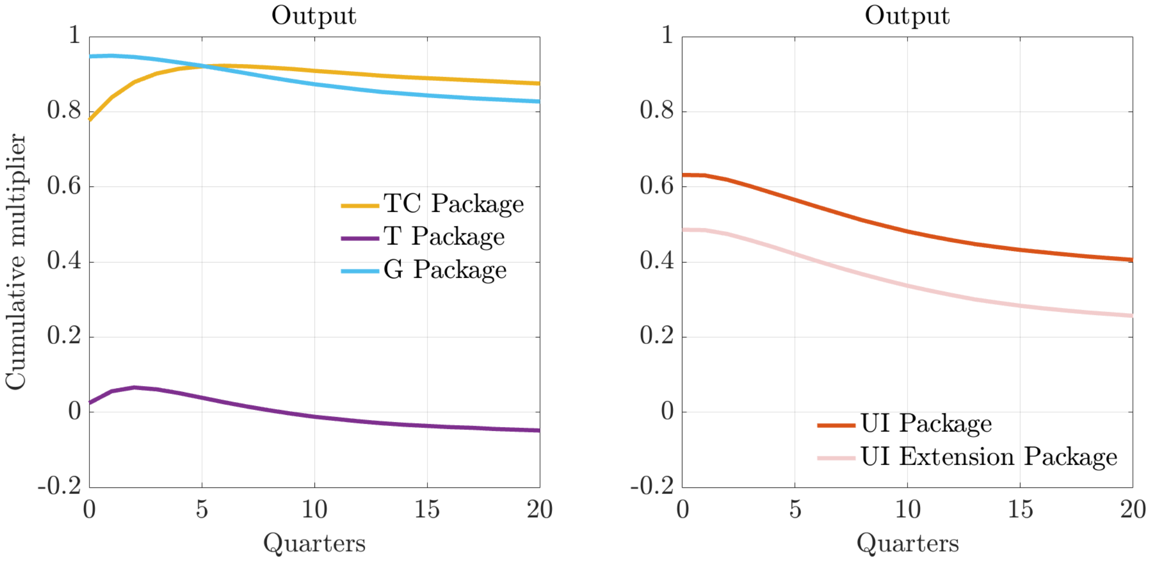

Figure 14: Cumulative Multipliers for Three Additional Stabilization Packages

Note: The left panel presents cumulative output multipliers for two new packages: the T package, a one-time lump-sum check of $200; and the G package, a temporary increase in public spending. For comparison we also report the case of the TC package. The right panel presents cumulative output multipliers for an extension of the UI benefits. For comparison we also report the case of the UI package. The x-axes report quarters.

when replicating the exercise in Zidar (2019), we find that a tax cut to the bottom-90 income group leads to a 1.7% increase in employment, larger than the 1% obtained with the previous calibration, and closer to the range of 3% employment response estimated in Zidar (2019). That is, the higher-*lpe* calibration comes closer to evidence, but remains a conservative calibration of the *labor supply channel*, as the aggregate effects of tax shocks remain larger than in this calibration, and the *lpe* distribution remains moderate, at 0.45 on average and below unity for the bottom quartile.

The TC package is even more effective in stimulating the economy in the higher-*lpe* calibration. Figure 15 reports the multipliers for both the UI package and the TC package. Multipliers for the UI package are comparable to the benchmark calibration. Instead, multipliers for the TC package are well above unity. That is, the TC package appears more attractive when the model-implied effects of a tax shocks are better aligned with evidence.

5.4 Monetary Policy Across Fiscal Packages

The effectiveness of different fiscal packages may depend on the response of monetary policy. Indeed, since we assume that the policy rate responds to inflation only, the degree of monetary policy accommodation may differ across fiscal packages depending on their inflationary pressures. That is, monetary policy may effectively implement a different path of real rates under each fiscal package, leading to different effectiveness in attenuating the recession.

