The Macroeconomic Consequences of Unemployment Scarring

Johns Hopkins University

William Du*

August 29, 2025

Abstract

Job loss leaves scars on wages that persist for more than 20 years. Yet, the importance of this well-documented micro fact for macro dynamics remains largely unexplored. This paper argues that these scars are a key determinant of the speed of macroeconomic recovery following recessions. I incorporate human capital into a heterogeneous agent New Keynesian (HANK) model with search and matching frictions. During unemployment, human capital depreciates, leading to lower wages for reemployed workers. Unemployment scarring, mediated by the fraction of temporary versus permanent layoffs, enables the model to capture *both* the sluggish recovery from the Great Recession and the rapid rebound from the COVID Recession. In particular, the presence of scarring reveals the pivotal role that temporary layoffs fulfilled in supporting the swift post-pandemic recovery and in preventing a subsequent permanent rise in inequality. In a counterfactual analysis of the Great Recession, a U.S. fiscal consolidation would have proven substantially less effective at reducing debt-to-GDP as scarring erodes future tax revenues and therefore increases pressure on the fiscal deficit.

*Johns Hopkins University, Department of Economics, 3100 Wyman Park Drive, Baltimore, MD 21211. E-mail: wdu9@jhu.edu. I am deeply indebted to Christopher Carroll, Jonathan Wright, and Francesco Bianchi for their guidance and support in the development of this paper. For their helpful comments, I thank Mateo Velásquez-Giraldo, Wonsik Ko, Bence Bardóczy, Jeongwon Son, John Green, Tao Wang, Laurence Ball, Greg Duffee, Robert Moffitt, Xincheng Qiu, Yucheng Yang, Jeffrey Sun, Sebastian Graves, Adrian Monninger, Jamie Lenney, and Kyung Woong Koh. Finally, I thank participants at the 2024 IAAE annual conference and 2024 SCE annual conference.

1 Introduction

Since the seminal work of Jacobson et al. (1993), job loss from stable employment has been understood to cause large and persistent earnings losses.[1] On average, these earnings losses are 15% after 20 years (e.g. Davis and Wachter, 2011; Huckfeldt, 2022), reflect a permanent loss in wages as opposed to hours (e.g. Moore and Scott-Clayton, 2019; Lachowska et al., 2020; Huckfeldt, 2022), are worse in recessions (Davis and Wachter, 2011; Schmieder et al., 2023), and are concentrated among workers who switch into lower paying occupations (Huckfeldt, 2022).[2] While a growing *microeconomic* literature seeks to explain the origins of these 'scars', few *macroeconomic* papers explore whether these scars matter for business cycle dynamics, fiscal policy, and monetary policy.

In this paper, I argue that microeconomic unemployment scarring is a key determinant of the speed of macroeconomic recovery following a recession. In particular, I show that the extent to which micro-level scarring translates into a persistent loss in aggregate output is an important reason why the recovery from the COVID recession was markedly faster than the recovery from the Great Recession, even after accounting for the extraordinary fiscal stimulus during the pandemic. Furthermore, I quantify the impact of the unprecedented surge in temporary layoffs during the pandemic and demonstrate their crucial and complementary role to fiscal policy in preventing a sluggish recovery following the COVID Recession.

To quantify the macroeconomic role of microeconomic unemployment scarring, I extend a heterogeneous agent New Keynesian (HANK) model with search and matching (SAM) frictions to include human capital dynamics. In the model, households make a consumption/saving decision in the face of unemployment risk and search frictions in the labor market. To account for the empirical fact that only workers who are permanently laid off suffer from scarring (Fujita, 2016), [3] the model differentiates between permanent layoffs, temporary layoffs, and other types of unemployment. Temporary layoffs can transition to permanent layoffs and, motivated by recent evidence using U.S. that suggests these scars reflect a loss in productivity [4], only households who find reemployment after a permanent layoff spell *may* experience human capital depreciation.The model does not capture the sources that lead firms to engage in temporary layoffs. Instead, using the estimates from Gertler et

[1] In the microeconomic literature, these losses apply to workers who have been employed for 3 to 10 years.

[2] Huckfeldt (2022) and Fujita and Moscarini (2017) document that over 50% of the unemployed switch occupations.

[3] A permanent layoff refers to a worker who has been permanently separated from their previous employer.

[4] The current literature suggests that,in the U.S., the these scars are largely due to losses in firm specific human capital. To begin, Lachowska et al. (2020) find that the decline in wages is largely explained by losses in match specific productivity. Poletaev and Robinson (2008) find that reemployed workers who suffer large wage losses employ substantially different skills in their new job. Huckfeldt (2022) documents that scarring is concentrated among workers who switch into lower paying occupations.

al. (2022), the unemployment process across different layoff states is calibrated to match *how* each state evolves during recessions.

I begin by showing that when the model accounts for the microeconomic estimates of unemployment scarring from Davis and Wachter (2011), the resulting decline in macroeconomic activity is sufficiently persistent to validate unemployment scarring as a new microfoundation for hysteresis and endogenous growth. In particular, with scarring, recessions induce a near-permanent decline in output, consumption, and aggregate labor productivity. Furthermore, since these scars arise from a loss of human capital that reduces both labor income and productivity, the persistent decline in macroeconomic activity occurs without a sustained rise in the unemployment rate. In addition, unemployment scarring induces a permanent increase in wage dispersion that results in a lasting increase in income inequality, a result supported by the data but unaccounted for in standard models of hysteresis or endogenous growth. Finally, the near-permanent decline in wages caused by scarring reduces future tax revenues, increasing the pressure that recessions place on the fiscal deficit since losses in tax revenues necessitate a larger increase in debt to sustain government expenditures.

Having shown that scarring induces large and persistent declines in macroeconomic activity, I then demonstrate that unemployment scarring, when disciplined by the microeconomic evidence, successfully captures the sluggish recovery from the Great Recession, a challenging feat that can only be accomplished by a model that can generate a decline in income that is more persistent than the increase in the unemployment rate. To do so, I simulate the model to replicate the path of unemployment from 2008 to 2019 and then compare the untargeted paths of consumption and output against the data. The goal of this exercise is to ask, does the model's predicted path of consumption and output, conditional on the unemployment rate, match the data? Without unemployment scarring, the model only accounts for the first year of the sluggish recovery of consumption and output from The Great Recession. With unemployment scarring, the model's untargeted paths of consumption and output replicate the data from 2008 to 2015, highlighting the substantial role of scarring during the Great Recession. In addition, unemployment scarring also allows the model to replicate the untargeted path of hourly labor compensation for the whole simulation period, providing further validation that the role of scarring during and after the Great Recession is being captured. Finally, unemployment scarring enables the model successfully captures the permanent rise in income inequality following the Great Recession —a result that standard HANK models with search and matching frictions cannot replicate. In those models, income inequality is largely shaped by the path of unemployment, which, during the Great Recession, increased persistently but not permanently. Overall, the model suggests that scarring played a key role in driving the sluggish recovery from the Great Recession, explaining most of the recovery from 2008 to 2015. This result, however, does not rule out other explanations for the slow recovery from the Great Recession. The aim is to emphasize that unemployment scarring was one of the primary channels that drove the sluggish recovery from the Great Recession.

Although unemployment scarring explains a substantial fraction of the recovery from the Great Recession, it is the model's ability to predict *both* the swift rebound from the COVID Recession and the slow recovery from the Great Recession that validates unemployment scarring as a key determinant of the speed of macroeconomic recovery from recessions. To illustrate this, I repeat the estimation exercise of matching the path of unemployment during and after the COVID recession and then comparing the untargeted paths of consumption, output, and the Gini index for income. I recalibrate the model such that 78% of an increase in unemployment is attributed to temporary layoffs, the proportion of the rise in the unemployment rate accounted by temporary layoffs estimated in Gertler et al. (2022). Naturally, with an enormous proportion of temporary layoffs, micro unemployment scarring does not translate to macro scarring. As a result, the model is able to replicate the swift rebound in consumption and output observed in the data, along with the transitory increase in the income Gini.[5]

The model's success in capturing the COVID recession reveals the crucial role that temporary layoffs fulfilled in supporting the swift post-pandemic recovery and in preventing a lasting rise in inequality. In particular, I demonstrate that if the rise in unemployment during the COVID recession had been driven primarily by permanent layoffs, GDP would not have returned to its pre-recessionary trend and income inequality (income Gini index) would have permanently risen. To illustrate this, I replicate the COVID recession simulation and recalibrate the model to minimize the share of temporary layoffs contributing to the surge in unemployment. In this counterfactual scenario where temporary layoffs account for only 5% of the rise in unemployment, GDP would have settled on a new trend that is a 2% deviation below the pre-2020 trend and the income Gini index would have permanently increased by 0.2 percentage points. The emphasis on temporary layoffs does not diminish the role of fiscal policy in accelerating the recovery after the Pandemic. In contrast, temporary layoffs likely complemented fiscal policy, supporting the rapid return to the pre-recession trend. In fact, Gertler et al. (2022) find that the *Paycheck Protection Program* increased employment by increasing the likelihood of being recalled during a temporary layoff. Given this paper's insight that temporary layoffs can prevent unemployment scarring from translating into macroeconomic scarring, the *Paycheck Protection Program* likely played a crucial role in supporting a swift recovery through mitigating the effects of unemployment scarring.

[5] The simulation exercise implicitly incorporates the macroeconomic impact of the fiscal policy response because the model is made to match the *observed* unemployment rate in the data during and after the pandemic.

The transmission of fiscal policy changes considerably in the presence of unemployment scarring. Contractionary fiscal multipliers are 0.4 to 1.0 larger and rise, instead of fall, with the horizon due to persistent losses in output. Unemployment scarring also shapes the dynamics of debt in response to contractionary fiscal policy. In particular, when the government cuts spending, losses in future tax revenues increase pressure to issue government debt. This increase in debt combined with larger fiscal multipliers can significantly reduce the effectiveness of fiscal policies aimed at sustaining debt. Furthermore, because unemployment scarring induces a near permanent rise in income inequality, this naturally implies that contractionary fiscal policy also leads to a persistent increase in income inequality.

To quantify the effectiveness of fiscal consolidation, I consider a counterfactual where the U.S. engages in a reduction of government transfers during the Great Recession, a policy pursued by a number of European countries during this period. I demonstrate that unemployment scarring leads fiscal consolidation to cause a significant and prolonged contraction in GDP, with only a minimal reduction in debt-to-GDP. In particular, without scars to unemployment, a 2% of GDP reduction in government transfers lowers debt-to-GDP by 4.75 percentage points. With scarring, the decline in debt-to-GDP is only 1.23 percentage points. In addition, the fall in GDP from this consolidation lasts 3 to 4 years longer because of losses to human capital that stem from unemployment scarring.

Fiscal consolidation, however, is not always ineffective at stabilizing debt-to-GDP. The zero lower bound plays a crucial role in the ineffectiveness of a U.S. fiscal consolidation during the Great Recession. Without the zero lower bound, debt to GDP would fall by 5 percentage points instead of 1.2 percentage points. The larger decline in debt-to-GDP stems from the monetary authority's ability to lower the cost of debt that the government faces. On the other hand, the effects of a lower interest rate do little to mitigate the scarring effects of unemployment on output unless the nominal interest rate is kept lower for considerably longer.

Literature Review This paper's contributions lie at the intersection of several strands of literature.

The first strand is the nascent literature on the role of unemployment scarring in shaping business cycle dynamics and macroeconomic policy. To date, this literature comprises only of Alves and Violante (2023) and Alves and Violante (2024), both of which examine how scarring affects the transmission of monetary policy. This paper makes three contributions to this literature. First, it demonstrates that unemployment scarring can simultaneously account for *both* the sluggish recovery after the Great Recession and the rapid rebound following the COVID Recession. Second, it shows that temporary layoffs played a pivotal role during the pandemic by preventing a sluggish and incomplete recovery and a permanent rise in income inequality. This second contribution highlights that the unusually large share of temporary layoffs during the pandemic was a key reason the post-COVID recovery was significantly faster than the recovery from the Great Recession, even after accounting for the unprecedented fiscal stimulus during COVID. Third, this paper quantifies the importance of scarring in the transmission of fiscal policy.

The second is the theoretical literature on endogenous growth and hysteresis that largely emphasizes the role of endogenous innovation and R&D as a micro foundation that explains the sluggish recovery of productivity from past recessions (Comin and Gertler, 2006; Moran and Queralto, 2018; Bianchi et al., 2019). Although unemployment scarring has long been considered as a potential mechanism for the sluggish recoveries from past recessions (Cerra et al., 2023), there is surprisingly little work that captures unemployment scarring in a macroeconomic model of the business cycle. This paper addresses this gap by quantifying the importance of these unemployment scars across past recessions. More interestingly, I show that unemployment scarring is a mechanism for hysteresis that can also explain the swift recovery from the COVID Recession when accounting for the large fraction of temporary layoffs during the pandemic. Finally, papers in the literature have also documented that contractionary monetary policy can have persistent effects on the economy (Moran and Queralto, 2018; Jorda et al., 2023). I show that unemployment scarring is an alternative theoretical mechanism that can explain their results (see appendix D).

This paper also relates to the literature that documents that fiscal consolidation during the Great Recession induced large and persistent contractions in output (Jordà and Taylor, 2016; Fatás and Summers, 2018; House et al., 2020). Most closely related is the work of Fatás and Summers (2018), who estimate the impact of fiscal consolidation on output in Europe during the Great Recession. They find that, on average, the austerity measures pursued by European countries were 'self-defeating'. had persistent and contractionary effects on GDP that lasted for at least 10 years. Further, the authors consider unemployment scarring as a possible explanation for their empirical findings. Overall, the authors conclude that fiscal consolidation was 'self-defeating'. This paper complements their work by assessing their conjecture with a macroeconomic model that accounts for the microeconomic evidence on unemployment scarring. I show that fiscal consolidation is ineffective at stabilizing debt-to-GDP and has both contractionary and persistent effects on GDP.

With regards to the distributional consequences of fiscal consolidation, using a sample of 17 OECD countries over the period 1978-2009, Ball et al. (2013) show that fiscal consolidation raises income inequality. This paper provides a rationale for their empirical results by demonstrating that in the presence of scarring, fiscal contractions lead to a substantial and permanent increase in the Gini index for income.

Finally, this paper also contributes to the literature on heterogeneous agent New Keynesian (HANK) models, in particular those with search and matching (SAM) frictions. This HANK and SAM literatures emphasizes the interaction between nominal rigidities, search and matching frictions, and incomplete markets to generate counter-cyclical unemployment risk that amplify business cycle fluctuations (McKay and Reis, 2016; Ravn and Sterk, 2017; Den Haan et al., 2018). The first contribution of this paper to this literature is the construction of a HANK and SAM model that can capture the scarring effect of unemployment with the inclusion of human capital. The second contribution, found in appendix B, is that the role of unemployment risk as an amplifier of business cycles is considerable larger in the presence of scarring.

Outline The rest of the paper is as follows. Section 2 presents the model. Section 3 describes the parameterization of the model. Section 4 shows that the model is consistent with the microeconomic estimates of earnings loss following job displacement, Section 5 through 10 presents the results. Section 11 concludes.

2 Model

I present a heterogenous agents model with human capital dynamics, search and matching frictions, and nominal rigidities.

2.1 Households

There is a continuum of households of mass 1 indexed by i who face both idiosyncratic permanent and transitory income shocks, stochastic transitions between employment and unemployment, and is subject to human capital accumulation or erosion. A household's employment state is indexed by n_{it}. Employed households ($n_{it} = 1$) receive a wage w_t that is taxed at rate τ_t, accumulate human capital h_{it} with probability π_L, and separate from employment with probability ω. If an employed household is separated, he finds a job in the same period with probability $\eta_{r,t}$ or else he transitions to unemployment ($n_{it} = 0$). When a household becomes unemployed, he randomly enters one of three unemployment states X_{it}. A household is either a permanent layoff (P), a temporary layoff (T), or a quitter/other (O). The probability of entering each state is $\lambda(X)$ where $X \in \{P, T, O\}$. As in Gertler et al. (2022), households who are in temporary layoff can transition to a permanent layoff with probability p_{TLPL}. During a permanent or temporary layoff spell, households receive unemployment benefits that expire after $\bar{d}$ periods. Quitters/other types of unemployment do not receive unemployment benefits. During unemployment, a household in unemployed state X_{it} finds employment with probability $\eta_t(X_{it})$. Only households who reenter employment from a permanent layoff have a probability of experiencing human capital erosion that is realized during the new employment spell. In addition, households are subject to a constant probability of death (perpetual youth) and are ex-ante heterogeneous in their discount factors. After all shocks and transitions are realized, households choose to consume and save into government bonds.

