The Macroeconomic Consequences of Unemployment Scarring

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Abstract

Job loss leaves scars on wages that remain for more than 20 years. This paper argues that this well-documented microeconomic fact is a key mechanism in determining the speed of recovery from recessions. To capture these scars, I incorporate human capital into a heterogeneous agent New Keynesian model with search and matching frictions. During unemployment, human capital depreciates, leading to lower wages for reemployed workers. Unemployment scarring introduces a novel dimension that allows the model to capture both the sluggish recovery from the Great Recession and the rapid rebound from the COVID Recession. Furthermore, in the presence of scarring, temporary layoffs can serve as a crucial ingredient in driving a swift recovery. In a counterfactual analysis of the Great Recession, a U.S. fiscal consolidation would have proven ineffective at reducing debt-to-GDP because scarring erodes future tax revenues and therefore increases pressure on the fiscal deficit.

Keywords Unemployment Scarring, Business Cycles, Inequality, Fiscal Policy

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1 Introduction

Since the seminal work of Jacobson, LaLonde, and Sullivan (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, Mas, and Woodbury, 2020; Huckfeldt, 2022), are substantially worse in recessions (Davis and Wachter, 2011; Schmieder, von Wachter, and Heining, 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. Macroeconomists have long believed that these scars may play an important role in business cycle dynamics. This paper bridges this gap by showing that these microeconomic scars play a pivotal role in determining the speed of recovery from recessions.

To quantify the macroeconomic role of 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,[3] [4]the model differentiates between permanent layoffs, temporary layoffs, and other types of unemployment. Temporary layoffs can transition to permanent layoffs and only households who find reemployment after a permanent layoff spell experience human capital depreciation. The model does not capture the sources that lead firms to engage in temporary layoffs. Instead, using the estimates of Gertler, Huckfeldt, and Trigari (2022), the unemployment process across different layoff states is calibrated to match *how* each state evolves during recessions. When the model is calibrated to match the microeconomic estimates of unemployment scarring in Davis and Wachter (2011), a transitory increase in the

[1]The earnings loss following job displacement documented in the microeconomic literature pertain to displaced workers who have had job tenures from 3 to 10 years. In fact, earnings losses rise with job tenure.

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

[3]A permanent layoff indicates a worker who has been permanently separated from the firm he/she was previously employed. It does not indicate a worker is permanently unemployed. The majority of workers who are permanently laid off find jobs within a year.

[4]The microeconomic literature on unemployment scarring either restrict their sample to workers who lost their jobs in mass layoffs or, in studies with survey data, those who report to be involuntarily unemployed. Losing a job during a mass layoff event is reasonably considered to be a permanent layoff.

unemployment rate induces a persistent decline in both aggregate labor productivity and aggregate labor income.

I begin by demonstrating that the decline in macroeconomic activity caused by unemployment scarring is sufficiently persistent to validate it 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. Notably, since these scars arise from losses in human capital that reduce both labor income and productivity, the persistent decline in macroeconomic activity occurs without a sustained rise in the unemployment rate. Moreover, the increased wage dispersion resulting from scarring contributes to a lasting increase in income inequality, a result supported by the data but unaccounted for in standard quantitative models of hysteresis. Furthermore, unemployment 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 a substantial and persistent decline in aggregate labor productivity, I then demonstrate that unemployment scarring allows the model to match the sluggish recovery from the Great Recession, a challenging feat that can only be accomplished with a mechanism that generates 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[5]. Without unemployment scarring, the model can only account 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 importance of scarring during the Great Recession. In addition, unemployment scarring also allows the model to replicate the untargeted path of hourly labor compensation and the permanent rise in income inequality for the whole simulation period, providing further validation that the role of scarring during and after the Great Recession is being captured. 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.

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 val-

[5]The goal of this exercise is to ask, does the predicted path of consumption and output from the model conditional on the unemployment rate match the data?

idates the role of unemployment scarring as a key factor in determining the speed of recovery from recessions. To demonstrate 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 98.8% 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, Huckfeldt, and Trigari (2022). Naturally, with an enormous proportion of temporary layoffs, scarring is absent. 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.