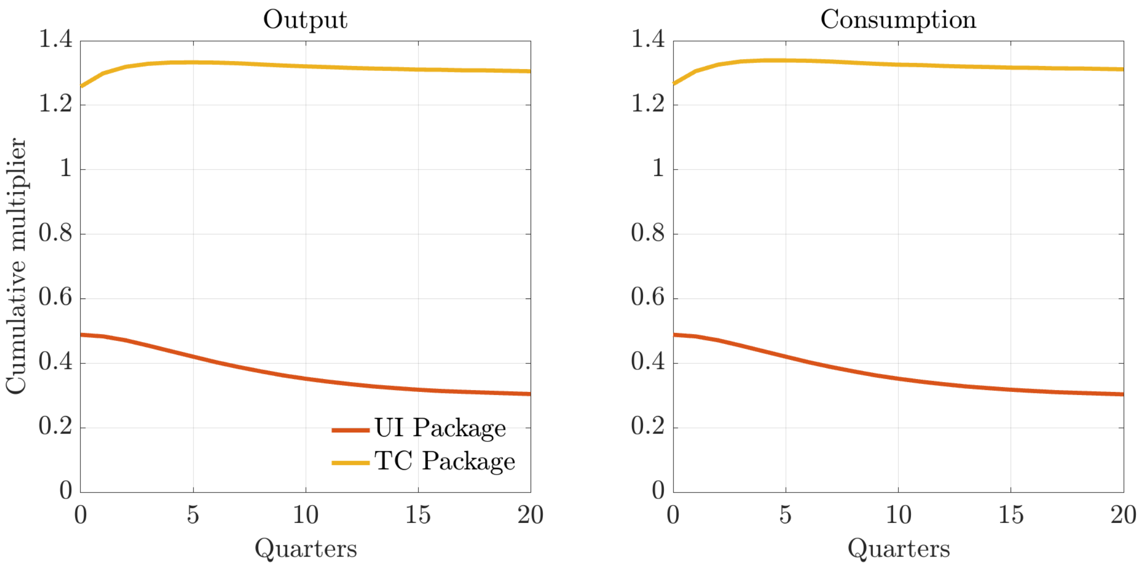

Figure 15: Cumulative Multipliers for an Alternative Calibration

Note: Alternative Calibration with larger and steeper *lpe*. Cumulative output and consumption multipliers. The UI package implements a transfer to unemployed households; the TC package implements a tax credit to working-poor households. The x-axes report quarters.

In turn, in this section we consider two variations to the baseline monetary policy rule. First, we consider an alternative monetary policy rule that implements the same real rate as in the benchmark economy without any fiscal intervention. In this case, the effect of monetary policy is equalized across all fiscal packages (and the benchmark). We label this variation as "real rate target".

Second, we consider an augmented monetary policy rule that responds to output deviations as well as inflation. We do so because a more accommodative monetary policy may reduce the need of a fiscal intervention, thus rendering the alternative fiscal packages we consider generally less effective. In particular, we augment the Taylor rule to include deviations from steady-state, as:

$$\ln\left(\frac{1+i_{t+1}}{1+\bar{i}}\right) = \phi_{\Pi}\ln\left(\frac{\Pi_t}{\bar{\Pi}}\right) + \phi_Y \ln\left(\frac{Y_t}{\bar{Y}}\right), \tag{17}$$

where $\bar{Y}$ is the steady-state level of output. We maintain $\phi_{\Pi} = 1.5$ as in our benchmark, and assume a rather strong reaction of the interest rate to output deviations, with $\phi_Y = 0.25$.[19] We label this second variation as "augmented Taylor rule".

Figure 16 shows output multipliers for the two monetary policy variations just discussed. The left panel reports multipliers under the "real rate target", and the second column reports multipliers under the "augmented Taylor rule". There are two main findings from these exercises. First, monetary policy indeed shapes the effects of the fiscal packages. Second, the TC package remains the most effective package in attenuating the

[19]For comparison, Galí (2015), chapter 3, uses $\phi_Y = 0.125$.

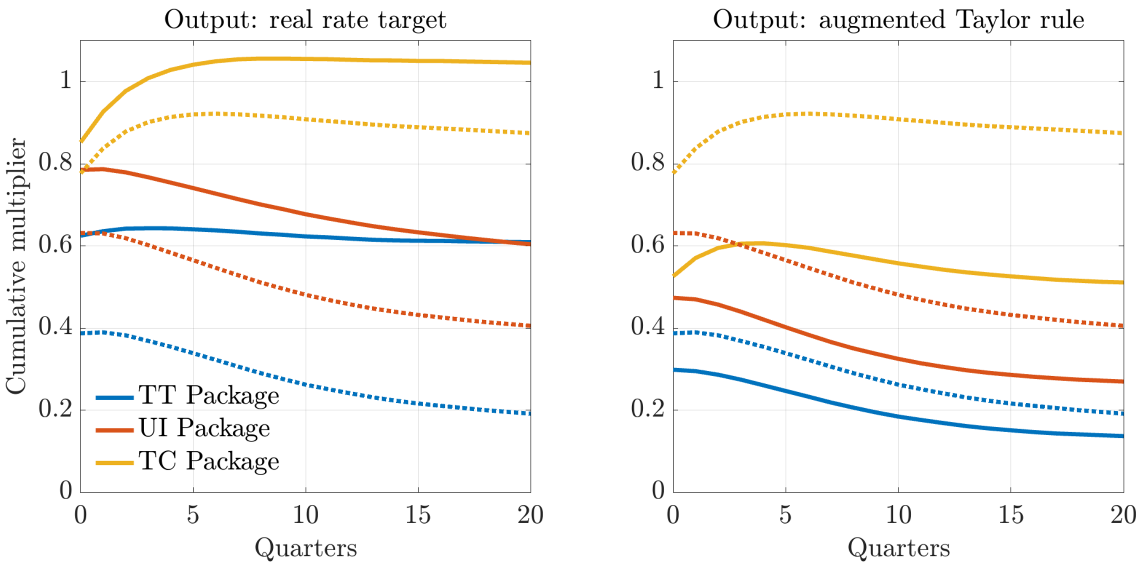

Figure 16: Cumulative Multipliers Under Different Monetary Policies

Note: The left panel presents cumulative output multipliers when monetary policy implements the real rate of the benchmark economy. The right panel presents cumulative output multipliers when monetary policy follows an augmented Taylor including output deviations from steady state. The dashed lines report multipliers under the baseline monetary policy. The x-axes report quarters.

recession.

The "real rate target" yields higher multipliers, because monetary policy doesn't respond to inflationary pressure induced by fiscal stimulus. Indeed, multipliers rise especially for the packages that generate inflation the most. For example, the TT package—previously the most inflationary under the baseline policy rule—sees its multiplier increase by 24bp on impact and 40bp after five years. By contrast, the TC package, which was the least inflationary in the baseline, sees a smaller gain: just 8bp on impact and 17bp after five years. Importantly, the TC package remains the most effective option even under the "real rate target", with a multiplier above 1 after four quarters, compared to 0.77 for the UI package and 0.64 for the TT package.