The timing of the household problem is illustrated in figure 1

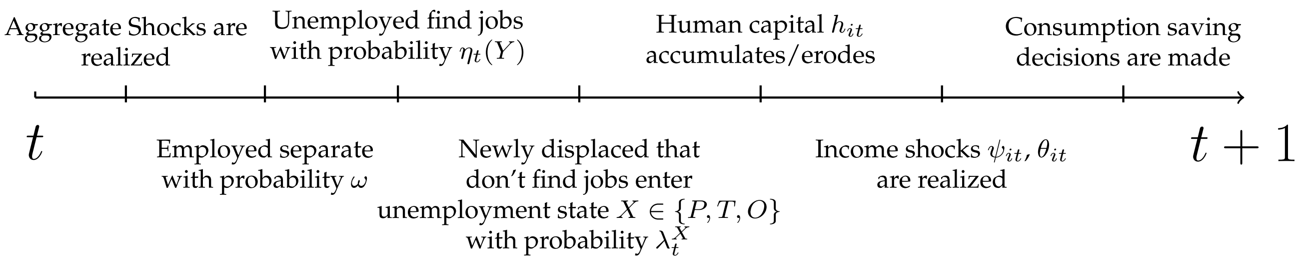

Figure 1: Timing of model

The Bellman problem is:

$$v_t\left(m_{it}, p_{it}, h_{it}, n_{it}, X_{it}\right) = \max_{\{c_{it}, a_{it}\}} \left\{U\left(c_{it}\right)\right) + \beta_i(1-D)\mathrm{E}_\mathrm{t}\left[v_{t+1}\left(m_{t+1}, p_{it+1}, h_{it+1}, n_{it+1}, X_{it+1}\right)\right]\right\}$$

subject to the budget constraint

$$\begin{aligned} a_{it} &= m_{it} - c_{it} \\ a_{it} + c_{it} &= z_{it} + (1 + r_t^a)a_{it-1} \\ a_{it} &\geq 0 \end{aligned}$$

where m_{it} denotes market resources to be expended on consumption or saved into government bonds. c_{it} is the level of consumption and a_{it} is the value of government bonds where the return is r_{t+1}^a. m_{it} is determined by labor income, z_{it}, and the gross return on assets from the last period, $(1 + r_t^a)a_{it-1}$. D is the probability of death and β_i is the discount factor. When households die, their market resources are distributed to those alive in proportion to how much market resources is owned with respect to the aggregate level of wealth. Newborns are born with no wealth in order to raise the marginal propensity to consume (MPC).

2.1.1 Labor Income and Human Capital

Labor income is composed of permanent income p_{it}, transitory income θ_{it}, human capital h_{it}, and (un)employment income ζ_{it}.

$$\mathbf{z}_{it} = p_{it}\theta_{it}\zeta_{it}h_{it}$$

Permanent income is subject to shocks ψ_{it+1}.

$$p_{it+1} = p_{it}\psi_{it+1}$$

Both θ_{it} and p_{it} are iid mean one lognormal with standard deviation σ_θ and σ_ψ, respectively.

Following Birinci (2019), human capital lies on an equally spaced grid with a minimum value of $\underline{h}$ and a maximum value of $\bar{h}$. I define $\mathbf{h}_{it}$ as "shadow" human capital. The purpose of this variable is to capture the erosion of human capital during unemployment without allowing unemployment income to fall during a household's unemployment spell. This ensures that losses to human capital are only realized upon reemployment and is meant to capture the microeconomic fact that displaced households receive a lower wage after finding a new job. The dynamics of h_{it} and $\mathbf{h}_{it}$ are elaborated below.

To simplify the discussion on the dynamics of human capital, define:

- E: Employment

- U: Unemployment (Any type)

- U_P: Permanent layoff unemployment

- U_T: Temporary layoff unemployment

- U_O: Quit or other types of unemployment

If a household transitions from $E \to E$, then human capital accumulates with probability π_L.

$$h_{it+1} = \begin{cases} h_{it} & \text{with probability } 1 - \pi_L \\ h_{it} + \Delta_E & \text{with probability } \pi_L \end{cases}$$

And shadow human capital does not change.

$$\mathbf{h}_{it+1} = h_{it}$$

If a household transitions from $E \rightarrow U$ or $U \rightarrow U$, human capital is unaffected while shadow human capital erodes with probability π_U.

$$h_{it+1} = h_{it}$$

$$\mathbf{h}_{it+1} = \begin{cases} \mathbf{h}_{it} & \text{with probability } 1 - \pi_U \\ \mathbf{h}_{it} - \Delta_U & \text{with probability } \pi_U \end{cases}$$

Only when a household transitions from $U_P \rightarrow E$ does the erosion to their shadow human capital becomes realized as their new human capital.

$$h_{it+1} = \mathbf{h}_{it}$$

Otherwise, for a household transitioning from $U_T \rightarrow E$ or $U_O \rightarrow E$, their human capital does not change.

$$h_{it+1} = h_{it}$$

$$\mathbf{h}_{it+1} = h_{it}$$

As documented in Kekre (2023), non UI income makes up a large proportion of the income of the unemployed. This income is likely supplemented from a spouse as an "added worker effect", or other social insurance programs such as SNAPS. In order to capture these non UI income sources, I follow Kekre (2023) and assume (Un)Employment income follows

$$\zeta_{it} = \begin{cases} (1 - \tau_t) w_t, \text{ if employed} \\ \\ UI_t + \omega_1 w_{ss}, \text{ if unemployed and receiving UI} \\ \\ T^s + \omega_2 w_{ss}, \text{ if unemployed and not receiving UI} \\ \end{cases}$$

where $UI_t = bw_{ss}(1-\tau_{ss})$, b is the unemployment insurance replacement rate, T^s is a parameter that captures other social programs, w_{ss} and τ_{ss} are the real wage and tax rate in steady state. The parameters ω_1 and ω_2 allow me to calibrate the amount of non UI income to be empirically consistent with administrative data.

2.2 Goods Market

There is a continuum of monopolistically competitive intermediate good producers indexed by $j \in [0,1]$ who produce intermediate goods Y_{jt} to be sold to a final good producer at price P_{jt}. I assume intermediate good producers consume all profits each period. Using intermediate goods Y_{jt} for $j \in [0,1]$, the final good producer produces a final good Y_t to be sold to households at price P_t.

2.2.1 Final Good Producer

A perfectly competitive final good producer purchases intermediate goods Y_{jt} from intermediate good producers at price P_{jt} and produces a final good Y_t according to a CES production function.

$$Y_t = \left(\int_0^1 Y_{jt}^{\frac{\epsilon_p - 1}{\epsilon_p}} \, dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

where ϵ_p is the elasticity of substitution.

Given P_{jt} , the price of intermediate good j , the final good producer maximizes his profit by solving:

$$\max_{Y_{jt}} P_t \left(\int_0^1 Y_{jt}^{\frac{\epsilon_p - 1}{\epsilon_p}} \, dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}} - \int_0^1 P_{jt} Y_{jt}, \; dj$$

The first order condition leads to demand for good j

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\epsilon_p} Y_t$$

and the price index

$$P_t = \left(\int_0^1 P_{jt}^{1-\epsilon_p} \, dj \right)^{\frac{1}{1-\epsilon_p}}$$

2.2.2 Intermediate Good Producer

Intermediate goods producers produce according to a production function linear in labor L_t.

$$Y_{jt} = Z_t L_{jt}$$

where $log(Z_t) = \rho_Z log(Z_{t-1}) + \epsilon_Z$

Each Intermediate goods producer hires labor L_t from a labor agency at cost κ_t^h. Given the cost of labor, each Intermediate goods producer chooses P_{jt} to maximize its profit facing price stickiness a la Rotemberg (1982). I assume intermediate good producers hold all profits as HANK models with sticky prices produce countercyclical profits which combined with households with high MPCs can lead to countercyclical consumption responses out of dividends. I therefore abstract from consumption behavior in response to firm profits. Intermediate goods producers maximize profit by solving:

$$J_t\left(P_{jt}\right) = \max_{\{P_{jt}\}} \left\{ \frac{P_{jt} Y_{jt}}{P_t} - c_t L_{jt} - \frac{\varphi}{2} \left(\frac{P_{jt} - P_{jt-1}}{P_{jt-1}} \right)^2 Y_t + J_{t+1}\left(P_{jt+1}\right) \right\}$$

The problem can be rewritten as the standard New Keynesian maximization problem:

$$\max_{\{P_{jt}\}} \mathrm{E}_t \left[\sum_{s=0}^{\infty} M_{t,t+s} \left(\left(\frac{P_{jt+s}}{P_{t+s}} - MC_{t+s} \right) Y_{jt+s} - \frac{\varphi}{2} \left(\frac{P_{jt+s}}{P_{jt+s-1}} - 1 \right)^2 Y_{t+s} \right) \right]$$

where $MC_t = \frac{\kappa_t^h}{Z_t}$

Given all firms face the same adjustment costs, there exists a symmetric equilibrium where all firms choose the same price with $P_{jt} = P_t$ and $Y_{jt} = Y_t$.

The resulting Phillips Curve is

$$\epsilon_p MC_t = \epsilon_p - 1 + \varphi(\Pi_t - 1)\Pi_t - M_{t,t+1}\varphi(\Pi_{t+1} - 1)\Pi_{t+1}\frac{Y_{t+1}}{Y_t}$$

where $\Pi_t = \frac{P_t}{P_{t+1}}$.

2.3 Labor market

2.3.1 Labor agency

A risk neutral labor agency sells effective labor $L_t = \int_0^1 h_{it} n_{it} di$ to intermediate good producers at cost c_t by hiring households. To hire households, the labor agency posts vacancies v_t that are filled with probability ϕ_t. Households search is random. Following Bardóczy (2020), I assume the labor agency cannot observe the labor productivity of individual households. Instead, the labor agency can only observe the average productivity of all employed workers $H_t^E =: \int_0^1 h_{it} \mathbb{1}(n_{it} = 1)\, di$. Since $\int_0^1 h_{it} n_{it}\, di = H_t^E N_t$, this assumption is sufficient for the labor agency to choose the optimal level of households to hire.

$$J_t(N_{t-1}) = \max_{N_t, v_t} \{ (\kappa_t^h - w_t) \left(\int_0^1 h_{it} n_{it}\, di \right) - \kappa v_t + \mathrm{E}_t \left[\frac{J_{t+1}(N_t)}{1 + r_t^a} \right] \}$$

s.t.

$$N_t = (1 - \omega) N_{t-1} + \phi_t v_t$$

The resulting job creation curve is:

$$\frac{\kappa}{\phi_t} = (c_t - w_t) H_t^E + (1 - \omega) \mathrm{E}_t \left[\frac{\kappa}{(1 + r_t^a)\phi_{t+1}} \right]$$

2.3.2 Matching

Household and labor agency matching follows a Cobb Douglas matching function:

$$m_t = \chi e_t^{\alpha} v_t^{1-\alpha}$$

where m_t is the mass of matches, e_t is the mass of job searchers, and χ a matching efficiency parameter.

The vacancy filling probability ϕ_t, job finding probabilities $\eta_t(X_{it})$ of a household in state $X_{it} \in \{\text{P, T, O}\}$ and the job finding probability $\eta_{r,t}$ of a recently separated (but not unemployed) household evolve according to:

$$\eta_{r,t} = \chi \Theta_{it}^{1-\alpha}$$

$$\eta_t(X) = \chi q(X) \Theta_{it}^{1-\alpha}$$

$$\phi_t = \chi \Theta_t^{-\alpha}$$

where $\Theta_t = \frac{v_t}{e_t}$ is labor market tightness and $q(X)$ captures the search efficiency of state X.

2.3.3 Employment to Unemployment transition dynamics

An employed individual who separates from their job in period t and does not find a job within the same period transitions to unemployment in $t+1$. In particular, probability of transitioning from employment to unemployment (EU) is:

$$EU_t = \omega(1-\eta_t)$$

where ω is the job separation probability.

Upon job loss, a household is either in permanent layoff unemployment (P), temporary layoff unemployment (T), or quits/other unemployment (O). In order to capture the empirical fact that increases in the unemployment rate is largely explained by increases in permanent layoffs and that EU transition probabilities to quits/others is acyclic, I assume the probability of entering each unemployment state follows:

$$\lambda_t^X = \lambda_{ss}^X + \zeta^X(EU_t - EU_{ss})$$

ζ^X for $X \in \{P, T, O\}$ provide freedom to match the proportion of the increase in the unemployment rate that is attributed to permanent layoffs without explicitly modeling firm decisions of whether to permanently or temporarily layoff households.

2.4 Wage Determination

Similar to Gornemann et al. (2021) and Blanchard and Galí (2010) , I assume the real wage follows the rule :

$$log\left(\frac{w_t}{w_{ss}}\right) = \phi_w log\left(\frac{w_{t-1}}{w_{ss}}\right) + (1-\phi_w) log\left(\frac{N_t}{N_{ss}}\right)$$

where ϕ_w dictates the extent real wages are rigid.

2.5 Fiscal Policy

The government issues long term bonds B_t at price q_t^b in period t that pays δ^s in period $t+s+1$ for $s = 0, 1, 2, ..$

The bond price satisfies the no arbitrage condition:

$$q_t^b = \frac{1 + \delta \mathrm{E}_t[q_{t+1}^b]}{1 + r_t^a}$$

The government finances its expenditures with debt and taxes.

$$(1 + \delta q_t^b) B_{t-1} + G_t + S_t = \tau_t w_t \int_0^1 h_{it} n_{it} \, di + q_t^b B_t$$

where S_t are payments for unemployment insurance and other transfers.

Following Auclert et al. (2019), the tax rate adjusts to stabilize the debt to GDP ratio:

$$\tau_t - \tau_{ss} = \phi_B q_{ss}^b \frac{B_{t-1} - B_{ss}}{Y_{ss}}$$

where ϕ_B governs the speed of adjustment.

2.6 Monetary Policy

The central bank follows the Taylor rule:

$$i_t = r^* + \phi_\pi \pi_t + \phi_Y (Y_t - Y_{ss}) + \epsilon_t^m$$

where ϕ_π and ϕ_Y are the Taylor rule coefficient for inflation and output, respectively. r^* is the steady state interest rate, Y_{ss} is the steady state level of output, $\epsilon_t^m = \rho_v \epsilon_{t-1}^m + \varepsilon_t$ are innovations to the Taylor rule.

2.7 Equilibrium

An equilibrium in this economy is a sequence of:

- Policy Functions $(c_{it}(m))_{t=0}^{\infty}$ normalized by permanent income

- Prices $\left(r_t, r_{t+1}^a, i_t, q_t^b, w_t, \kappa_t^h, \pi_t, \tau_t\right)_{t=0}^{\infty}$

- Aggregates $(C_t, Y_t, N_t, \Theta_t, B_t, A_t)_{t=0}^{\infty}$

Such that:

$(c_{it}(m))_{t=0}^{\infty}$ solves the household's maximization problem given $(w_t, \eta_t(X), r_t^a, \tau_t)_{t=0}^{\infty}$.

The final goods producer and intermediate goods producers maximize their objective function.

The nominal interest rate is set according to the central bank's Taylor rule.

The tax rate is determined by the fiscal rule and the government budget constraint holds.

The value of assets is equal to the value of government bonds.:

$$A_t = q_t^b B_t$$

The goods market clears: [6]

$$C_t = w_t \int_0^1 h_{it} n_{it}\, di + G_t$$

where $C_t \equiv \int_0^1 p_{it} c_{it}\, di$

[6]Note if profits were not held by firms then the goods market condition would be $C_t + G_t = Y_t - \kappa v_t - \frac{\varphi}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 Y_t$. In particular, since firm profits are $D_t = Y_t - w_t \int_0^1 h_{it} n_{it}\, di - \kappa v_t - \frac{\varphi}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 Y_t$, then the goods market condition would become $C_t + G_t = w_t N_t + D_t = Y_t - \kappa v_t - \frac{\varphi}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 Y_t$.

The labor demand of intermediate good producers equals labor supply of labor agency:

$$L_t = \int_0^1 h_{it} n_{it} \, di$$

3 Calibration

The model is calibrated to a quarterly frequency. There are three goals to the parameterization of households. The first is to match the earnings loss following job displacement documented in Davis and Wachter (2011). The second is to simultaneously match a large aggregate MPC consistent with micro estimates while also matching aggregate liquid wealth in the 2007 Survey of Consumer and Finances. I choose the 2007 survey as I aim to match The Great Recession in section 7. The third is to match labor market transition probabilities of permanent layoffs, temporary layoffs, other types of unemployment from estimated in Gertler et al. (2022). The parameterization of households is broken into two steps. I first calibrate all parameters excluding the discount factors. I then estimate three uniformly distributed discount factors to match the aggregate liquid wealth from the 2007 SCF and a quarterly MPC of 0.21 as in Kekre (2023). The remaining parameters are calibrated to standard values in the New Keynesian and search and matching literatures.

3.1 Households

Labor transition probabilities The job separation rate ω is set to 0.1 in line with JOLTS. I set the job finding probability of households separated in the current period, $\eta_{r,t}$, to 0.675 to target an employment to unemployment (EU) transition probability of 4.1%, the estimate of the monthly EU probability in Gertler et al. (2022) (henceforth GHT) aggregated to a quarterly frequency. The probabilities of becoming a permanent layoff γ_P, a temporary layoff γ_P, and a quitter/other γ_O, are calibrated to match the EU probabilities of entering each unemployment state estimated in GHT and Graves et al. (2023)[7]. The job finding probabilities of each unemployment state $\eta_t(X)$ is calibrated the estimated monthly job finding probabilities in GHT, aggregated to a quarterly frequency. I let the job finding probability of permanent layoffs and quits/others to equal the estimate of the job finding probability of permanent

[7] Gertler et al. (2022) estimate the E to U probability of entering a permanent separation and a temporary layoff while Graves et al. (2023) estimate the E to U probability of entering as a layoff or as a quitter/other. Both papers use the CPS from 1976 to 2019, and the same methodology, to estimate the transition probability between both different unemployment states. In addition, the estimation of both papers yield the same mean unemployment rate, the same E to E probability, and the same E to inactive probability. The probability of E to U in both papers are similar as well. I use estimates of both papers to deduce the E to U probability of permanent layoffs, temporary layoffs, and quits/others.

separators in GHT as they do not distinguish between permanent layoffs and quits/others. The probability of transitioning from temporary layoff to permanent layoff, P_{TLPL}, is set to 0.47 which follows from the estimate in (GHT). The resulting steady state unemployment rate is 6.2%, equal to the mean unemployment rate estimated from the Current Population Survey in GHT. I calibrate ζ_P, ζ_T, and ζ_O such that permanent layoffs, temporary layoffs, and quits/others, account for 63%, 20%, and 17%, respectively, of an increase in the unemployment rate. GHT estimate the distribution of the increase in the unemployment rate from trough to peak across permanent separations and temporary layoffs for during the Great Recession. Their estimates indicate that the average increase in unemployment that is attributed to temporary layoffs is 17%. For increases in the unemployment rate attributed to quits/others and permanent layoffs, I use the decomposition of unemployment by reason constructed by Fujita and Moscarini (2017) using data from the BLS. Using the Fujita and Moscarini (2017) series, I calculate that during the Great Recession, 20% of the increase in the unemployment rate from trough to peak are attributed to reentrants and use this as my target for the quits/others group as my model does not include inactive/out of the labor force as a state. I assign the remaining proportion of the increase in the unemployment rate is attribute to the permanent layoffs unemployment type.