The "augmented Taylor rule" yields lower multipliers on fiscal packages, as the more accommodative monetary policy already mitigates output losses, reducing the need for fiscal support. In turn, multipliers fall the most for the packages that generate inflation the least. For example, the TC package multiplier decreases by 25bp on impact and by 35bp after five years. In contrast, the TT package multiplier decrease modestly, only by 9bp on impact and 5bp after five years. Still, the TC package remains the most effective option even under the "augmented Taylor rule", with a multiplier at 0.6 after four quarters, compared to 0.44 for the UI package and 0.27 for the TT package.

5.5 Nominal Rigidities

Our benchmark model assumes nominal rigidities in price setting, but abstracts from sticky, wages which are often used in DSGE literature. Abstracting from sticky wages could be consequential. When labor is demand-driven, the importance of the labor supply channel may be damped, thus reducing the efficacy of the TC package. In turn, in this section we discuss the robustness of our results to introducing sticky wages.

We consider an environment with sticky wages as developed in Ferriere and Navarro (2024), which extends Erceg, Henderson, and Levin (2000) to a set-up with heterogeneous households. We model the labor market with two layers, with a labor packer and a labor union, and we accommodate households' heterogeneity by introducing a competitive market between unions and households. A key advantage of our modeling is to generate labor market outcomes that depend not only on firms' labor demand but also on the distribution of individual labor supply decisions.

The labor packer produces a final labor bundle by combining the differentiated labor produced by each union. Labor unions operate under monopolistic competition and set wages w_t subject to a quadratic adjustment cost. They hire households' labor in a competitive market at rate w_t^h and use it to produce their union-specific labor with a one-to-one technology. In a symmetric equilibrium, the unions' optimal decisions yield the wage Phillips curve:

$$\left(\Pi_t^w - \bar{\Pi}\right) \Pi_t^w + \frac{\epsilon^w - 1}{\Theta^w} w_t = \frac{\epsilon^w}{\Theta^w} w_t^h + \frac{1}{1 + r_{t+1}} \left(\Pi_{t+1}^w - \bar{\Pi}\right) \Pi_{t+1}^w \frac{N_{t+1}}{N_t} \tag{18}$$

where $\Pi_t^w = W_t / W_{t-1}$ is nominal wage inflation. Further details of the modeling and equilibrium conditions are presented in Appendix B.1 and B.2.

Appendix B.3 establishes an equivalence result between environments with sticky prices and those with sticky wages. In particular, we show that under linear production technology, equilibrium allocations and prices are identical across the two environments, provided the calibration yields the same Phillips curve slope. Intuitively, when output is equal to labor, it makes no difference whether output or labor is demand driven. As a result, our findings are robust to modeling nominal rigidities as sticky wages instead of sticky prices.

6 Conclusion

We developed a HANK model to analyze the effectiveness of different fiscal packages in response to a demand-driven recession. The model features an empirically realistic distribution of *mpc* and *lpe*, and also matches the cross-sectional incidence of unemployment risk over the business cycle. We find that the targeted labor-tax credits implemented in the TC package serve as the most effective policy we consider in stabilizing a recession. The TC package is effective because it operates on both the *consumption channel*, as it provides income to low-income working households with high *mpc*, and the *labor supply channel*, as it lowers taxes on low-income working households with high *lpe*. The other fiscal packages we consider, such as targeted transfers or more generous unemployment benefits, operate largely through a *consumption channel* only.

We argued that the strength of the *labor supply channel* in our calibration is conservative relative to available empirical estimates. Furthermore, the model includes empirically founded unemployment risk dynamics, restricting workers' labor supply decisions in a realistic manner. As such, we think our model captures a realistic, yet conservative, response of labor supply to tax cuts.

Fiscal stabilization packages based on temporary labor tax cuts could raise concerns about who benefits the most, as well as concerns on implementation. Nonetheless, the substantial efficacy of labor tax cuts that we find warrants further discussion in policy debates.

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A Computations

We provide computational details below. We start discussing the steady-state computations in Section A.1 and then discuss computations for the the transitions in Section A.2.

A.1 Steady State

To solve for the steady state of the economy, we need to find the real interest rate r and the level of taxes λ. We explain next how we do this.

0. Set grids for assets $\vec{a}$, productivity levels $\vec{x}$, and discount factor $\vec{\beta}$. Let N_a, N_x, and N_β be the number of points in each grid, respectively. Compute the transition matrix of productivities $\pi_x(x', x)$ using Tauchen (1986) method and the transition matrix of discount factors $\pi_\beta(\beta', \beta)$.

1. Guess values for the interest rate r and the tax parameter λ. Compute implied wages w from the price Phillips curve (7).

2. Solve for household policies by value function iteration. In particular, for a given guess of the value function $V(a, x, \eta, \beta)$, update the value function in three steps. Update the value function of being unemployed $\eta = u$ as

$$\begin{aligned} V_t(a, x, u, \beta) &= \max_{c,a'} \left\{ \log(c) - B\bar{h} + \beta \mathbb{E}_t \left[V_{t+1}(a', x', \eta', \beta') | x, u, \beta) \right] \right\} \\ \text{subject to} & \\ c + a' &\leq a + y^k - \mathcal{T}_t(0, y^k) + \mathcal{B}_t(w_t x) + T_t + d_t^h(x), \\ y^k &= r_t a, \qquad a' \geq 0. \end{aligned}$$

where $\mathcal{T}(y^\ell, y^k) = \tau_k y^k + y^\ell - \lambda (y^\ell)^{1-\gamma}$ and $\mathcal{B}_t(w_t x) = \zeta \min(\rho w_t x \bar{h}, \bar{ui}) + \chi w_t x \bar{h}$. Update the value function when $\eta = \ell$ for each level of hours $\{h = 0, h = \bar{h}\}$ as

$$\begin{aligned} V_t^h(a, x, \ell, \beta) &= \max_{c,a'} \left\{ \log(c) - Bh + \beta \mathbb{E}_t \left[V_{t+1}(a', x', \eta', \beta') | x, \ell, \beta) \right] \right\} \\ \text{subject to} & \\ c + a' &\leq a + y^\ell + y^k - \mathcal{T}_t(y^\ell, y^k) + T_t + \tilde{d}_t(x), \\ y^\ell &= w_t x h, \quad h \in \left\{0, \bar{h}\right\}, \\ y^k &= r_t a, \qquad a' \geq 0, \end{aligned}$$

Then, aggregate over the Gumbel shocks to obtain the value function when working as: $\hat{V}(a, x, \ell, \beta) = \varrho \ln \left(\sum_{h \in \{0, \bar{h}\}} \exp\left(\frac{\hat{V}^h(a,x,\ell,\beta)}{\varrho} \right) \right)$. Iterate until $\left\| \hat{V} - V \right\| < \varepsilon^V$. We use $\varepsilon^V = 1e - 13$.

3. Compute the stationary measure implied by the optimal policies of step 2. In particular, for a given guess $\mu(a, x, \eta, \beta)$, compute implied measure $\hat{\mu}(a, x, \eta, \beta)$ as

$$\hat{\mu}(a_{i'}, x_{j'}, \eta_{k'}, \beta_{m'}) = \sum_{i=1}^{N_a} \sum_{j=1}^{N_x} \sum_{k=1}^{2} \sum_{m=1}^{N_\beta} \sum_{h \in \{0, \bar{h}\}} \mathbb{L}\left\{ a_{i'} = a^{h\prime}(a_i, x_j, \eta_k, \beta_m) \right\} \pi_x(x_{j'}, x_j) \times \ldots$$
$$\ldots \pi_\beta(\beta_{m'}, \beta_m) \pi_\eta(\eta_{k'} | \eta_k, x_j) \mathbb{h}^h(a_i, x_j, \beta_k) \mu(a_i, x_j, \eta_k, \beta_m) \text{ if } \eta_k = \ell,$$
$$\hat{\mu}(a_{i'}, x_{j'}, \eta_{k'}, \beta_{m'}) = \sum_{i=1}^{N_a} \sum_{j=1}^{N_x} \sum_{k=1}^{2} \sum_{m=1}^{N_\beta} \mathbb{L}\left\{ a_{i'} = a'(a_i, x_j, \eta_k, \beta_m) \right\} \pi_x(x_{j'}, x_j) \pi_\beta(\beta_{m'}, \beta_m) \times \ldots$$
$$\ldots \pi_\eta(\eta_{k'} | \eta_k, x_j, x) \mu(a_i, x_j, \eta_k, \beta_m) \text{ if } \eta_k = u.$$

if $\eta = u$, where $\mathbb{L}$ computes a linear interpolation: $\mathbb{L}(a_i, a') = \mathbb{I}\left(a' \in (a_{i-1}, a_i]\right) \frac{a - a_{i-1}}{a_i - a_{i-1}}$. Iterate until $\|\hat{\mu} - \mu\| < \varepsilon^\mu$. We use $\varepsilon^\mu = 1e - 13$.

4. Compute excess fiscal revenues using the government's budget constraint $E^X = \int \left(y_\ell(a, x, \eta, \beta) - \lambda \int y_\ell(a, x, \eta, \beta)^{1-\gamma} + \tau_k a - \mathcal{B}(x, \eta) \right) d\mu(a, x, \eta, \beta) - (G + rD + T)$

and compute excess demand of government bonds: $E^A = A - D$, where $A = \int a d\mu(a, x, \beta)$.

5. If $\|E^X\| < \varepsilon^X$ and $\|E^A\| < \varepsilon^A$, the model converged. Otherwise, update r and λ and go to step 2 We use $\varepsilon^X = 1e - 8$ and $\varepsilon^X = 1e - 6$.

A.2 Transition

We describe the transition for the no-stabilization benchmark. Implementing a fiscal stabilization package does not alter the solution method.