Human Capital Dynamics I use an equally spaced grid with the maximum value of human capital, $\bar{h}$, to 1.8 and the minimum value, $\underline{h}$, to 0.2 as in Birinci (2019). I set the number of human capital grid points to 20 and assume $\Delta_L = 0.1$ so that when an employed household accumulates capital it increases by one grid point. The probability of human capital erosion during unemployment π_U is set to 0.75 as in Birinci (2019). I then estimate the magnitude of human capital erosion, Δ_U and the probability of human capital accumulation during employment, π_L to minimize the distance between the earnings loss following job loss in the model and the earnings loss following job loss during recessions estimated by Davis and Wachter (2011). I target the estimate of earnings loss following job loss in recessions as I will later simulate all past recessions since the 1980s. The resulting estimation yields $\Delta_U = 0.3$ and $\pi_L = 0.085$.

Income process The calibration of permanent and transitory income shock distributions follow Carroll et al. (2017) with the standard deviation of permanent shocks set to 0.06 and the standard deviation of transitory shocks set to 0.2. The real wage is normalized to 1.0 and the real wage rigidity parameter $\phi_w = 0.837$ as in Gornemann et al. (2021). The unemployment insurance replacement rate is set to 50%. The income parameters that dictate the amount of non-UI income and government transfers, ω_1, ω_2, and T^s, are calibrated to match microeconomic moments on household income throughout unemployment documented in

Kekre (2023). In particular, these parameters are calibrated such that total income of unemployed households who receive UI is 76% of pre job loss income, total of income of unemployed households who do not receive UI is 55% of pre job loss income, and government transfers capture 13% of pre job loss income of households who have been unemployed for longer than two quarters.

Discount Factor Estimation Following Carroll et al. (2017), households are ex-ante heterogenous in their discount factors. I let three discount factors, $(\bar{\beta} - \nabla, \bar{\beta}, \bar{\beta} + \nabla)$, be uniformly distributed across the population. I estimate the mean discount factor, $\bar{\beta}$, to target the aggregate liquid wealth to aggregate quarterly permanent income ratio in the 2007 Survey of Consumer Finances and the spread, ∇, to target an aggregate quarterly MPC of 0.21 as in Kekre (2023). Following Kaplan et al. (2014), I define liquid wealth as checking, saving, money market and call accounts as well as directly held mutual funds, stocks, corporate bonds, government bonds less credit card balances. I restrict my sample of liquid wealth to households with nonnegative liquid wealth as the model does not feature borrowing. I also remove all households with zero permanent income. Table 1 presents the estimated discount factors. [8]

Discount Factors		
.937	.964	.991

Table 1: Discount factor estimates

Remaining Parameters I let $U(c) = \frac{c^{1-\rho}}{1-\rho}$ and I set the CRRA parameter, ρ, to 2 and the probability of death to .00625 match a 40 year work life. The real rate is 3% annualized.

3.2 Rest of the Economy

The quarterly vacancy filling rate is 0.71 as in Ramey et al. (2000). The matching elasticity is 0.65 following Ravn and Sterk (2017) and the vacancy cost is set to 7% of the real wage as in Christiano et al. (2016)[9]. The elasticity of substitution is set to 6. The price adjustment cost

[8]This is consistent with the work of Allcott et al. (2021) and Skiba and Tobacman (2009), who estimate discount factors of 21% at a 2 week frequency and discount factors between 0.74 to 0.83 at a 8 week frequency, respectively. Although both papers assume hyperbolic discounting, the point is that a very low discount factor is needed to match the proportion of the population who are willing to take out payday loans at very high interest rate.

[9]The range of plausible values lie between 4% and 14% as documented in Silva and Toledo (2009)

parameter is set to 96.9 as in Ravn and Sterk (2017). The tax rate is set to 0.3 and government spending is set to clear the government budget constraint. I follow Auclert et al. (2019) in calibrating the fiscal adjustment parameter as well as the decay rate of government coupons by setting $\phi_b = 0.1$ and $\delta = 0.95$ to match a maturity of 5 years[10].

Description	Parameter	Value	Source/Target
CRRA	ρ	2	Standard
Real Interest Rate	r	$1.03^{\frac{1}{4}} - 1$	3% annualized real rate
Probability of Death	D	0.00625	40 Year Work Life
$\frac{\text{Liquid Wealth}}{\text{Quarterly Permanent Income}}$	$\frac{A}{\Phi}$	4.4	2007 Survey of Consumer Finances
Prob. of human capital accumulation	π_L	0.085	See text
Prob. of human capital erosion	π_U	0.75	Birinci (2019)
Human capital accumulation step	Δ_L	0.1	Normalized
Human capital erosion step	Δ_U	0.3	See text
Tax Rate	τ	0.3	Kaplan et al. (2018)
Real Wage	w	1.0	Normalized
UI replacement rate	b	0.5	50% replacement rate
Non UI income parameter 1	ω_1	0.182	$\frac{\text{HH income w. UI}}{\text{pre job loss income}} = 0.76$
Non UI income parameter 2	ω_2	0.294	$\frac{\text{HH income w.o. UI}}{\text{pre job loss income}} = 0.55$
Gov. transfers	T_s	0.091	$\frac{\text{SNAPS and Soc. Security Inc}}{\text{Pre Job Loss Income}} = 0.13$
Std Dev of Log Permanent Shock	σ_ψ	0.06	Carroll et al. (2017)
Std Dev of Log Transitory Shock	σ_θ	0.2	Carroll et al. (2017)

Table 2: Household Calibration

[10] The duration of bonds in the model is $\frac{(1+r)^4}{(1+r)^4 - \delta}$

Description	Parameter	Value	Source/Target
Job Separation Prob.	ω	0.1	JOLTS
Job Finding Prob. of recently separated	$\eta_{r,t}$	0.59	EU probability of 4.1%
Job Finding Prob. of perm. layoff	$\eta_t(P)$	0.51	Gertler et al. (2022)
Job Finding Prob. of temp. layoff	$\eta_t(T)$	0.82	Gertler et al. (2022)
Job Finding Prob. of quit/other	$\eta_t(O)$	0.51	Gertler et al. (2022)
Prob. of perm. layoff in steady state	λ_{ss}^P	0.35	35% of EU from perm. layoffs
Prob. of temp. layoff in steady state	λ_{ss}^T	0.31	31% of EU from temp. layoffs
Prob. of quit/other in steady state	λ_{ss}^O	0.33	33% of EU prob. quit/other layoffs
Perm. layoff deviation param.	ζ^P	10.3	63% of Δ Urate from perm layoffs
Temp. layoff deviation param.	ζ^T	-4.4	17% of Δ Urate from temp layoffs
Quits/other layoff deviation param.	ζ^O	-5.9	20% of Δ Urate from quits/other

Table 3: Labor Transition Calibration

Description	Parameter	Value	Source/Target
Elasticity of Substitution	ϵ_p	6	Standard
Price Adjustment Costs	φ	96.9	Ravn and Sterk (2017)
Vacancy Filling Rate	ϕ	0.71	Ramey et al. (2000)
Matching Elasticity	α	0.65	Ravn and Sterk (2017)
Real Wage Rigidity parameter	ϕ_w	0.837	Gornemann et al. (2021)
Vacancy Cost	κ	0.056	$\frac{\kappa}{w\phi} = 0.07$
Government Spending	G	0.38	Gov. budget constraint
Decay rate of Government Coupons	δ	0.95	5 Year Maturity of Debt
Taylor Rule Inflation Coefficient	ϕ_π	1.5	Standard
Response of Tax Rate to Debt	ϕ_b	0.1	Auclert et al. (2019)

Table 4: Rest of Economy Calibration

4 Model Validation

In this section, I verify the model generates persistent earnings loss following job displacement that matches the estimates in Davis and Wachter (2011).

4.1 Persistent earnings loss following unemployment

To evaluate the path of earnings loss following job displacement, I run a regression similar to Davis and Wachter (2011) with the same sample restrictions on model simulated data. Since the model is calibrated to a quarterly frequency, I aggregate the simulated data to a yearly frequency. For a given year b, the sample of displaced workers constitutes households who enter unemployment in year $b, b+1$, or $b+2$. Households who do not enter employment during year $b, b+1$, or $b+2$ constitute the sample of non displaced workers. I restrict the the sample to households who have been continuously employed for 6 years prior to year b[11]. With these sample restrictions, I run the following regression on simulated data.

$$log(z^b_{iy}) = c^b + \Sigma^{20}_{k\geq -6}\delta^b_k D^k_{iy} + \epsilon^b_{iy}$$

where z_{iy} is labor income, D^k_{iy} is a indicator denoting a household that was displaced k years ago, and c is a constant in the regression. The regression features no fixed effects as human capital is exogenous with respect to becoming unemployed. δ_k for $k = 1, 2, ..., 20$ are the key estimates that capture the earnings of an individual who was displaced k years ago compared to an individual who was not displaced k years ago.

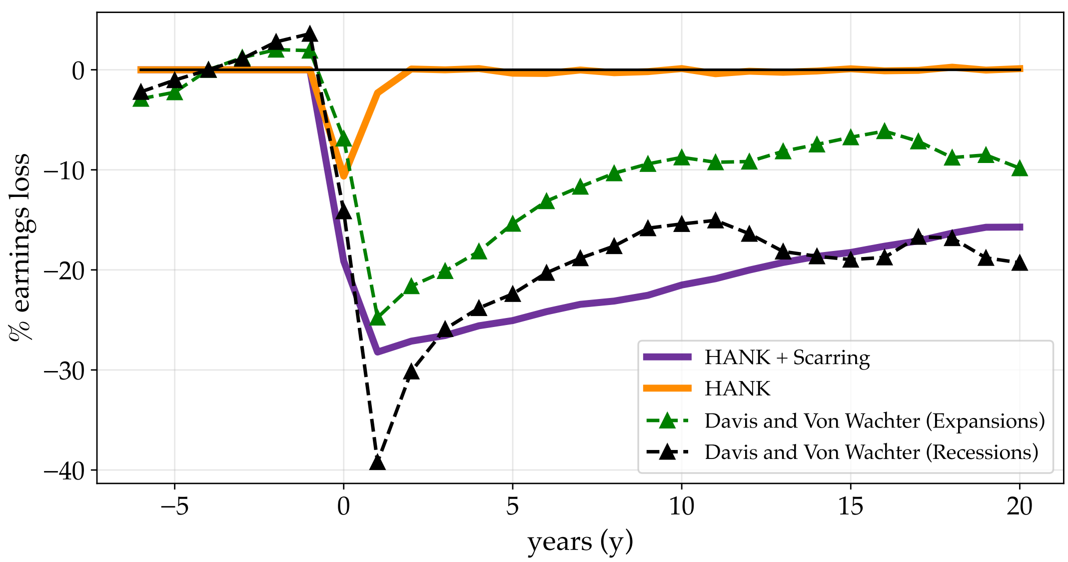

Figure 2: Earnings loss following job loss in $y = 0$: Model vs Data

Figure 2 illustrates the path of earnings loss following displacement for the baseline model with scarring (HANK + Scarring) and the model without scarring (HANK). Scarring is eliminated by assuming the probability of accumulation or erosion in human capital is eliminated. The baseline model produces a severely persistent earnings loss that is missing in the model without human capital dynamics. As in the data, these losses remain after 20 years.

[11]When aggregating to annual frequency, a worker who was unemployed for at least one quarter is denoted as displaced for that year. and is therefore not considered as employed for that year.

5 Partial Equilibrium Results

5.1 Consumption Response to an Increase in Unemployment in Partial Equilibrium

In this section, I show in partial equilibrium that the aggregate consumption response to a transitory increase in the unemployment rate is deeply persistent in the presence of scarring. I simulate the consumption response to a transitory 1% increase in the unemployment rate in $t = 0$. To capture the effects of scarring on consumption, I compare the simulated path of consumption in the baseline model to the simulated path of consumption to a version of the model where scarring is eliminated. I eliminate scarring by setting the probability of human capital accumulation π_L and the probability of human capital erosion π_U to zero. Figure 3 plots the simulated path of consumption to this experiment with and without scarring. Even with 55% of the increase in unemployment rate accounted for by permanent layoffs who are subject to scarring, the response of consumption is significantly more persistent than the response of the unemployment rate.

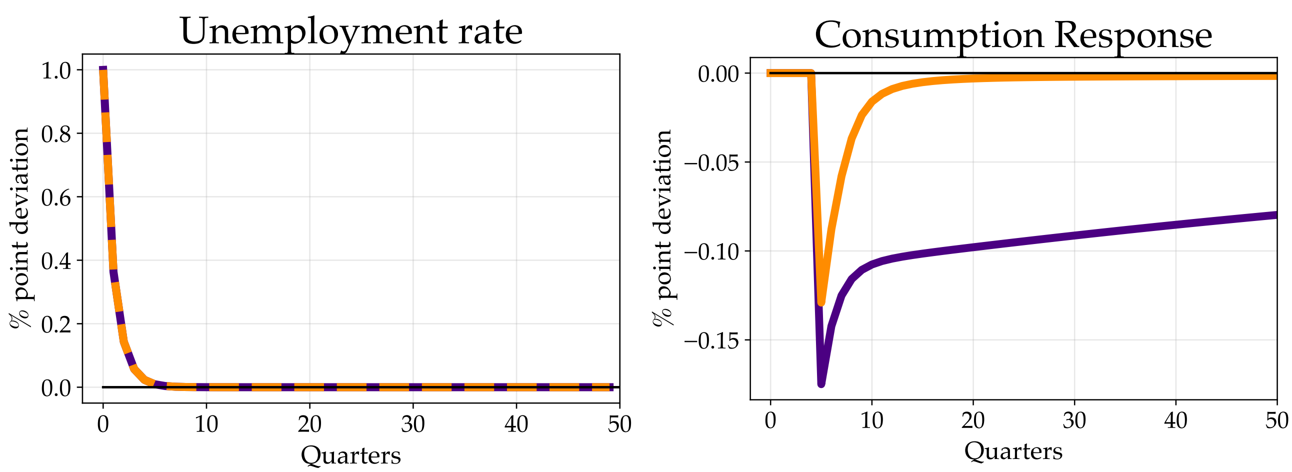

Figure 3: Consumption response to a transitory increase in the unemployment rate

Note: The exercise above plots the consumption response to a one time negative shock to the job finding probability in $t = 0$. The size of the one time shock is calibrated to increase the unemployment rate by one percentage point on impact.

6 Business Cycle Implications

6.1 Macroeconomic Hysteresis

In this section, I show that unemployment scarring generates hysteresis in macroeconomic fluctuations. To illustrate this, I solve for the impulse responses to a negative demand shock, modeled as a positive discount factor shock. For simplicity, the size of the shock is the same for all ex-ante discount factor groups. The impulse responses to key aggregate variables is plotted in figure 4. In response to this demand shock, increased patience reduces aggregate consumption leading to decreases in output and labor demand. As a result, firms post less vacancies lowering the job finding probability and raising the unemployment rate. As households lose their jobs, on average, they find jobs at a lower wage leading to persistent losses in mean human capital. This causes consumption, output, and labor income to exhibit hysteresis while the unemployment rate recovers with the demand shock. Notably, the responses of output, and aggregate labor productivity (mean human capital) still do not recover after 100 quarters, long after the recovery in the unemployment rate. Since unemployment does not exhibit hysteresis, wages nor the vacancy filling rate will either. As a result marginal costs, and therefore inflation, do not exhibit any persistence.

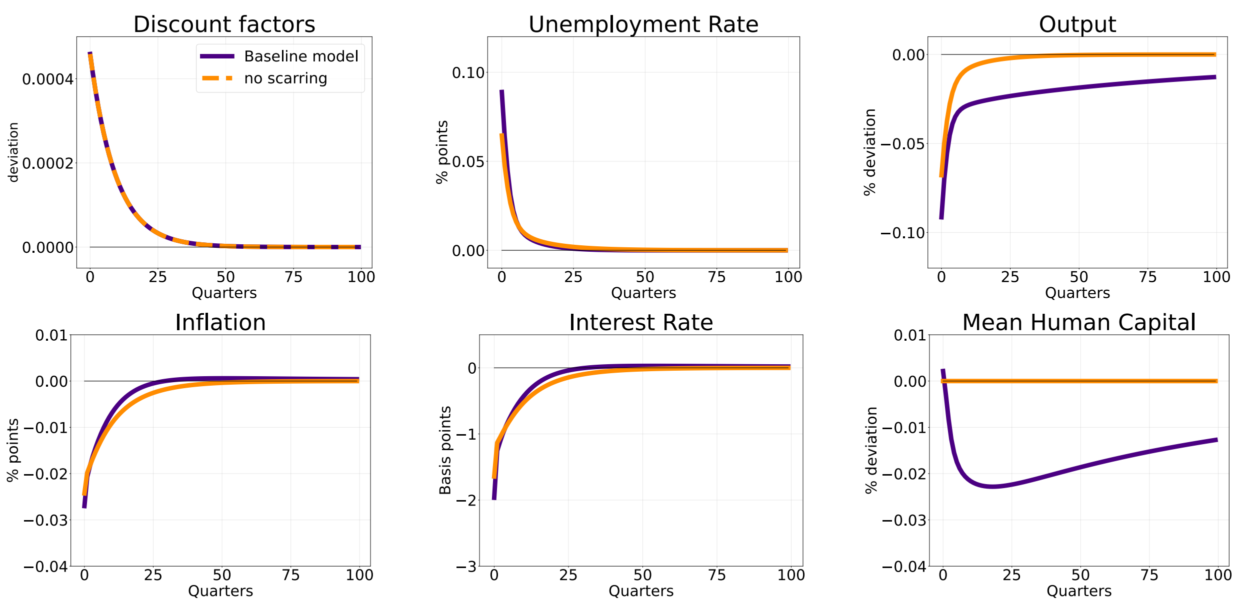

Figure 4: Impulse responses to a negative demand shock

Note: The exercise above plots the impulse responses to a positive discount factor shock. The quarterly persistence of the shock is 0.9 and the size of the shock is then calibrated to generate a 0.1 percentage point increase in the unemployment rate.

6.2 Unemployment Scarring and Inequality

With unemployment scarring, an increase in unemployment leads to a persistent rise in income inequality. Figure 5 plots the impulse response of the labor income gini index across households to the negative demand shock under the baseline model and under the model without scarring. In the baseline model, the initial increase in the gini index is attributed to the rise in unemployment and the decline in the aggregate wage. The persistence of the gini index response is due to the recomposition of the distribution of human capital of employed households. In particular, as unemployed households find reemployment at lower levels of human capital. Since the human capital of newly employed households accumulates slowly, this causes hysteresis in the gini index. In the model without scarring, the increase in income inequality is transitory as it is only affected by transitory changes in the unemployment rate and the aggregate wage.

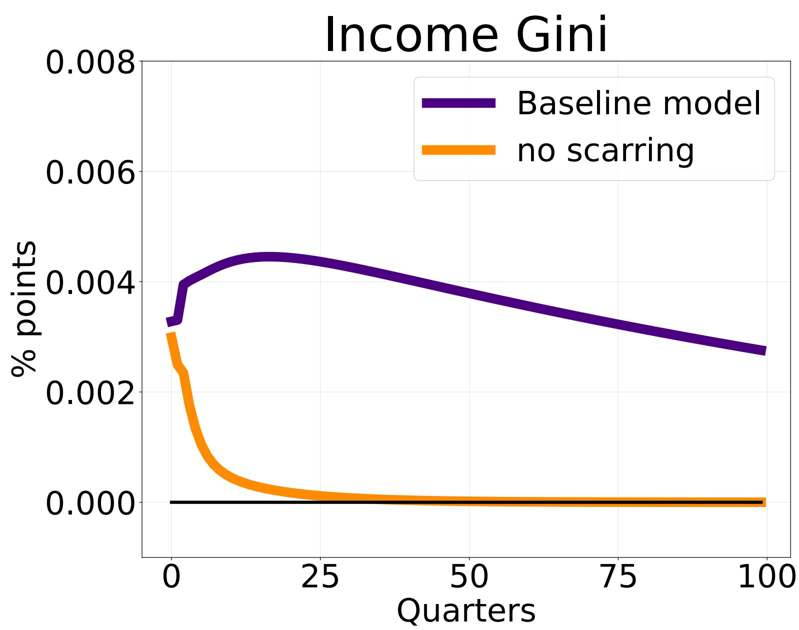

Figure 5: Response of income Gini index to negative demand shock.

Note: This exercise plots the impulse response of the Gini index from the negative demand shock in 4.

6.3 Scarring and Debt to GDP

Unemployment scarring increases the pressure that recessions place on national debt. Figure 6 plots the responses of debt to GDP and debt to the demand shock from previous section. The figure demonstrates that the debt to GDP and debt increase much more persistently in the presence of scarring. This is due to the pressure that scarring places on tax revenues.

As households lose their jobs and find reemployment at a lower effective wage, the tax base is scarred. This persistent decline in tax revenues require the government to borrow substantially more to maintain their expenditures.

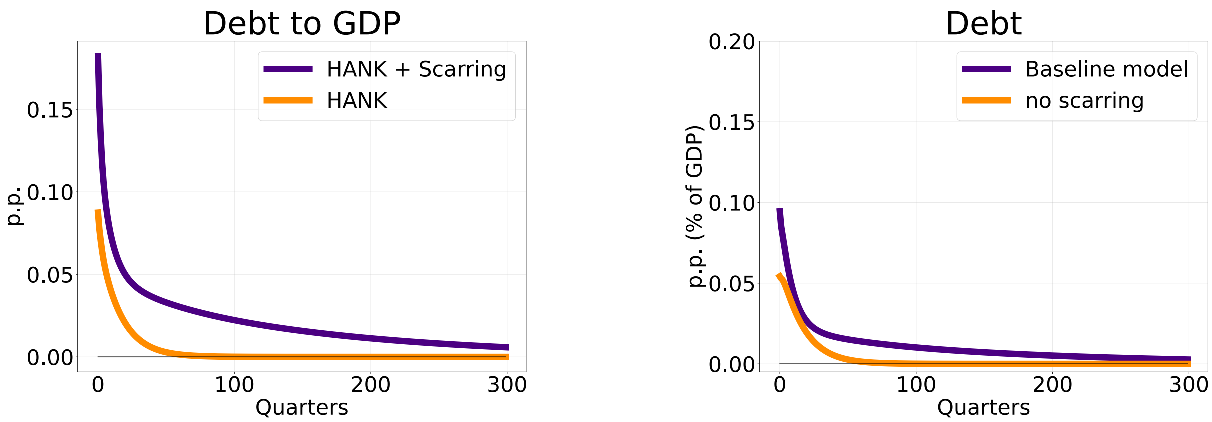

Figure 6: Responses of debt and debt to GDP to negative demand shock

Note: This exercise plots response of the debt-to-GDP and debt from the negative demand shock in 4.

7 Scarring and the Transmission of Fiscal Policy

7.1 Fiscal Multipliers

Having established that in the presence of unemployment scarring, aggregate shocks lead to persistent responses in output. In this section, I show that fiscal multipliers are substantially larger and rise with the horizon because of unemployment scarring. To do so, I consider a negative government spending shock in the baseline model and the model without scarring and compute the multipliers across the horizon. In particular the multiplier is defined as:

$$\text{Multiplier} = \frac{\Sigma_{t=0}^{H} \frac{1}{R^t} \Delta Y_t}{\Sigma_{t=0}^{H} \frac{1}{R^t} \Delta G_t}$$

where H is the horizon of the mulitplier.

Figure 7 plots the fiscal multipliers to a contractionary government spending shock across the horizon of the multiplier under the baseline model and model without scarring.

The multipliers under the baseline model rise sharply with the horizon while the multipliers in the model without scarring falls gradually with the horizon. This is because unemployment scarring leads the decline in output in response to the fall in government spending

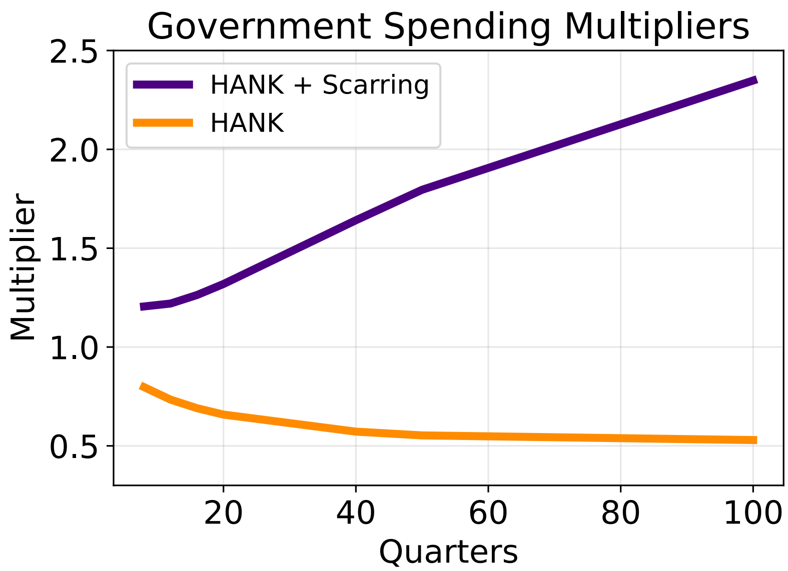

Figure 7: Fiscal Multipliers to a negative government spending shock.

Note: This figure plots the multiplier out of negative government spending shock with a quarterly AR(1) persistence of 0.933 across the horizon H of the multiplier. For example, a point on the purple line at quarters = 20 represents the fiscal multiplier: $\frac{\Sigma_{t=0}^{20} \frac{1}{R^t} \Delta Y_t}{\Sigma_{t=0}^{20} \frac{1}{R^t} \Delta G_t}$.

to persist long after the government spending shock recovers.

8 Simulating The Great Recession

8.1 Model vs Data

In this section, I quantify the extent to which unemployment scarring explains the sluggish recovery from the Great Recession. In particular, I demonstrate that unemployment scarring explains a large share of the sluggish recovery from the Great Recession. To illustrate this, I simulate consumption and output during and after The Great Recession by estimating a sequence of negative demand shocks that allows the model to match the path of unemployment from 2008 to 2018. I perform this exercise in both the baseline HANK model with scarring and the HANK model without scarring. I then compare the untargeted paths of consumption and output to their empirical counterparts. I use data on consumption (real PCE), output (Real GDP), prices (PCE deflator), nominal wages (average earnings of private production employees), real hourly and real aggregate labor compensation (labor compensation from wages and salaries). I de-trend each series from the first quarter of 1990 to the last quarter of 2019 and then scale them down such that they represent deviations from the first quarter of 2008.

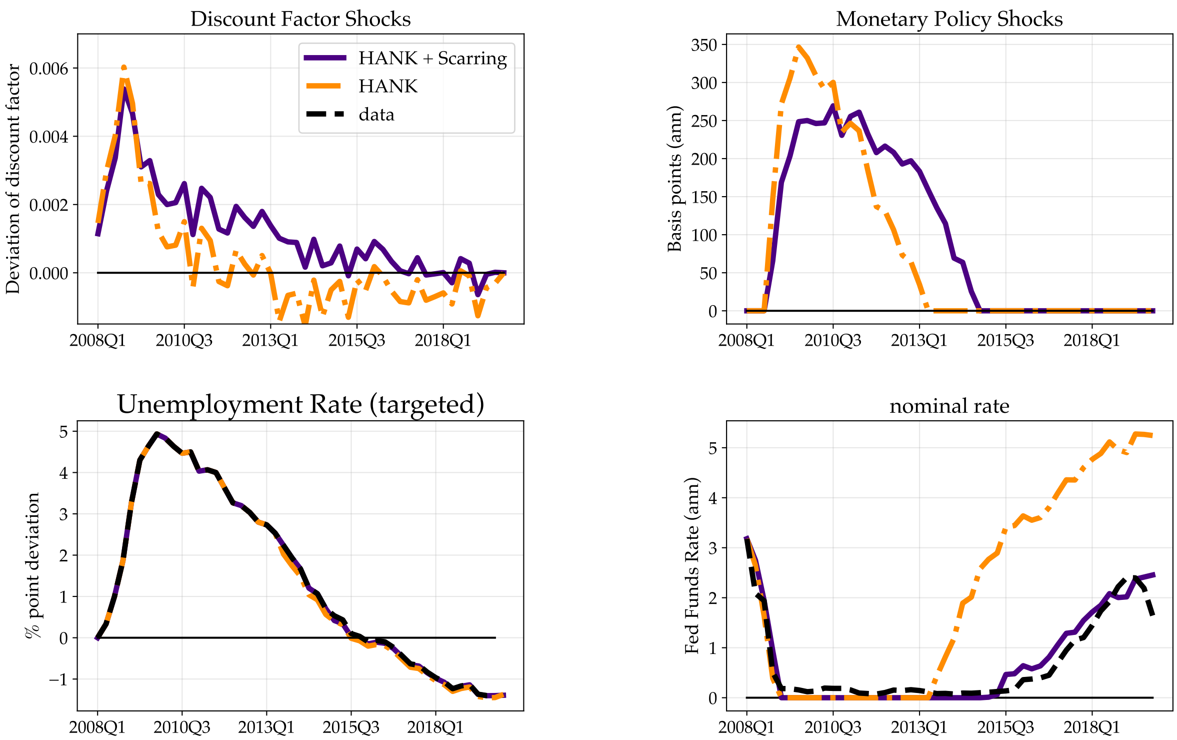

Figure 8: Estimated shocks to discount factor and nominal rate

For the estimation, I follow Kekre (2023) and jointly estimate a sequence of discount factor shocks to match the path of unemployment from 2008 to 2018 monetary policy shocks to account for the zero lower bound. I use discount factor shocks for parsimony as the goal of this exercise is not to answer what caused The Great Recession but to answer why did The Great Recession lead to such a slow recovery[12]. For these discount factor shocks, I set the fiscal adjustment parameter to $\phi_b = 0.015$, the lower bound of the estimates documented by Auclert et al. (2019), and assume that the government cannot adjust taxes for 40 quarters to obtain a more accurate assessment of the effects of the Great Recession on debt. When estimating these discount factor shocks, I assume all discount factors follow an AR(1) with quarterly persistence 0.95. As noted in Kekre (2023), the chosen AR(1) persistence does not alter the results as a different persistence will alter the estimated sequences of shocks but not the path of unemployment as that is what is targeted. The monetary policy shocks are assumed to have no persistence. I repeat this procedure over a grid of different wage rigidities

[12]The same simulation exercise can be reproduced with shocks to the household borrowing limit or to the job separation rate and would not affect the results below as unemployment scarring is present in the responses to all aggregate shocks in the model.

ϕ_w and choose the wage rigidity parameter that minimizes the squared distance between the response of price index and its counterpart in the data. To capture the effects of unemployment scarring, I repeat this procedure for the version of the model where unemployment scarring is turned off in the same manner as in section 6.

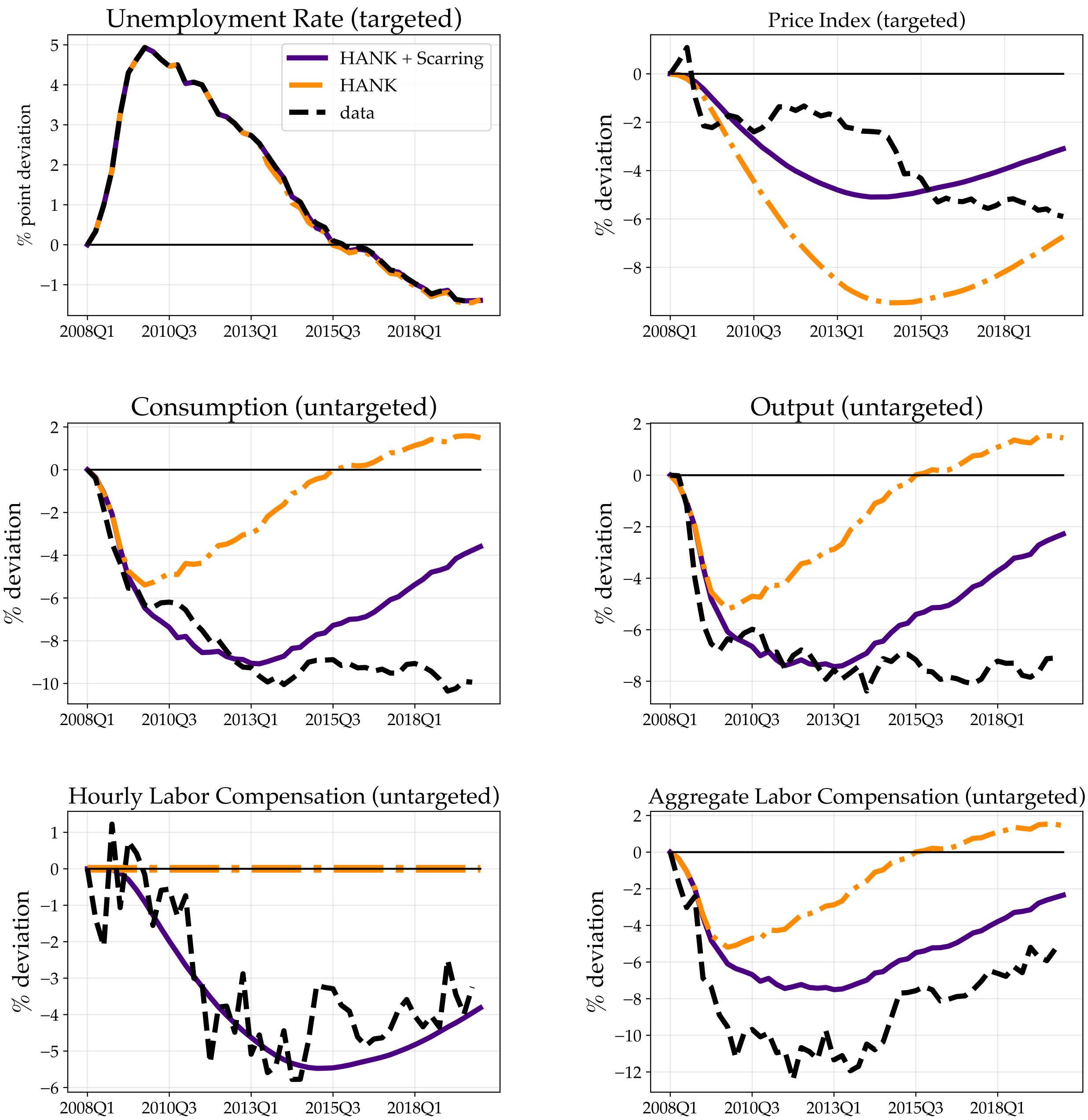

Figure 9: Great Recession: Model vs Data (detrended)

Note: This figure compares the paths of various aggregates in the model with and without unemployment scarring to the data. The series display deviation from steady state for the model and from 2008Q1 for the data. In the data, real PCE, PCE deflator, real GDP, real hourly labor compensation, aggregate labor compensation are detrended from 1990Q1 to 2019Q4 and then rescaled such that the data represent deviation from 2008Q1.