We solve for the transition using a *shooting algorithm*. We assume the economy returns to its steady state $\bar{T}$ periods after the shock. During the transition, we know the path $\{\omega_t\}_{t=1}^{\bar{T}}$. We also know that the value function at $t = \bar{T}$ is equal to its steady-state value $V_{\bar{T}}(a, x, \eta, \beta) = V(a, x, \eta, \beta)$. We assume that unemployment shocks respond to changes in output even in the first period of the recession, so that the measure at $t = 1$ *before* the unemployment shocks are realized $\tilde{\mu}_1$ is equal to its steady-state counterpart: $\tilde{\mu}_1(a, x, \eta_-, \beta) = \mu(a, x, \eta_-, \beta)$. Then, given a guess for taxes and prices $\{Y_t, \Pi_t, \lambda_t\}_{t=1}^{\bar{T}}$ such that $(Y_{\bar{T}}, \Pi_{\bar{T}}, \lambda_{\bar{T}}) = (Y, \Pi, \lambda)$, we compute unemployment risk and prices and solve the household problem backwards. We iterate on the sequence $\{Y_t, \Pi_t, \lambda_t\}_{t=1}^{\bar{T}}$ using a quasi-Newton algorithm to clear markets. More formally, we proceed as follows:

1. Guess sequences $\{Y_t, \Pi_t, \lambda_t\}$ for aggregate output, inflation and taxes—such that $(Y_{\bar{T}}, \Pi_{\bar{T}}, \lambda_{\bar{T}}) = (Y, \Pi, \lambda)$. Given the path for inflation, compute the nominal rate $\{i_t\}_{t=1}^{\bar{T}}$ using the Taylor rule in equation (9), assuming that the nominal rate is fixed at the moment of the shock. Compute the real rate $\{r_t\}_{t=1}^{\bar{T}}$ using the Fisher equation (10). Compute wages using the Phillips curve in equation (7) and profits using the firms' problem as in equation (6). Finally, compute unemployment risk each period using the guessed path for output and equations (15) and (14).

2. Solve for the household problem backwards. That is, given the value function $V_{t+1}(a, x, \eta, \beta)$ in period $t + 1$, solve for value of working h in period t and iterate backwards. As terminal condition, use $V_{\bar{T}}(a, x, \eta, \beta) = V(a, x, \eta, \beta)$.

3. Compute the time $t + 1$ measure using the household's policies of step 2. In particular, given $\mu_t(a, x, \eta, \beta)$, compute $t + 1$ measure using transition probabilities for unemployment computed in step 1 and policy functions computed in step 2. In $t = 1$ compute $\mu_1(a, x, \eta, \beta)$ using the steady-state measure before unemployment shocks are realized $\tilde{\mu}(a, x, \eta_-, \beta)$ and unemployment flows in $t = 1$ given output Y_1.

4. Compute market clearing errors:

- $E_t^X = \int \left(y_{\ell,t}(a,x,\eta,\beta) - \lambda_t \int y_{\ell_t}(a,x,\eta,\beta)^{1-\gamma} + \tau_k a_t - \mathcal{B}_t(x,\eta)\right) d\mu_t(a,x,\eta,\beta) - (G_t + r_t D_t + T_t)$ the error in government budget constraint, where D_t given by the law of motion for debt in equation (16); in the case of the adoption of the stabilization package adjust the government budget constraint accordingly.
- $E_t^A = A_t - D_t$, where $A_t = \int a d\mu_t(a,x,\eta,\beta)$;
- $E_t^L = L_t - Y_t$, where $L_t = \int x h_t(a,x,\ell,\beta) d\mu_t(a,x,\ell,\beta)$.

Let $E_t = \left(E_t^X, E_t^A, E_t^L\right)'$ collect all errors. Let $\mathcal{E}(\mathcal{X})$ collect the $3\bar{T} \times 1$ errors for all periods along the transition, where $\mathcal{X} = \{Y_t, \Pi_t, \lambda_t\}_{t=1}^{\bar{T}}$. An equilibrium can be written as

$$\mathcal{E}(\mathcal{X}) = 0 \tag{19}$$

We solve for $\mathcal{X}$ in equation (19) using a quasi-Newton method, with a tolerance level of $\varepsilon^{\mathcal{X}} = 1e-6$.

B Sticky Prices and Sticky Wage: Equivalence Result

This section proves an equivalence result between an environment with sticky prices and an environment with sticky wages. In particular, we show that the equilibrium allocations and prices are identical in both environments, provided that the calibration generates the same slope of the Phillips curve. Next, we explain how we introduce wage rigidities in our model of Section 2, and then prove the equivalence result.

B.1 Modeling Sticky Wages

The model is identical to the one in Section 2, expect that we add a friction in the labor market. In particular, we assume a two-layer labor market, with a labor packer and a labor union, on, akin to the final-good producer and the intermediate-good producer. We accommodate households heterogeneity by introducing a market between unions and households, as we discuss next.

The labor packer produces a final labor bundle by combining the differentiated labor n_{kt} from each union $k \in [0,1]$. The labor bundle is produced as

$$N_t = \left(\int_0^1 n_{kt}^{\frac{\epsilon_w - 1}{\epsilon_w}}\right)^{\frac{\epsilon_w}{\epsilon_w - 1}},$$

and optimal labor demand for each variety reads

$$n_{kt}^d = \left(\frac{W_{kt}}{W_t}\right)^{-\epsilon_w} N_t \tag{20}$$

where W_{kt} is the nominal wage paid to union k and $W_t = w_t P_t$ is the wage paid by intermediate-goods producers in nominal terms.