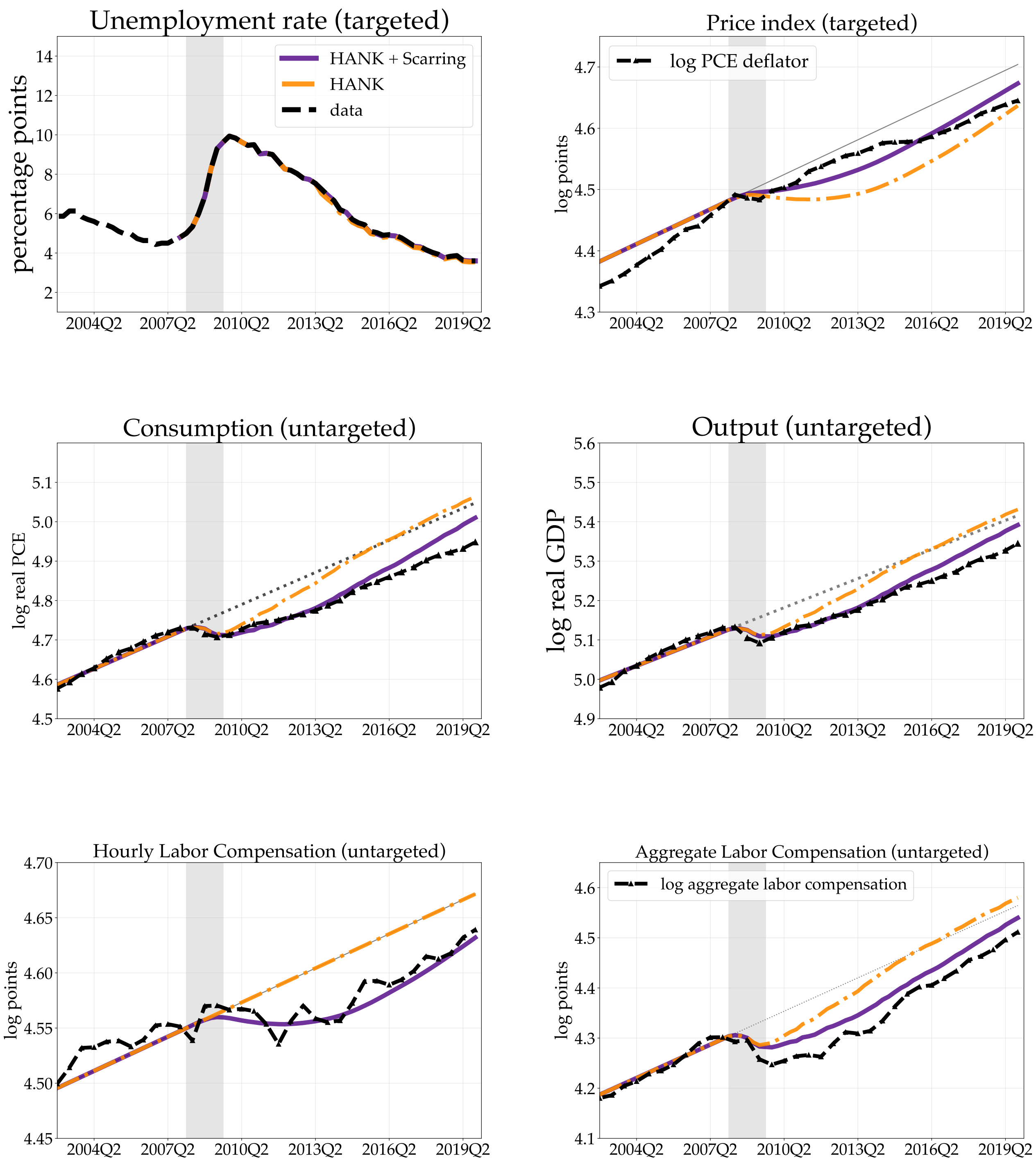

Figure 10: Great Recession: Model vs Data (with trend)

Note: This figure plots the responses from figure 9 with the trend.

Figure 8 plots the estimated shocks, the unemployment rate, and the nominal rate against the data under the baseline model and the model without scarring. Figure 9 plots the key aggregate variables against their detrended observed counterpart in the data and 10 plots the model responses against the data without detrending. Only the unemployment rate and price index are targeted.

Overall, unemployment scarring explains a substantial share of slow recovery following the Great Recession. In particular, scarring allows the model to match the path of the PCE and GDP until the beginning of 2015. Furthermore, the model under predicts the response of aggregate labor compensation likely due to the absence of labor force participation in the model. The path of hour labor compensation is matched especially well and provides macroeconomic validation that for unemployment scarring. Without unemployment scarring, the response of PCE, GDP, and aggregate labor compensation exhibit a 'V' shaped recovery as it mirrors the response of the unemployment rate. Unemployment scarring generates a persistent decline in labor productivity without a prolonged increase in the unemployment rate. This allows model to produce an income response that is significantly more persistent than the response of unemployment.

8.2 Debt to GDP during the Great Recession

Having shown that the model can replicate the sluggish recovery from The Great Recession, in this section I evaluate the extent to which human capital losses increased debt to GDP during and after the Great Recession. Figure 11 plots the simulated path of debt to GDP and tax revenues under the baseline model and the model without scarring. The model suggests that, by 2019, unemployment scarring increased debt to GDP by 5.5 % points. Human capital losses cause persistent losses in GDP as well as tax revenues which in turn increases debt.

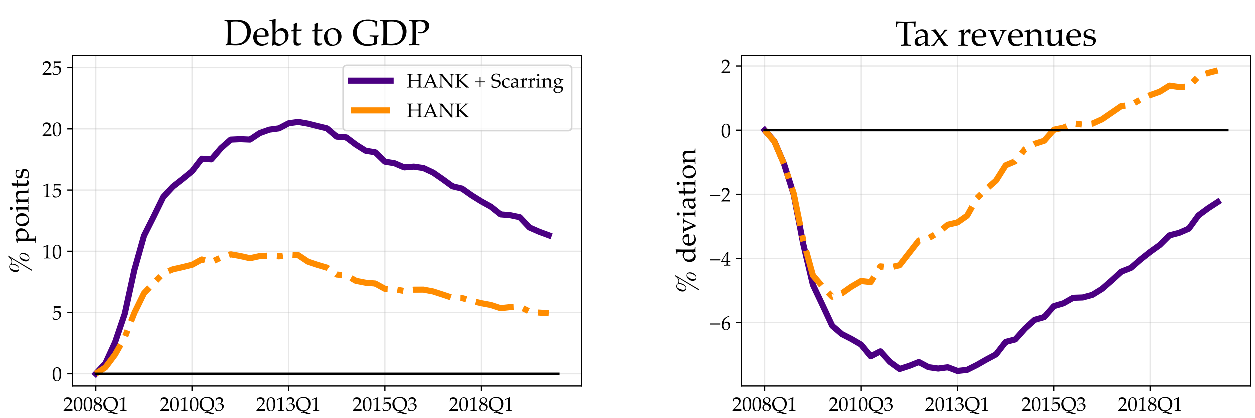

Figure 11: The response of debt to GDP and tax revenues

8.3 Income Inequality during the Great Recession

Unemployment scarring increases the dispersion in human capital during a recession. As households become unemployment and later find reemployment at a lower wage, the variance of the distribution of wages increases persistently as the re-accumulation of human capital is slow. Figure 12 shows that unemployment scarring allows the model to generate a near-permanent response in the Gini index of income that is consistent with the data.

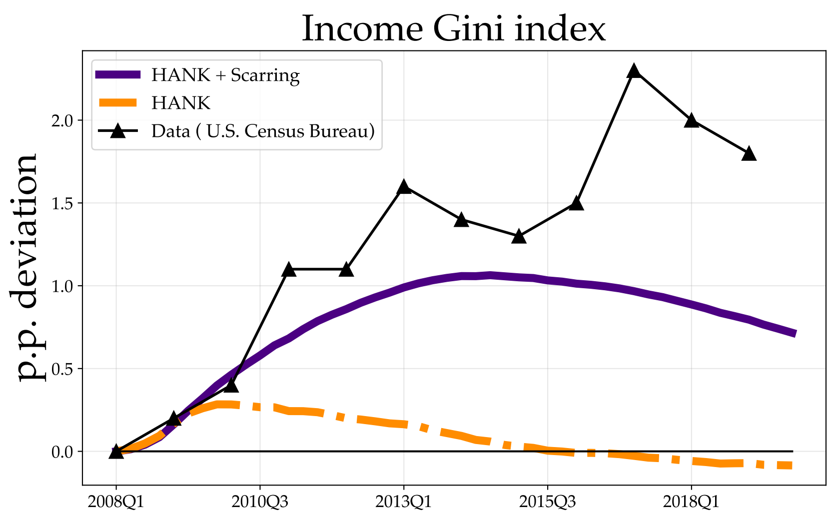

Figure 12: Gini Coefficient: Model vs Data

9 The COVID Recession and Temporary Layoffs

9.1 The COVID Recession and the Absence of Scarring

The behavior of unemployment during the COVID recession was unprecedented due to various reasons. One of these reasons is that 78% of the increase in the unemployment rate was attributed to temporary layoffs (Gertler et al., 2022). In this section, I show that, during the COVID recession, unemployment scarring did not translate to macro scarring because of the unprecedented fraction of temporary layoffs . Further, this section also shows that the model can explain both recessions with sluggish recoveries as well as recessions with quick recoveries. I repeat the estimation procedure of the previous section and recalibrate ζ^X for each unemployment state X to maximize the proportion of temporary layoffs that is attributed to a change in the unemployment rate. Further I assume that temporary layoffs cannot transition to a permanent layoff by setting $P_{TLPL} = 0$.[13] Figure 13 plots the responses of unemployment rate, Gini index for income, consumption, output under the model with scarring calibrated to maximize the proportion of temporary layoffs (purple), and the version of the model without scarring (orange). With a large mass of temporary layoffs, the effects of unemployment scarring are effectively eliminated as temporary layoffs are reemployed at their pre-job layoff wage. The effective absence of unemployment scarring reduces the persistence of the responses of consumption and output in the baseline model leading leading the model to be consistent with the empirical paths of consumption and GDP. Further, the response of the Gini index is transitory, similar to the data.

9.2 Temporary Layoffs and Swift Recoveries

In this section, I demonstrate that temporary layoffs, following the COVID recession, were instrumental in both accelerating the swift recovery of GDP and in preventing a permanent rise in income inequality. To show this, I repeat the estimation procedure of matching the unemployment rate during the COVID Recession but recalibrate the model to maximize the fraction of permanent layoffs that can be attributed to an increase in the unemployment rate. Because the job probabilities of workers who are in temporary layoff falls endogenously with the unemployment rate, the duration of a temporary layoff rises therefore preventing the model from producing an increase in an unemployment rate that is entirely explained by permanent layoff.[14]

Figure 14 and figure 15 compares the path of output and income Gini, respectively, under the original calibration (from section 9.1) against the counterfactual scenario with a large fraction of permanent layoffs. In all lines in each figure, the path of unemployment remains identical and instead only differs in the composition of the unemployment rate between permanent and temporary layoffs. Figure 14 demonstrates that if the rise in unemployment has been primarily due to permanent layoffs, GDP would not have returned to its pre-recessionary trend. Although the long run difference between the counterfactual and the data may appear small —due to the sharp initial contraction in GDP— the percentage deviation of the counterfactual from the trend reaches 2 $\%$ by the second quarter of 2023. This magnitude is within range of long run output deviations observed after the 1990-1991 and 2000s recessions. Moreover, emphasizing the role of temporary layoffs does not diminish the significance of fiscal policy in shaping the recovery from the pandemic. Fiscal mea-

[13] Gertler et al. (2022) note that 98$\%$ of these temporary layoffs do not transition to a permanent layoff.

[14] In other words, even if the increase in the EU probability in this simulation is completely captured by permanent layoffs, the UE probability of workers who were in temporary layoff prior to the recession must also fall.

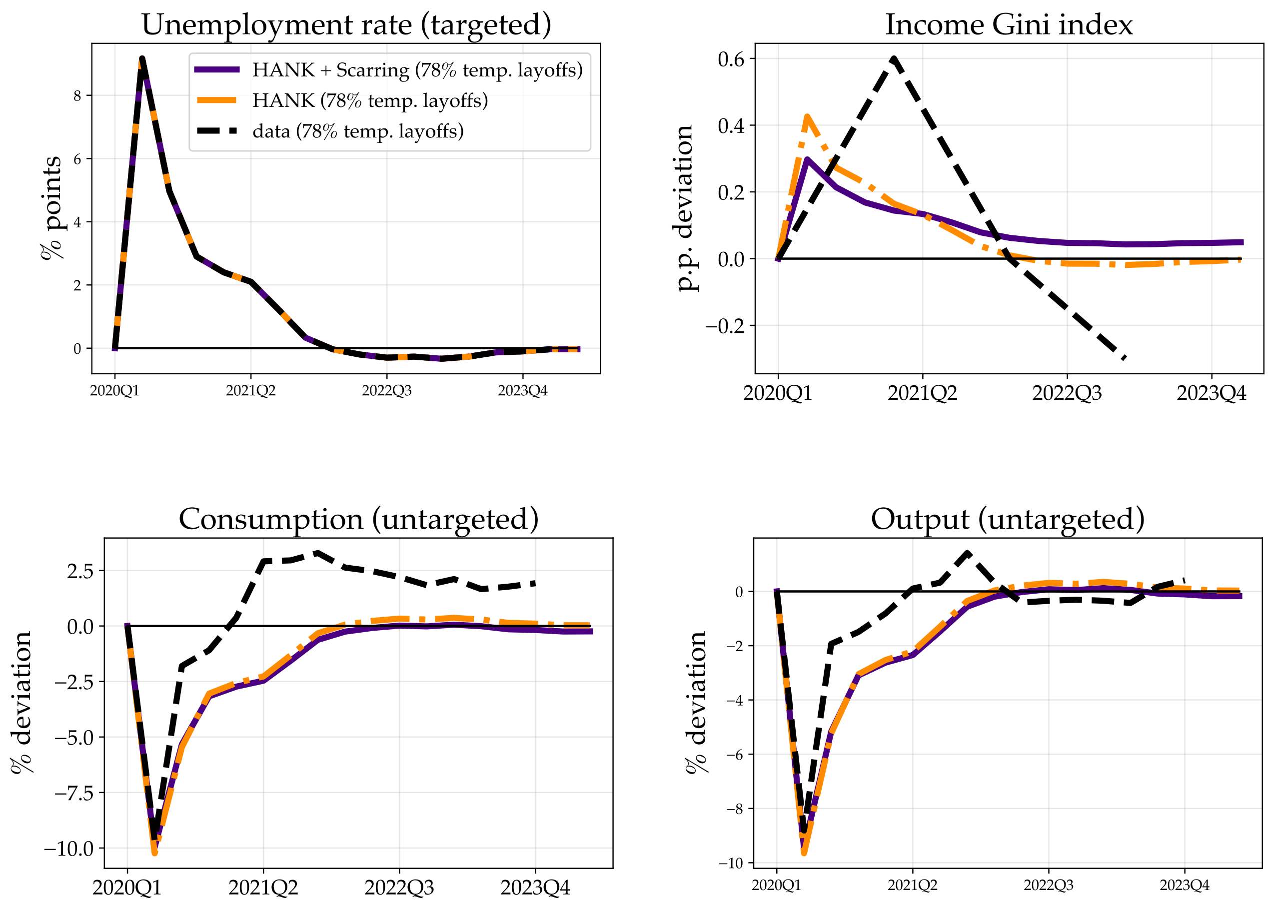

Figure 13: Model vs data: The COVID Recession

Note: In this exercise, the effects unemployment scarring are eliminate when the model is recalibrated to match the large proportion of temporary layoffs that explain the rise in unemployment. In particular, for this calibration, 78.5 % of the increase in the unemployment rate is attributed to temporary layoffs. Empirically, 97.7% of the increase in the unemployment rate is due to temporary layoffs. The model is unable to account for such a large proportion of temporary layoffs because the fall in labor market tightness during the simulation lowers the job finding probability of those who were already in a permanently layoff prior to the recession. Thus, the duration of those permanent layoffs rises.

sures may have contributed to the large proportion of temporary layoffs during the COVID Recession. Overall, temporary layoffs were a key factor in enabling GDP to return to its pre-recessionary trend and likely complemented the effectiveness of fiscal stimulus during this period. Similarly, Figure 15 illustrates that temporary layoffs prevented the permanent rise in the Gini index for income. Notably, the red line demonstrates that if the majority of the increase in the unemployment rate was due to permanent layoffs, then the Gini index for income would have permanently risen.