Labor unions are under monopolistic competition and set wages subject to a quadratic adjustment cost. They hire households labor in a competitive market at wage rate w_t^h and use it to produce their union-specific labor with a one-to-one technology. Let $J_t^w(W_{kt-1})$ be the maximal attainable value at time t to a labor union that posted wages W_{kt-1} last period:

$$J_t^w(W_{kt-1}) = \max_{W_{kt}, n_{kt}} \left\{ d_{kt}^w + \frac{1}{1+r_{t+1}} J_{t+1}^w\left(W_{jt}\right) \right\} \tag{21}$$

subject to

$$d_{kt}^w = \left(\frac{W_{kt}}{P_t} - w_t^h\right) n_{kt} - \Theta_t^w(W_{kt}, W_{kt-1}) - \Phi^w$$

$$n_{kt} = \left(\frac{W_{kt}}{W_t}\right)^{-\epsilon_w} N_t$$

$$\Theta_t^w(W_{kt}, W_{kt-1}) = \frac{\Theta^w}{2}\left(\frac{W_{kt}}{W_{kt-1}} - \bar{\Pi}\right)^2 N_t$$

where n_{kt} is the total efficient hours demanded from households, and w_t^h is the wage received by the households.

In a symmetric equilibrium, the unions' optimal decisions yield the wage Phillips curve:

$$\left(\Pi_t^w - \bar{\Pi}\right)\Pi_t^w + \frac{\epsilon^w - 1}{\Theta^w} w_t = \frac{\epsilon^w}{\Theta^w} w_t^h + \frac{1}{1+r_{t+1}}\left(\Pi_{t+1}^w - \bar{\Pi}\right)\Pi_{t+1}^w \frac{N_{t+1}}{N_t} \tag{22}$$

where $\Pi_t^w = W_t / W_{t-1}$ is wage inflation. Let $d_t^w = \int d_{kt}^w dk$ be the total dividends paid by unions.

Note that, from households' perspective, the labor market friction doesn't affect them directly. In particular, if the sequence of wages w_t^h remains unchanged, as well as other equilibrium prices, households make the same decisions. We leverage on this insight below to prove our equivalence result.

B.2 Equilibrium Conditions

Relative to Section 2, market clearing changes only for the labor market changes. In particular, the labor market between households and unions must clear, as well as between labor packers and intermediate-good producers—that is,

$$L_t = \int_0^1 n_{kt} dk, \text{ and } N_t = \int_0^1 n_{jt} dj,$$

where $L_t \equiv \int x h_t(a, x, \ell, \beta) d\mu_t(a, x, \ell, \beta)$ is households' effective labor supply, $\int_0^1 n_{kt} dk$ is the unions' total labor demand, N_t is labor bundle produced by labor packers, and $\int_0^1 n_{jt} dj$ is the labor demand by intermediate-goods producers. In a symmetric equilibrium we have $N_t = L_t$.

Additionally, we now have two Phillips curve: one for prices and one for wages. Thus, we can characterize an equilibrium as follows. Given sequences for government policies $\{\mathcal{P}_t\}_t = \{G_t, T_t, D_t, \mathcal{T}_t(\cdot), \mathcal{B}_t(\cdot)\}_t$, an equilibrium in this economy is given by: sequences of prices $\{r_t, w_t^h, w_t, i_t, \Pi_t\}_t$, household policies $\left\{h_t^h(\boldsymbol{s}), c_t^h(\boldsymbol{s}), a'^h_t(\boldsymbol{s})\right\}_{ht}$, and measures $\{\mu_t(\boldsymbol{s})\}_t$; intermediate-good producers' policies $\{n_{jt}\}_{jt}$; unions' policies $\{n_{kt}\}_{kt}$; such that all agents optimize, and all markets clear.

Then, using $Y_t = N_t$, the equilibrium for this model is given by the two Phillips curves

$$\frac{\Theta}{\epsilon - 1}\left(\Pi_t - \bar{\Pi}\right)\Pi_t + 1 = \frac{\epsilon}{\epsilon - 1} w_t + \frac{1}{1 + r_t}\frac{\Theta}{\epsilon - 1}\left(\Pi_{t+1} - \bar{\Pi}\right)\Pi_{t+1}\frac{Y_{t+1}}{Y_t} \tag{23}$$

$$\frac{\Theta_w}{\epsilon_w - 1}\left(\Pi_t^w - \bar{\Pi}\right)\Pi_t^w + w_t = \frac{\epsilon_w}{\epsilon_w - 1} w_t^h + \frac{1}{1 + r_t}\frac{\Theta_w}{\epsilon_w - 1}\left(\Pi_{t+1}^w - \bar{\Pi}\right)\Pi_{t+1}^w\frac{Y_{t+1}}{Y_t}; \tag{24}$$

dividends and price adjustment costs

$$d_t^p = (1 - w_t) Y_t - \Theta_t - \Phi \tag{25}$$

$$d_t^w = \left(w_t - w_t^h\right) Y_t - \Theta_{wt} - \Phi_w \tag{26}$$

$$d_t = d_t^p + d_t^w \tag{27}$$

$$\Theta_t = \frac{\Theta}{2}\left(\Pi_t - \bar{\Pi}\right)^2 Y_t \tag{28}$$

$$\Theta_{wt} = \frac{\Theta_w}{2}\left(\Pi_t^w - \bar{\Pi}\right)^2 Y_t; \tag{29}$$

policies for households

$$C_t = \mathbb{C}_t(\{r_j, w_j^h, d_j, Y_j, \mathcal{P}_j\}_{j \geq 0}), \quad L_t = \mathbb{L}_t(\{r_j, w_j^h, d_j, Y_j, \mathcal{P}_j\}_{j \geq 0}) \tag{30}$$

where $\mathbb{C}_t$ and $\mathbb{L}_t$ denote aggregate labor supply and consumption using households' optimal policies; the Taylor rule and the Fisher equation determining monetary policy

$$\ln\left(\frac{1 + i_{t+1}}{1 + \bar{i}}\right) = \phi_\Pi \ln\left(\frac{\Pi_t}{\bar{\Pi}}\right) \tag{31}$$

$$1 + r_t = \frac{1 + i_t}{\Pi_t}; \tag{32}$$

and feasibility

$$Y_t = C_t + G_t + \Theta_t + \Phi + \Theta_{wt} + \Phi_w \tag{33}$$

where $\Pi_t^w = \frac{w_t}{w_{t-1}}\Pi_t$ is wage inflation. That is, an equilibrium is a sequence of prices and quantities that satisfy equations (23)-(33).

B.3 Equivalence

Given some government policies $\mathcal{P}_t$, and some parameter values, let

$$X_t = \{r_t, w_t^h, d_t, \Pi_t, C_t, L_t, Y_t\}$$

collect several equilibrium objects.

Sticky-Price Economy.—Consider a model parametrization with sticky prices only, and no wage frictions. Let hats, " ^ ", denote the objects of the sticky-price model. Then, $\hat{\Theta}_w = \hat{\Phi}_w = 0$ and $\hat{\epsilon}_w = +\infty$. Similarly, $\hat{\Theta}, \hat{\Phi}, \hat{\epsilon} > 0$. Let $\hat{X}_t$ collect the equilibrium outcomes of for the sticky-price model.

Sticky-Wage Economy.—Consider a model parametrization with sticky wages only, and no price frictions. Let tildes, " ~ ", denote the objects of the sticky-wage model. Then, $\tilde{\Theta} = \hat{\Phi} = 0$ and $\tilde{\epsilon} = +\infty$. Similarly, $\tilde{\Theta}_w, \tilde{\Phi}_w, \tilde{\epsilon}_w > 0$. Let $\tilde{X}_t$ collect the equilibrium outcomes of for the sticky-price model.

Proposition 1 *Assume $\hat{\Theta} = \tilde{\Theta}_w$, $\hat{\Phi} = \hat{\Phi}_w$, and $\hat{\epsilon} = \tilde{\epsilon}_w$. If $\tilde{\mathcal{P}}_t = \hat{\mathcal{P}}_t$, then $\tilde{X}_t = \hat{X}_t$.*

To prove this, we show that, if $\hat{X}_t$ is an equilibrium in the sticky-price economy, then $\tilde{X}_t = \hat{X}_t$ is an equilibrium in the sticky-wage economy. That is, $\hat{X}_t$ satisfy equations (23)-(33) under the sticky-wage parametrization. We show this next

Equation (23) holds with $\tilde{w}_t = 1$. Thus, we have $\tilde{\Pi}_t^w = \tilde{\Pi}_t$. Then, from equation (24) we have

$$\begin{aligned}
\frac{\tilde{\Theta}_w}{\tilde{\epsilon}_w - 1}\left(\tilde{\Pi}_t^w - \bar{\Pi}\right)\tilde{\Pi}_t^w + \tilde{w}_t &= \frac{\tilde{\epsilon}_w}{\tilde{\epsilon}_w - 1}\tilde{w}_t^h + \frac{1}{1+\tilde{r}_t}\frac{\tilde{\Theta}_w}{\tilde{\epsilon}_w - 1}\left(\tilde{\Pi}_{t+1}^w - \bar{\Pi}\right)\tilde{\Pi}_{t+1}^w\frac{\tilde{Y}_{t+1}}{\tilde{Y}_t} \\
\frac{\tilde{\Theta}_w}{\tilde{\epsilon}_w - 1}\left(\tilde{\Pi}_t - \bar{\Pi}\right)\tilde{\Pi}_t + 1 &= \frac{\tilde{\epsilon}_w}{\tilde{\epsilon}_w - 1}\tilde{w}_t^h + \frac{1}{1+\tilde{r}_t}\frac{\tilde{\Theta}_w}{\tilde{\epsilon}_w - 1}\left(\tilde{\Pi}_{t+1} - \bar{\Pi}\right)\tilde{\Pi}_{t+1}\frac{\tilde{Y}_{t+1}}{\tilde{Y}_t} \\
\frac{\hat{\Theta}}{\hat{\epsilon} - 1}\left(\tilde{\Pi}_t - \bar{\Pi}\right)\tilde{\Pi}_t + 1 &= \frac{\hat{\epsilon}}{\hat{\epsilon} - 1}\hat{w}_t^h + \frac{1}{1+\hat{r}_t}\frac{\hat{\Theta}}{\hat{\epsilon} - 1}\left(\tilde{\Pi}_{t+1} - \bar{\Pi}\right)\tilde{\Pi}_{t+1}\frac{\hat{Y}_{t+1}}{\hat{Y}_t} \\
\frac{\hat{\Theta}}{\hat{\epsilon} - 1}\left(\tilde{\Pi}_t - \bar{\Pi}\right)\tilde{\Pi}_t + 1 &= \frac{\hat{\epsilon}}{\hat{\epsilon} - 1}\hat{w}_t + \frac{1}{1+\hat{r}_t}\frac{\hat{\Theta}}{\hat{\epsilon} - 1}\left(\tilde{\Pi}_{t+1} - \bar{\Pi}\right)\tilde{\Pi}_{t+1}\frac{\hat{Y}_{t+1}}{\hat{Y}_t} \qquad (34)
\end{aligned}$$