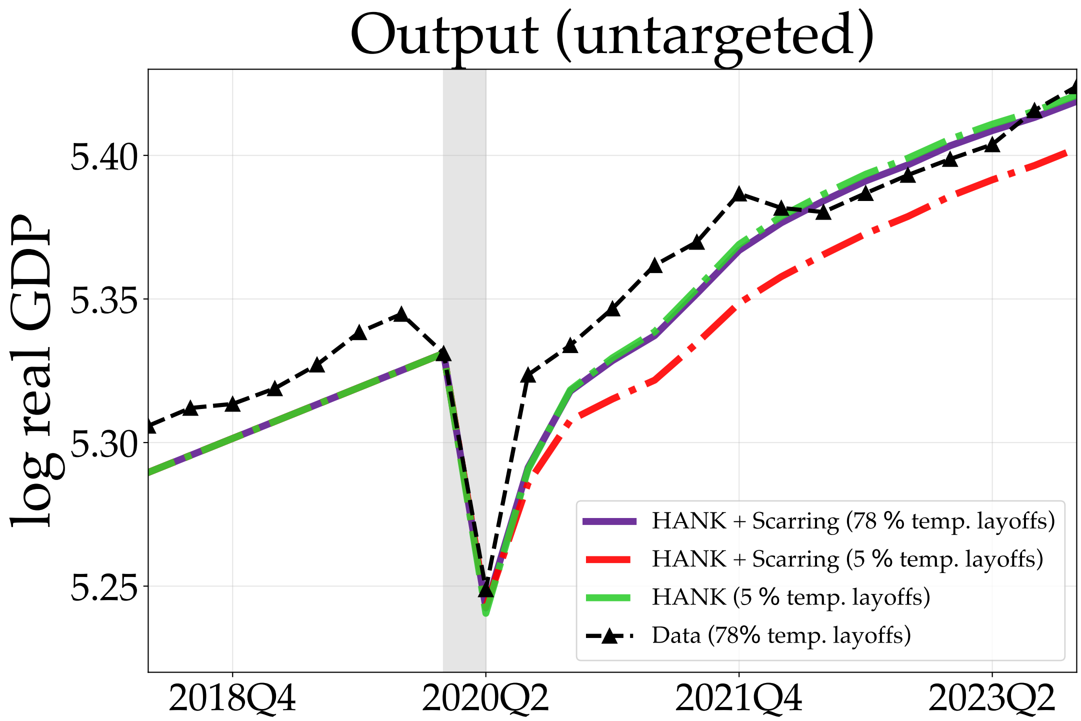

Figure 14: Counterfactual for GDP: What if the rise in unemployment during the pandemic was due to permanent layoffs?

This figure plots the paths of output with trend from the HANK + Scarring model (purple) under the baseline COVID calibration (with 78% temporary layoffs) against a counterfactual (red) where the rise in unemployment during COVID is largely explained by permanent layoffs. Note that for both paths of output, the unemployment rate is identical. Only the composition of the unemployment rate differs.

10 What if the US had pursued fiscal consolidation during the Great Recession?

10.1 A Reductions in Government Transfers in 2010

During The Great Recession, while the US pursued fiscal stimulus, European countries engaged in large fiscal consolidations. These austerity measures led to large contractions in GDP (Jordà and Taylor, 2016; Fatás and Summers, 2018; House et al., 2020). Further, unemployment scarring has been shown to be very much present, and slightly worse, in Europe.[15] In this section, I consider the path of the US economy had it engaged in similar austerity measures. I augment the simulation in the previous section by simulating a counterfactual

[15] Bertheau et al. (2023)

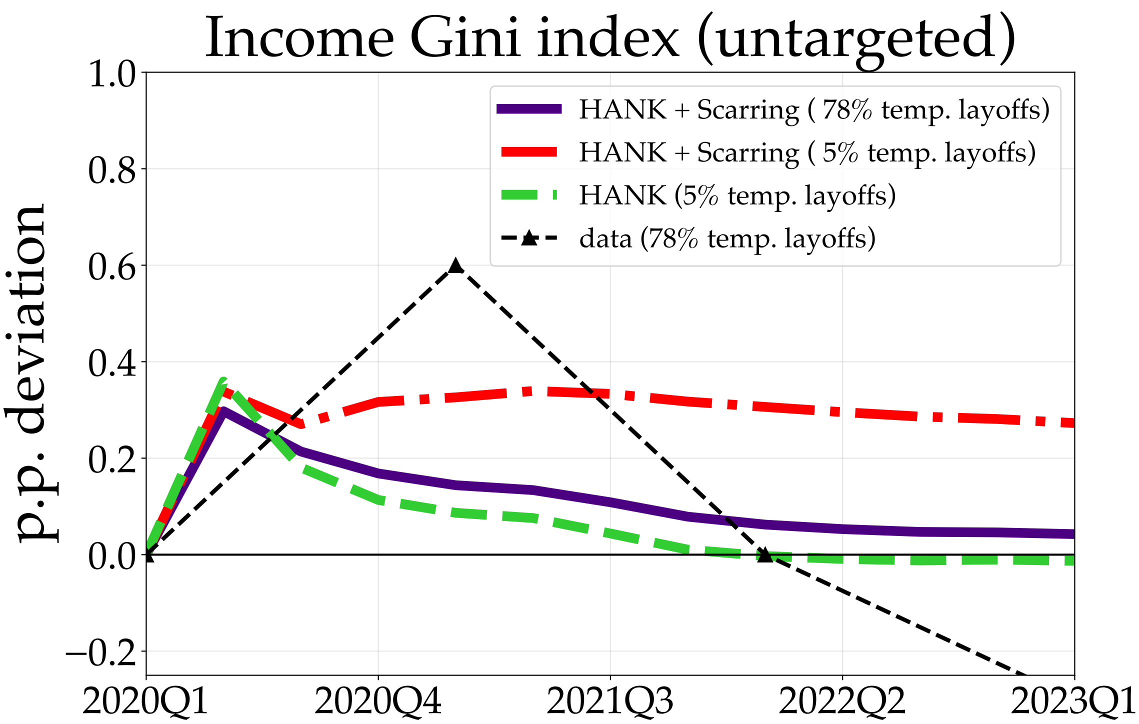

Figure 15: Counterfactual for Gini index: What if the rise in unemployment during the pandemic was due to permanent layoffs?

This figure plots the paths of the income Gini index from the HANK + Scarring model (purple) under the baseline COVID calibration (with 78% temporary layoffs) against a counterfactual (red) where the rise in unemployment during COVID is largely explained by permanent layoffs. Note that for both paths of the income Gini index, the unemployment rate is identical. Only the composition of the unemployment rate differs.

where the US reduces government spending by 2% of GDP at the beginning of 2010. I assume the shock has a quarterly persistence of 0.9 such that its path fades by 2016. As in the Great Recession simulation, the tax rate cannot adjust for 10 years and set $\phi_b = 0.015$. To account for the zero lower bound, I set the the coefficients of the Taylor rule on output, ϕ_Y, and inflation, ϕ_π, to zero such that the central bank fixes the nominal rate in response to this shock. I augment the estimated demand and monetary policy shocks from the previous section with this fiscal consolidation shock and simulate the path of the economy. Figure 16 plots the deviation in government spending, GDP, debt to GDP, and debt in the baseline simulation (purple), the simulation with fiscal consolidation (red), and the path of these aggregates without human capital losses (green dashed). In figure 16, fiscal consolidation causes a persistent decline in GDP while only generating a slight decline a debt and debt to GDP. In particular, the decrease in government spending of 2% of GDP only decreases debt to GDP by 1.23 percentage points. In the absence of human capital losses from scarring, the green dashed line demonstrates that debt to GDP would have fallen by 4.75 percentage points. Overall, fiscal consolidation during the Great Recession would have generated a large and persistent decline in GDP while being ineffective at reducing debt to GDP.

10.2 Fiscal Consolidation and the Zero Lower Bound

What are the effects of the zero lower bound on the counterfactual fiscal consolidation in section 7.3? To do so, I redo the experiment in section 7.3 but allow for an active Taylor rule. In particular, I set the Taylor rule coefficient on output, ϕ_Y, to $1/12$ and the Taylor rule coefficient on inflation, ϕ_π, to 1.5. Further, to illustrate the effect of an aggressive monetary authority, I also perform this experiment again with $\phi_Y = 0.2$ Figure 17 plots the fiscal consolidation exercise with and without the zero lower bound under the baseline Taylor rule and the more aggressive Taylor rule. Without the zero lower bound, fiscal consolidation becomes significantly more effective at reducing debt to GDP. The dashed blue and orange lines demonstrates that the decline in debt to GDP is substantially larger without the zero lower bound. The increased effectiveness of fiscal consolidation in reducing debt to GDP in the absence of the zero lower bound stems from decreasing the cost of debt. Decreasing the interest rate alleviates the fiscal authority's cost of borrowing, and therefore decreases the upward pressure that lost tax revenues place on debt.

11 Conclusion

This paper quantifies the macroeconomic role of a well-documented microeconomic fact, that job loss leads to scars on wages. Incorporating these microeconomic scars into a heterogeneous agent New Keynesian model with search and matching frictions introduces a novel channel that emerges as a key determinant of the speed of macroeconomic recovery from a recession. When estimated to match the microeconomic estimates on scarring, and calibrated to match the fraction of temporary layoffs in each recession, the model is able to quantitatively capture *both* the sluggish recovery from the Great Recession and the swift rebound from the COVID Recession. During a recession, the extent to which micro unemployment scarring translates to macro scarring hinges on the share of temporary layoffs driving the rise in the unemployment rate. In particular, had the majority of layoffs during the COVID Recession been permanent rather than temporary, GDP would not have returned to its pre-2020 trend, even when accounting for the large fiscal response during the pandemic.

In addition, the transmission of fiscal austerity changes considerably in the presence of

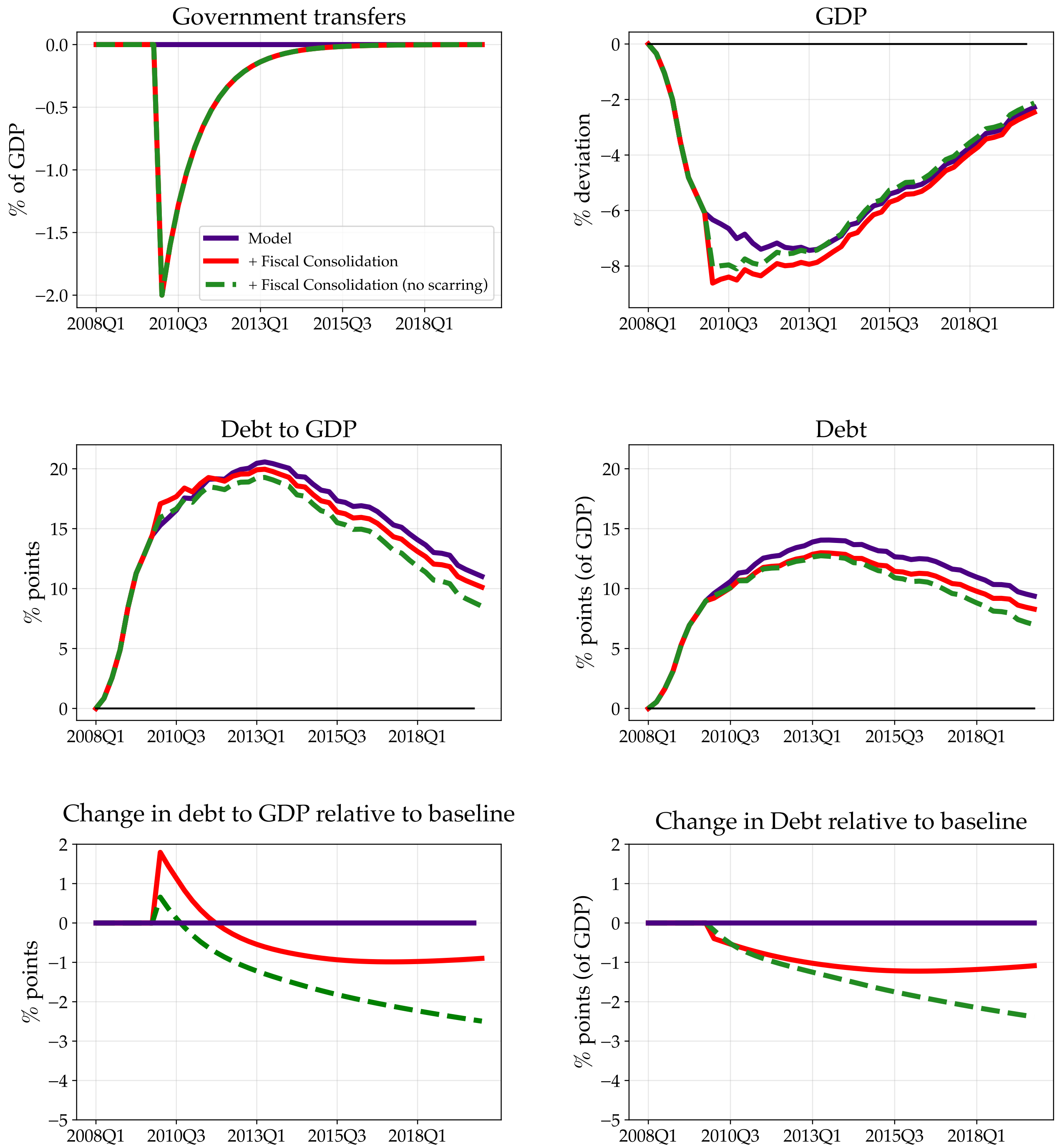

Figure 16: Counterfactual: Fiscal Consolidation in the US

Note: This exercise plots the simulated paths of of macro aggregates during the Great Recession from figure 9 with a fiscal consolidation shock that begins in 2010Q1 under the baseline model and the model without scarring.

these scars. Given a reduction in government spending, scarring erodes future tax revenues,

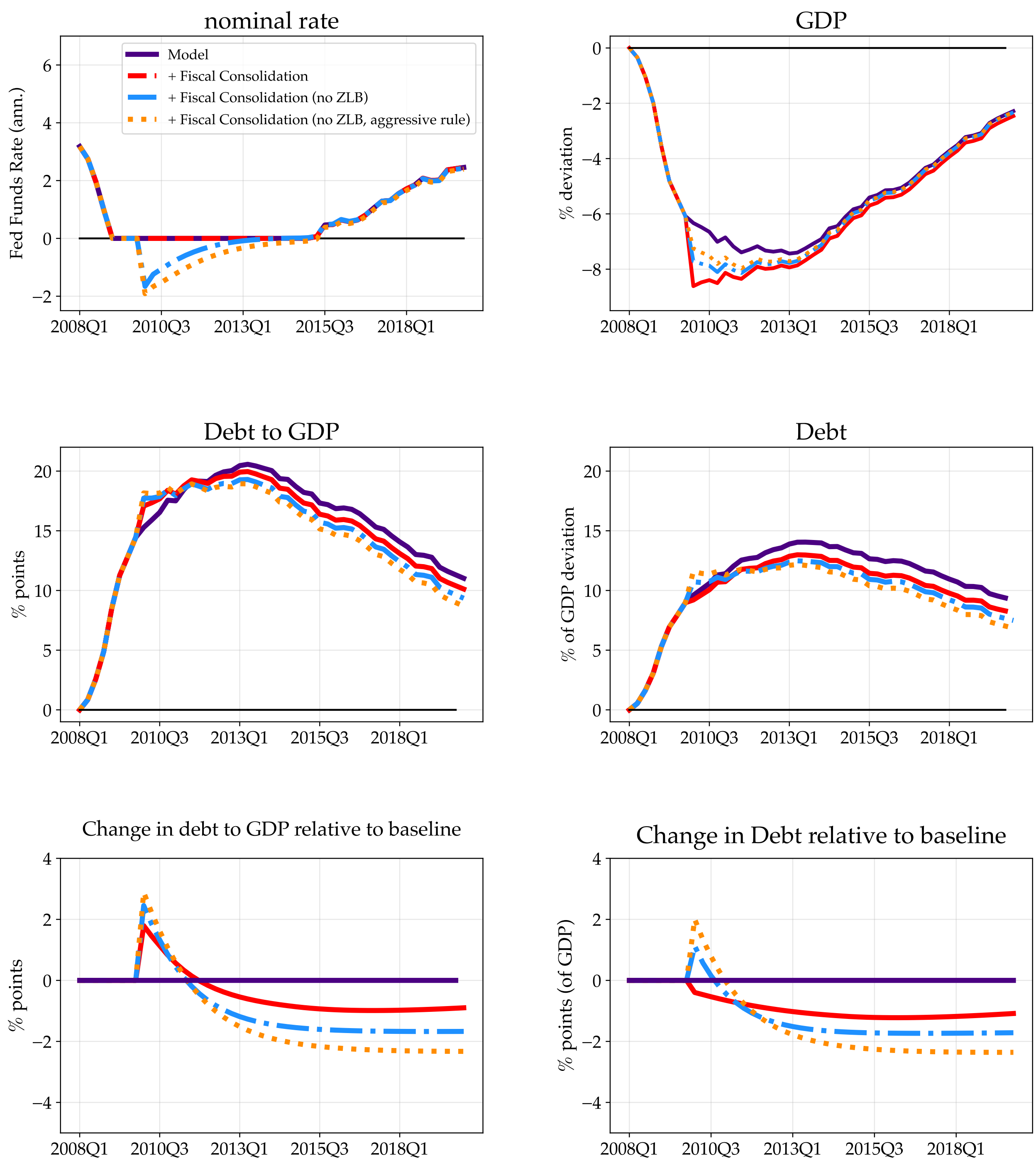

Figure 17: Counterfactual: Fiscal Consolidation in the US and the effects of the zero lower bound

increasing pressure on the fiscal deficit. Quantitatively, the decline in debt to GDP from a fiscal consolidation is four times smaller because of unemployment scarring and leads to a near permanent rise in income inequality as scarring increases the dispersion in wages.

The role of unemployment scarring in business cycle dynamics and macroeconomic policy presents many promising avenues for future research. First, the root causes of these scars remain an active area of research. Incorporating the origins of this microeconomic phenomenon into macroeconomic analysis could offer clearer guidance for designing policies to mitigate scarring. Additionally, the connection between unemployment scarring and sluggish recoveries highlights the potential of job retention schemes, like those implemented in Europe during the COVID recession, as an area for future research. As emphasized by Lachowska et al. (2020) and Jacobson et al. (1993), "something intrinsic to the employment relationship itself... is lost when workers are displaced." Job retention policies may serve as the most effective hedge against scarring, given the inherent challenges of finding a strong employer-employee match. I leave these important questions for future research.

References

Alves, Felipe and Gianluca Violante, "Some Like It Hot: Monetary Policy Under Okun's Hypothesis," 2023.

— **and Giovanni L. Violante**, "From Micro to Macro Hysteresis: Long-Run Effects of Monetary Policy," Staff Working Papers 24-39, Bank of Canada October 2024.

Auclert, Adrien, Ludwig Straub, and Matthew Rognlie, "Micro Jumps, Macro Humps: monetary policy and business cycles in an estimated HANK model," 2019 Meeting Papers 1449, Society for Economic Dynamics 2019.

Ball, Laurence, Davide Furceri, Daniel Leigh, and Prakash Loungani, "The Distributional Effects of Fiscal Consolidation," *IMF Working Paper*, 2013.

Bardóczy, Bence, "Spousal insurance and the amplification of business cycles," 2020.

Bertheau, Antoine, Edoardo Maria Acabbi, Cristina Barceló, Andreas Gulyas, Stefano Lombardi, and Raffaele Saggio, "The Unequal Consequences of Job Loss across Countries," *American Economic Review: Insights*, September 2023, *5* (3), 393–408.

Bianchi, Francesco, Howard Kung, and Gonzalo Morales, "Growth, slowdowns, and recoveries," *Journal of Monetary Economics*, 2019, *101*, 47–63.

Birinci, Serdar, "Spousal Labor Supply Response to Job Displacement and Implications for Optimal Transfers," Working Papers 2019-020, Federal Reserve Bank of St. Louis September 2019.

Blanchard, Olivier and Jordi Galí, "Labor Markets and Monetary Policy: A New Keynesian Model with Unemployment," *American Economic Journal: Macroeconomics*, April 2010, *2* (2), 1–30.

Carroll, Christopher, Jiri Slacalek, Kiichi Tokuoka, and Matthew N White, "The distribution of wealth and the marginal propensity to consume," *Quantitative Economics*, 2017, *8* (3), 977–1020.

Cerra, Valerie, Antonio Fatás, and Sweta C. Saxena, "Hysteresis and Business Cycles," *Journal of Economic Literature*, March 2023, *61* (1), 181–225.

Christiano, Lawrence J., Martin S. Eichenbaum, and Mathias Trabandt, "Unemployment and Business Cycles," *Econometrica*, July 2016, *84*, 1523–1569.

Comin, Diego and Mark Gertler, "Medium-Term Business Cycles," *American Economic Review*, June 2006, *96* (3), 523–551.

Davis, Steven J. and Till Von Wachter, "Recessions and the Costs of Job Loss [with Comments and Discussion]," *Brookings Papers on Economic Activity*, 2011, pp. 1–72.

Fatás, Antonio and Lawrence H. Summers, "The permanent effects of fiscal consolidations," *Journal of International Economics*, 2018, *112*, 238–250.

Fujita, Shigeru, "All Layoffs Are Not Created Equal," *Economic Insights*, July 2016, *1* (3), 1–8.

_ **and Giuseppe Moscarini**, "Recall and Unemployment," *American Economic Review*, December 2017, *107* (12), 3875–3916.

Gertler, Mark, Christopher K Huckfeldt, and Antonella Trigari, "Temporary Layoffs, Loss-of-Recall and Cyclical Unemployment Dynamics," Working Paper 30134, National Bureau of Economic Research June 2022.

Gornemann, Nils, Keith Küster, and Makoto Nakajima, "Doves for the rich, hawks for the poor? Distributional consequences of systematic monetary policy," 2021.

Graves, Sebastian, Christopher K. Huckfeldt, and Eric T. Swanson, "The Labor Demand and Labor Supply Channels of Monetary Policy," NBER Working Papers 31770, National Bureau of Economic Research, Inc October 2023.

Haan, Wouter J Den, Pontus Rendahl, and Markus Riegler, "Unemployment (fears) and deflationary spirals," *Journal of the European Economic Association*, 2018, *16* (5), 1281–1349.

House, Christopher L., Christian Proebsting, and Linda L. Tesar, "Austerity in the aftermath of the great recession," *Journal of Monetary Economics*, 2020, *115*, 37–63.

Huckfeldt, Christopher, "Understanding the Scarring Effect of Recessions," *American Economic Review*, April 2022, *112* (4), 1273–1310.

Jacobson, Louis S., Robert J. LaLonde, and Daniel G. Sullivan, "Earnings Losses of Displaced Workers," *The American Economic Review*, 1993, *83* (4), 685–709.

Jorda, Oscar, Alan Taylor, and Sanjay Singh, "The Long-Run Effects of Monetary Policy," *Federal Reserve Bank of San Francisco Working Paper*, 2023.

Jordà, Òscar and Alan M. Taylor, "The Time for Austerity: Estimating the Average Treatment Effect of Fiscal Policy," *The Economic Journal*, 2016, *126* (590), 219–255.

Kaplan, Greg, Benjamin Moll, and Giovanni L Violante, "Monetary policy according to HANK," *American Economic Review*, 2018, *108* (3), 697–743.

— **, Giovanni L. Violante, and Justin Weidner**, "The Wealthy Hand-to-Mouth," *Brookings Papers on Economic Activity*, 2014, *45* (1 (Spring)), 77–153.

Kekre, Rohan, "Unemployment insurance in macroeconomic stabilization," *Review of Economic Studies*, 2023, *90* (5), 2439–2480.

Lachowska, Marta, Alexandre Mas, and Stephen A. Woodbury, "Sources of Displaced Workers' Long-Term Earnings Losses," *American Economic Review*, October 2020, *110* (10), 3231–66.

McKay, Alisdair and Ricardo Reis, "The Role of Automatic Stabilizers in the U.S. Business Cycle," *Econometrica*, 2016, *84* (1), 141–194.

Moore, Brendan and Judith Scott-Clayton, "The Firm's Role in Displaced Worker Earnings Losses," 2019.

Moran, Patrick and Albert Queralto, "Innovation, productivity, and monetary policy," *Journal of Monetary Economics*, 2018, *93*, 24–41.

Poletaev, Maxim and Chris Robinson, "Human Capital Specificity: Evidence from the Dictionary of Occupational Titles and Displaced Worker Surveys, 19842000," *Journal of Labor Economics*, 2008, *26* (3), 387–420.

Ramey, Garey, Wouter J. den Haan, and Joel Watson, "Job Destruction and Propagation of Shocks," *American Economic Review*, June 2000, *90* (3), 482–498.

Ravn, Morten O and Vincent Sterk, "Job uncertainty and deep recessions," *Journal of Monetary Economics*, 2017, *90*, 125–141.

Rotemberg, Julio J, "Sticky prices in the United States," *Journal of political economy*, 1982, *90* (6), 1187–1211.

Schmieder, Johannes F., Till von Wachter, and Jörg Heining, "The Costs of Job Displacement over the Business Cycle and Its Sources: Evidence from Germany," *American Economic Review*, May 2023, *113* (5), 1208–54.

Silva, Jose and Manuel Toledo, "Labor Turnover Costs And The Cyclical Behavior of Vacancies and Unemployment," *Macroeconomic Dynamics*, 2009, *13* (S1), 76–96.

A Simulating The 1980s, 1990-91, and 2000s Recessions

In this section, I explore whether scarring can explain the recoveries of all other recessions since the 1980s. For each recession, I assume the steady state of the model is the quarter in which the given recession begins and recalibrate ζ^X to match the proportion of the increase in the unemployment rate due to permanent layoffs, temporary layoffs, and quits/others that is estimated in Gertler et al. (2022) and from the decomposition of unemployment flows constructed by Fujita and Moscarini (2017). In addition, I fix the real wage by setting $\phi_w = 1$. I then repeat the estimation procedure for simulating the Great Recession without estimating monetary policy shocks for parsimony. In addition, for each recession, the data are detrended from the end of the previous recession up until beginning of the next recession.[16]

A.1 The 80s Recession

The model suggests that scarring played a limited role in explaining the recovery of consumption and output from the recessions in the 80s. Figure A.1 plots the responses of the unemployment rate, hourly labor compensation, consumption and GDP against the data. The responses represent deviations from 1980Q1, the beginning of the first recession of the 80s. From the figure, the model with scarring has difficulty accounting for the response of consumption but can account for the long run behavior of output. The path of hourly labor compensation provides a good fit to the data until 1985. The model has difficulty accounting for the path of hourly labor compensation after 1985 because it cannot capture the compositional changes of hourly labor compensation due to the absence of working hours as well as not having the job separation rate depend on human capital.

[16] Pushing back the beginning of the detrending interval to be 20 years before the beginning of the recession makes little difference to the results.

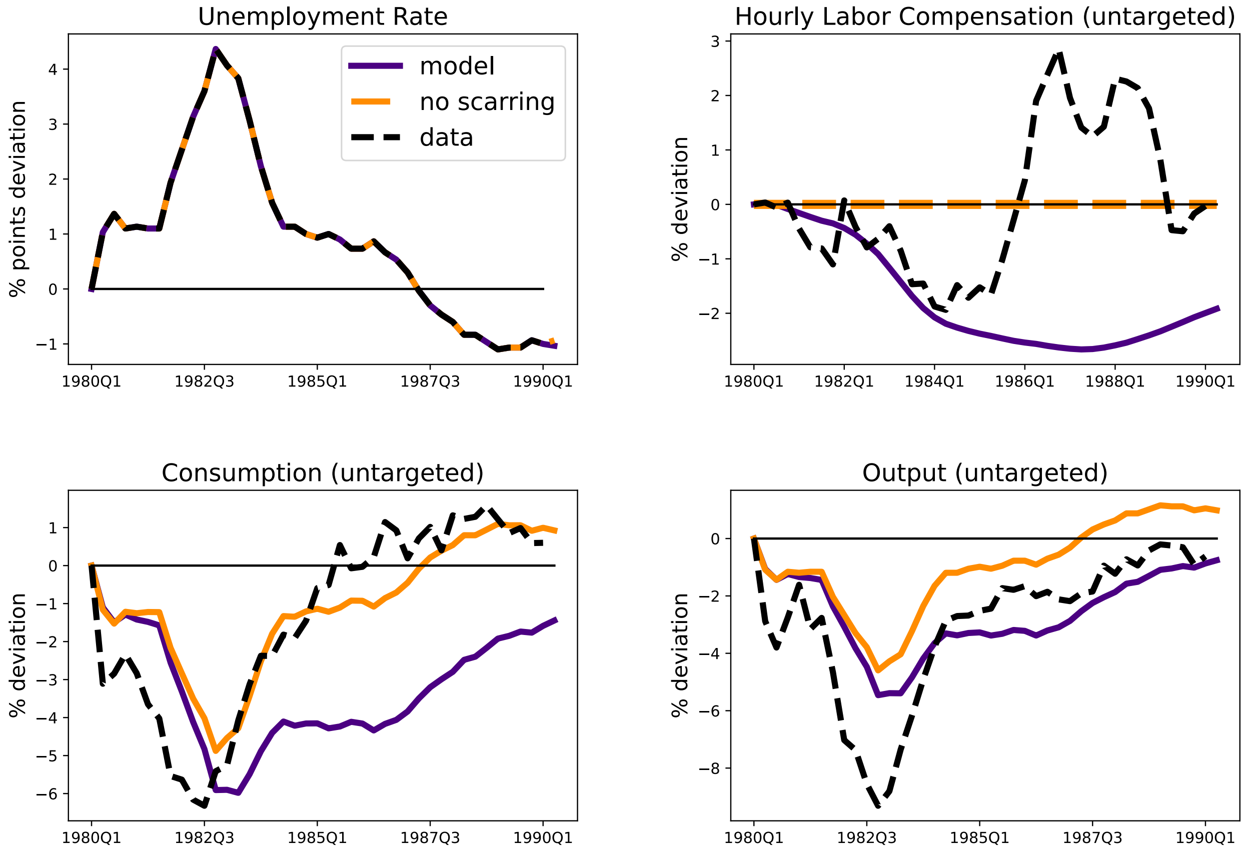

Figure A.1: Model vs data: 1980s

A.2 The 1990-1991 Recession

According to the model, scarring plays an important role in explaining the recovery from the 1990s recession. Figure A.2 plots the responses for the 1990-1991 recession against the data. The responses represent deviations from 1990Q3. With scarring, the model matches the responses of consumption and GDP well as well as matching the overall trend in hourly labor compensation. The response of hourly labor compensation likely rises in the beginning due lower wage workers being fired first. As mentioned previously, the model does not capture this fact.

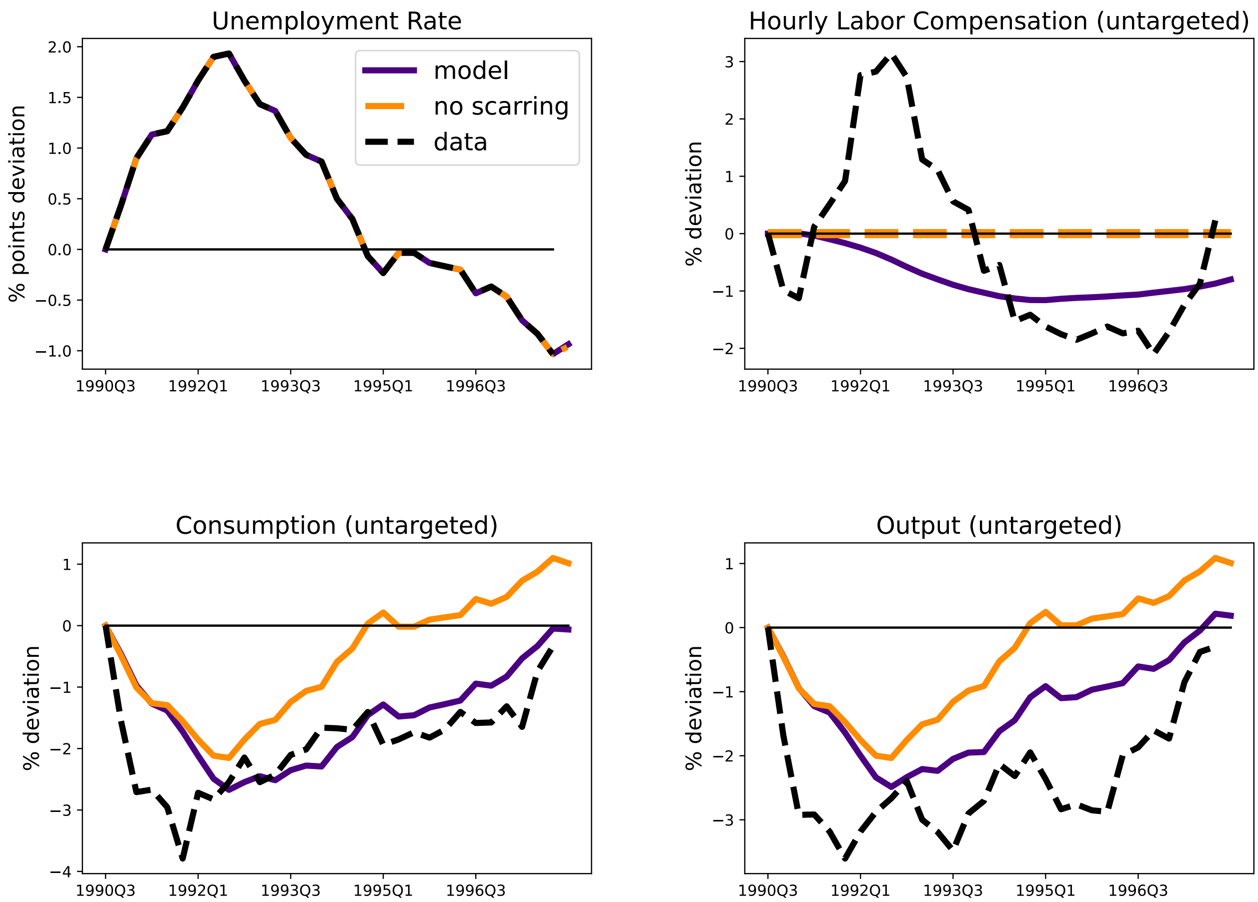

Figure A.2: Model vs data: 1990-1991 recession

A.3 The 2001 Recession

Similar to the 1990-1991 recession, scarring can help explain the recovery from the 2001 recession. Figure A.3 plots the responses for the 2001 recession against the data. The responses represent deviations from 2001Q2. With scarring, the model can help explain the long run behavior of consumption and GDP. The model also captures the trend in hourly labor compensation seen in the data.