where the second line use that $\tilde{w}_t = 1$ and $\tilde{\Pi}_t^w = \tilde{\Pi}_t$; the third line uses that $\hat{\Theta} = \tilde{\Theta}_w$, $\hat{\Phi} = \hat{\Phi}_w$, $\hat{\epsilon} = \tilde{\epsilon}_w$, $\tilde{r}_t = \hat{r}_t$, $\tilde{w}_t^h = \hat{w}_t^h$, and $\tilde{Y}_t = \hat{Y}_t$; and the fourth line uses that $\hat{w}_t^h = \hat{w}_t$. In turn, $\tilde{\Pi}_t = \hat{\Pi}_t$ holds for equation (34), because it's an equilibrium condition for the sticky-price economy.

Equations (25)-(29) hold, as they define quantities. More importantly, note that $\tilde{d}_t^p = 0$ since $\tilde{w}_t = 1$. Similarly, note that

$$\begin{aligned}\tilde{\Theta}_{wt} &= \frac{\tilde{\Theta}_w}{2}\left(\tilde{\Pi}_t^w - \bar{\Pi}\right)^2 \tilde{Y}_t \\ &= \frac{\hat{\Theta}}{2}\left(\hat{\Pi}_t - \bar{\Pi}\right)^2 \hat{Y}_t \\ &= \hat{\Theta}_t\end{aligned}$$

where the second $\tilde{\Theta}_w = \hat{\Theta}$, $\tilde{\Pi}_t = \hat{\Pi}_t$, and our guess $\tilde{Y}_t = \hat{Y}_t$. Then,

$$\begin{aligned}\tilde{d}_t^w &= \left(\tilde{w}_t - \tilde{w}_t^h\right)\tilde{Y}_t - \tilde{\Theta}_{wt} - \tilde{\Phi}_w \\ &= \left(1 - \hat{w}_t^h\right)\hat{Y}_t - \hat{\Theta}_t - \hat{\Phi} \\ &= \left(1 - \hat{w}_t\right)\hat{Y}_t - \hat{\Theta}_t - \hat{\Phi} \\ &= \hat{d}_t^p.\end{aligned}$$

where the second line uses that $\tilde{w}_t = 1$, $\tilde{\Theta}_{wt} = \hat{\Theta}_t$, $\tilde{\Phi}_w = \hat{\Phi}$, and $\tilde{Y}_t = \hat{Y}_t$; and the third line uses that $\hat{w}_t^h = \hat{w}_t$. In turn, since $\hat{d}_t^w = 0$, we have that $\tilde{d}_t = \tilde{d}_t^p + \tilde{d}_t^w = \hat{d}_t^p + \hat{d}_t^w = \hat{d}_t$. That is, $\hat{d}_t = \hat{d}_t$ holds in equilibrium for the sticky-wage economy.

Given that $\tilde{\mathcal{P}}_t = \hat{\mathcal{P}}_t$, $\hat{r}_t = \tilde{r}_t$, $\hat{w}_t^h = \tilde{w}_t^h$, and $\tilde{d}_t = \hat{d}_t$, the household faces the same sequence of budget constraints, and make the same decisions: $\tilde{c}_t(\boldsymbol{s}) = \hat{c}_t(\boldsymbol{s})$, and $\tilde{h}_t(\boldsymbol{s}) = \hat{h}_t(\boldsymbol{s})$. In turn, we have that $\tilde{C}_t = \hat{C}_t$ and $\tilde{L}_t = \hat{L}_t$. In turn, and $\tilde{C}_t = \hat{C}_t$ and $\tilde{L}_t = \hat{L}_t$ satisfy equation (30) in the sticky-wage economy.

Since $\tilde{\Pi}_t = \hat{\Pi}_t$, equation (31) implies $\tilde{i}_t = \hat{i}_t$, and (32) implies $\tilde{r}_t = \hat{r}_t$. Thus, $\tilde{r}_t = \hat{r}_t$ is consistent with the monetary policy block (31)-(32) in the sticky wage economy.

Finally, from the the aggregate resource equation (28), we have

$$\begin{aligned}\tilde{Y}_t &= \tilde{C}_t + \tilde{G}_t + \tilde{\Theta}_t + \tilde{\Phi} + \tilde{\Theta}_{wt} + \tilde{\Phi}_w \\ &= \hat{C}_t + \hat{G}_t + \hat{\Theta}_t + \hat{\Phi} + \hat{\Theta}_{wt} + \hat{\Phi}_w \\ &= \hat{Y}_t\end{aligned}$$

where the second line uses that $\tilde{C}_t = \hat{C}_t$, $\tilde{G}_t = \hat{G}_t$, $\tilde{\Theta}_t = \hat{\Theta}_{wt} = 0$, $\tilde{\Phi} = \hat{\Phi}_w = 0$, and $\tilde{\Theta}_{wt} = \hat{\Theta}_t = 0$. Thus, $\tilde{Y}_t = \hat{Y}_t$ satisfies equation (28) in the sticky-wage economy.