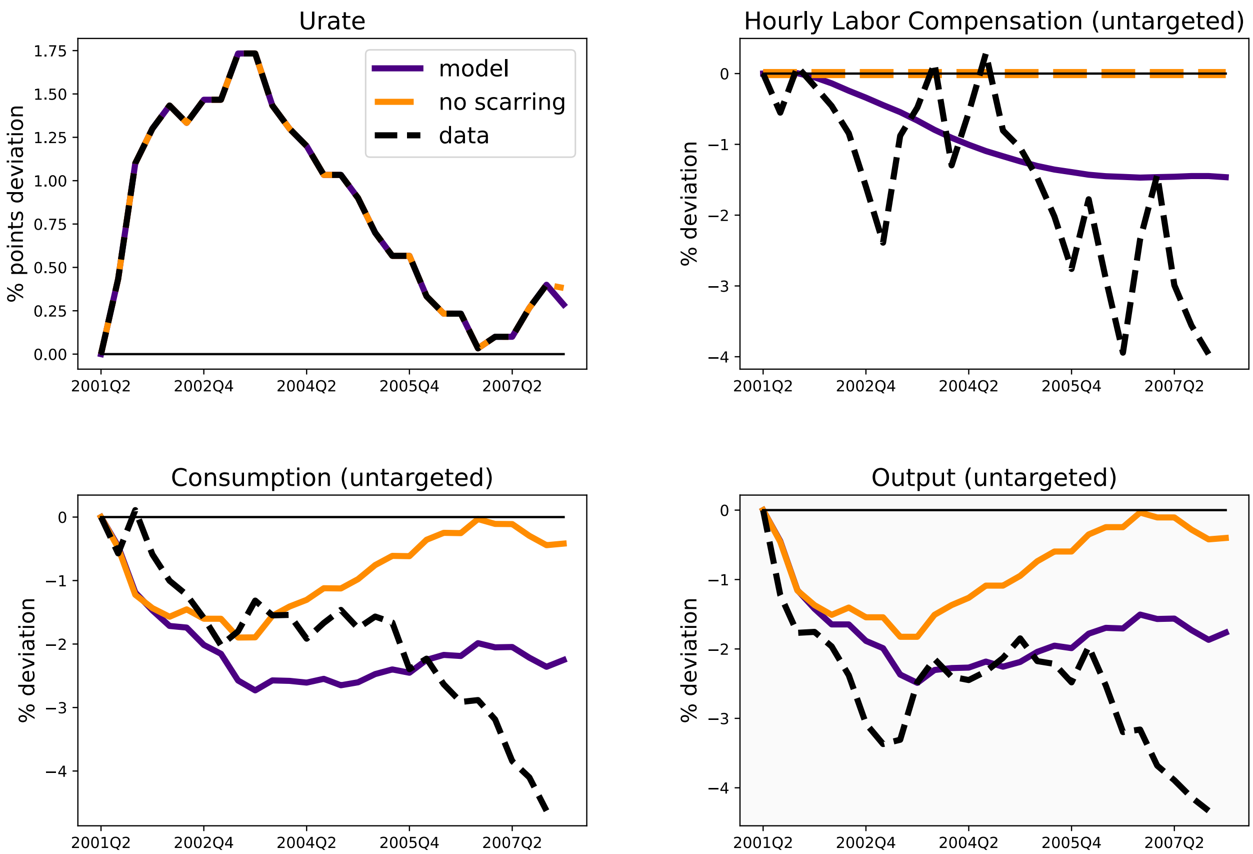

Figure A.3: Model vs data: 2000s

B Unemployment Risk as an Amplifier of Business Cycles

Precautionary saving in response to heightened unemployment risk is larger in the presence of scarring. This greater intensity in precautionary behavior leads unemployment risk to be a larger amplifier of business cycles. Figure A.4 (baseline calibration) and figure A.5 (fixed real wage) plot the response of consumption to the negative demand shock from section 6.1 with and without perceived unemployment risk under the baseline model and the model with no scarring. The plots demonstrate that unemployment risk is a larger amplifier of business cycles, especially under a fixed real wage. Increased precautionary saving in response to heightened unemployment risk dampens consumption, reduces labor demand, and therefore further raises the unemployment rate. This sequence of events is self reinforcing as the increase in the unemployment rate further increases precautionary saving. When households perceive that unemployment can lead to scars, this channel is substantially larger,

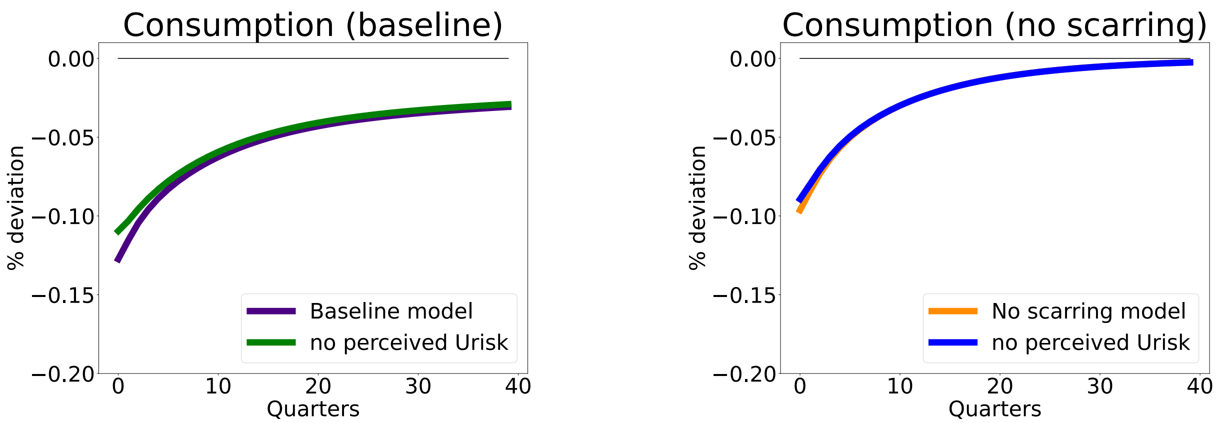

Figure A.4: Responses of Consumption to demand shock with and without perceived unemployment risk.

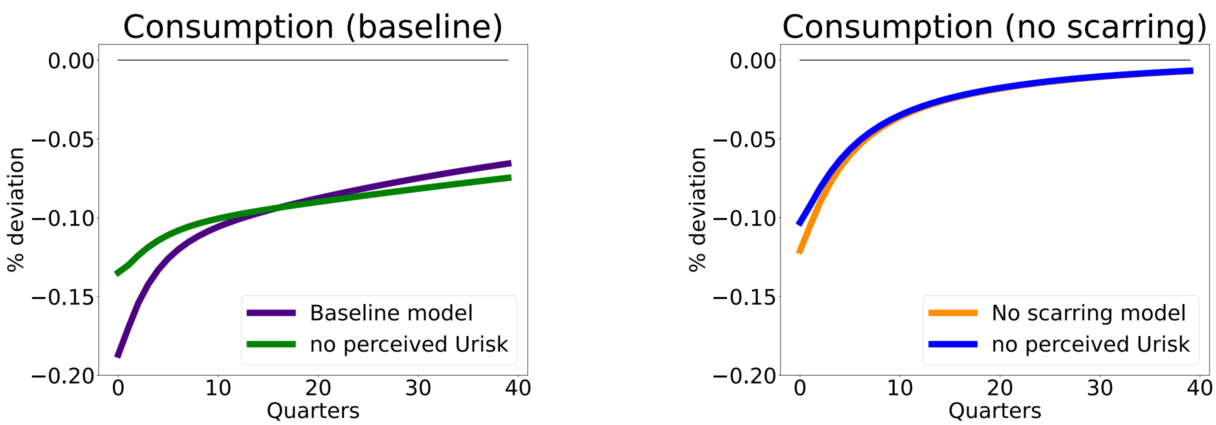

Figure A.5: Responses of Consumption to demand shock under a fixed real wage with and without perceived unemployment risk.

Note: The response of consumption in the baseline model is less persistent than its counterpart without scarring because the response of precautionary saving is front loaded in a model with perfect foresight. To be specific, in response to the negative demand shock, the decumulation of precautionary savings after $t = 0$ is larger in the model with scarring because their buffer stocks were substantially large to begin with. This decumulation is large enough to to reduce the persistence of consumption.

C Using other shocks to simulate the Great Recession

This section demonstrates that the choice of shock chosen to match the unemployment rate during the Great Recession in figure 8 does not matter. I consider a price markup shock and a shock to the variance of permanent income. For each type of shock, I estimate innovations to the respective variable to match the unemployment rate. Figure A.6 plots the responses of consumption and output when either shock process is estimated to match the unemployment rate during the Great Recession.

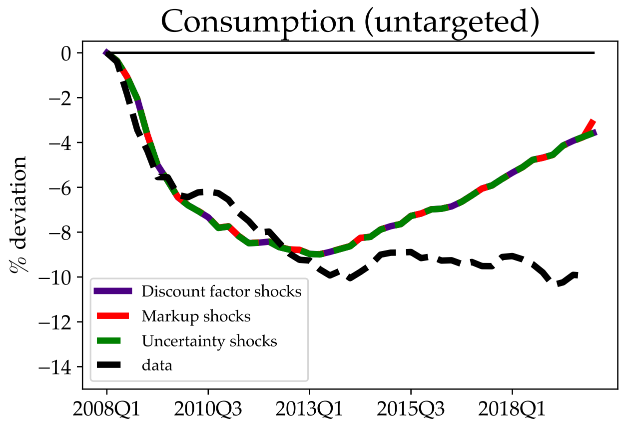

Figure A.6: Simulation of Great Recession Using different shocks.

D Monetary Policy and Unemployment Scarring

This section demonstrates that monetary policy exerts persistent effects on output, aggregate labor productivity, and income inequality when unemployment scarring is present. Figure A.7 plots the impulse responses to a 25 basis point shock to the Taylor rule. The results reveal that monetary policy triggers enduring responses in output, mean human capital, and the Gini index for income. For this analysis, I modify the Taylor rule to include inertia:

$$i_t = r^* + \phi_{ev} i_{t-1} + (1 - \phi_{ev})(\phi_\pi \pi_t + \phi_Y (Y_t - Y_{ss})) + \epsilon_t^m$$

where the inertial parameter ϕ_{ev} is calibrated to 0.8. The persistent impulse responses to a monetary tightening align with the findings of Jorda et al. (2023), who show that monetary contractions produce lasting declines in output without a prolonged increase in the unemployment rate. The key mechanism is that unemployment scarring results in a permanent decline in workers' human capital. Consequently, this scarring effect does not cause an extended rise in unemployment but instead transmits to output through a persistent reduction in aggregate labor productivity. As a result, unemployment scarring offers an alternative rationale for the empirical results in Jorda et al. (2023).

E Self Defeating Fiscal Consolidation

The idea of self defeating fiscal consolidation in the presence of hysteresis was proposed by Fatás and Summers (2018) in a simple toy model. This section shows that fiscal consolidation is indeed substantially less effective at reducing the debt-to-GDP ratio when hysteresis

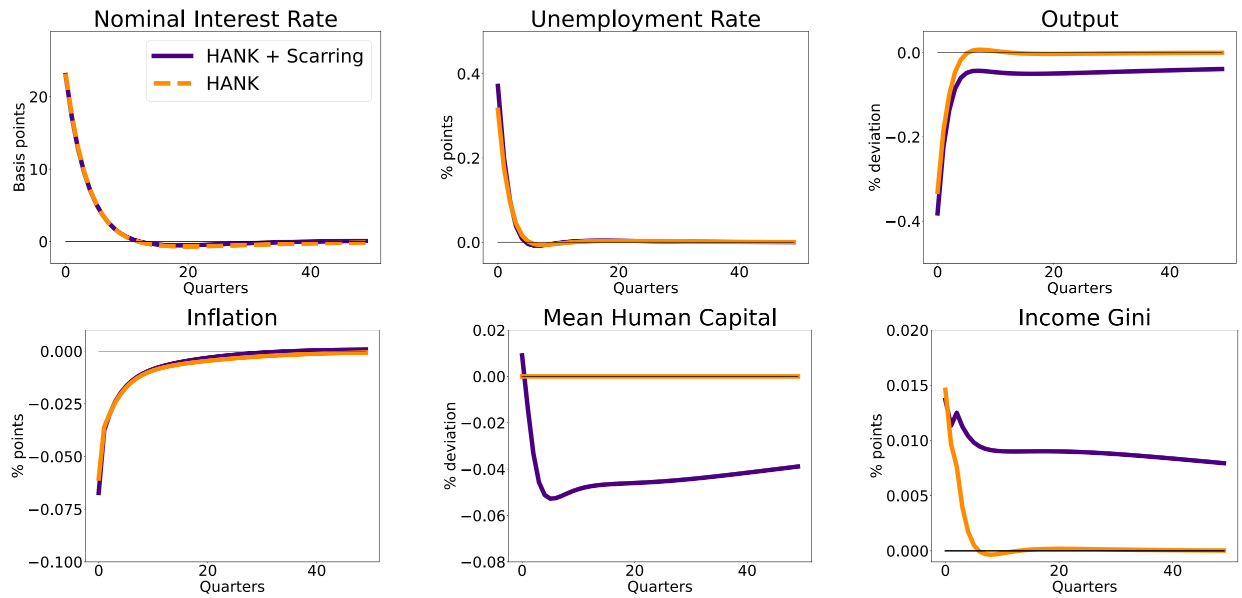

Figure A.7: Impulse responses to a monetary policy shock

Note: The exercise above plots the impulse responses to a 25 basis point shock to the Taylor rule. I assume that the Taylor rule now is $i_t = r^* + \phi_{ev} i_{t-1} + (1-\phi_{ev})(\phi_\pi \pi_t + \phi_Y (Y_t - Y_{ss})) + \epsilon_t^m$ where I set $\phi_{ev} = 0.8$ as in Bardóczy (2020)

is calibrated to microeconomic evidence on unemployment scarring. I consider a decrease in government spending shock that is 1% of GDP with a quarterly persistence of the shock is 0.933. Figure A.8 plots responses of relevant variables to this shock. With unemployment scarring, debt to GDP falls substantially less in response to a decrease in government spending and in the long run increases. The initial jump in debt to GDP is due to the model featuring realistic aggregate MPCs. In the long run, debt to GDP rises because of persistent losses in tax revenues. For debt to GDP, scarring drives both persistent losses in output as well as the increased pressure on debt to rise. The bottom right panel plots the response of the Gini index to the negative government spending shock and shows that fiscal consolidation almost permanently raises income inequality. In particular, a one percentage point decrease in government spending increases the income Gini index by 0.05 percentage points.

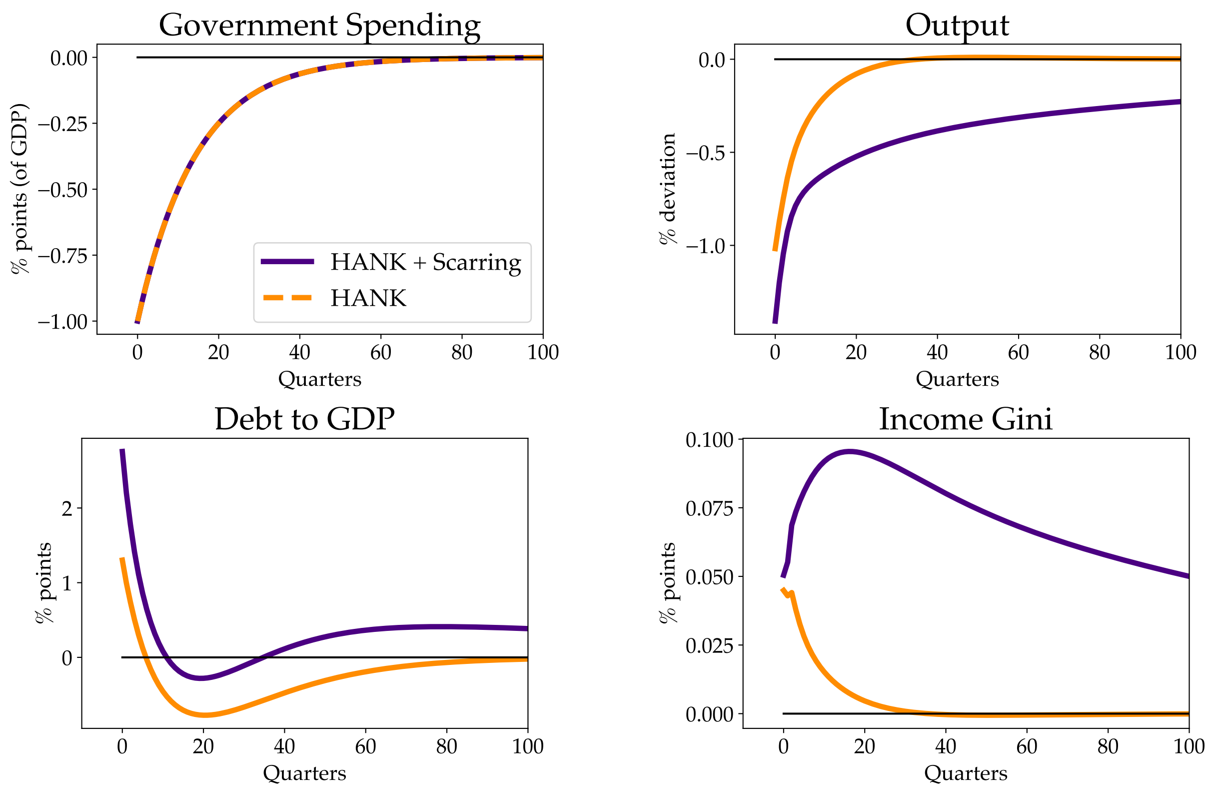

Figure A.8: Responses to a negative government spending shock

Note: This exercise plots the impulse responses to a one percentage point decrease in government spending G_t with AR(1) persistence 0.9.

F Overview of the Model