The model's ability to capture the COVID recession emphasizes the role that temporary layoffs can play in generating swift recoveries from recessions. In particular, I demonstrate that if the rise in unemployment during the COVID recession had been driven primarily by permanent layoffs, output would not have returned to its pre-recessionary trend. To illustrate this, I replicate the COVID recession simulation but recalibrate the model to minimize the share of temporary layoffs contributing to the surge in unemployment. In this counterfactual scenario, GDP would have settled on a new trend, 2% below the pre-2020 trend. The emphasis on the importance of 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.

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 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, Kung, and Morales, 2019). Although unemployment scarring has long been considered as a potential mechanism for the sluggish recoveries from past recessions (Cerra, Fatás, and Saxena, 2023), this paper formalizes this discussion by quantifying the effects of unemployment scarring in driving business cycle fluctuations. Further, papers in the literature have also documented that contractionary monetary policy can have persistent effects on the economy (Moran and Queralto, 2018; Jorda, Taylor, and Singh, 2023). I show that unemployment scarring is an alternative theoretical mechanism that can explain their results (see appendix).

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, Proebsting, and Tesar, 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, Furceri, Leigh, and Loungani (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.

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 countercyclical unemployment risk that amplify business cycle fluctuations(McKay and Reis, 2016; Ravn and Sterk, 2017; Den Haan, Rendahl, and Riegler, 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 the appendix, is that the role of unemployment risk as an amplifier of business cycles is considerable larger in the presence of scarring.

Finally, this paper is most closely related to the new yet small literature on the implications of unemployment scarring on business cycle fluctuations and macroeconomic policy. This literature consists of the work of Alves and Violante (2023) and Alves (2022). Alves and Violante (2023) demonstrate that a ‘lower for longer‘ monetary policy allows workers to build their human capital and therefore propel growth in output at the cost of inflation. Alves (2022) studies the implications of a job ladder in a macroeconomic model of the business cycle. To the best of my knowledge, this paper is the first to evaluate the implications of unemployment scarring in the transmission of fiscal policy and the first to quantify the extent to which unemployment scarring explains the recoveries from past recessions,

Outline The rest of the paper is as follows. Section 2 presents the model. Section

3 describes the parameterization of the model. Section 4 validates the model is consistent with the microeconomic estimates of earnings loss following job displacement, Section 5 and 6 presents the implications of unemployment scarring. Section 7 shows how the model compares to data during The Great Recession. Section 8 concludes.

2 The 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, Huckfeldt, and Trigari (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 experience human capital erosion that is realized upon reemployment. 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

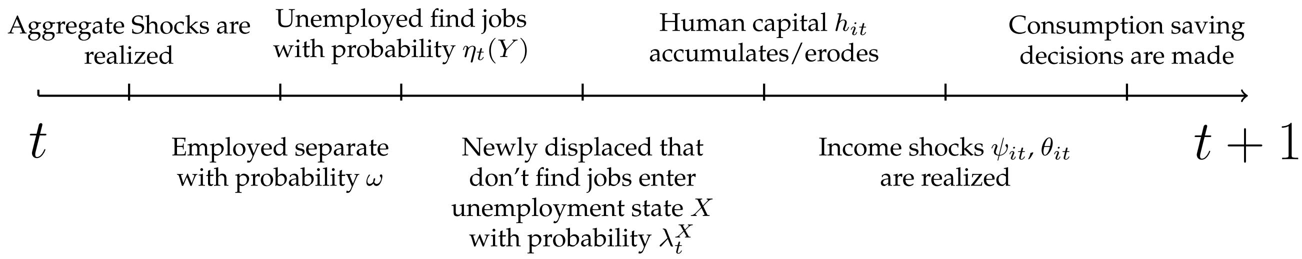

Figure 1 Timing of model

The Bellman problem is:

$$v_t\left(\mathbf{m}_{it}, \mathbf{p}_{it}, h_{it}, n_{it}, X_{it}\right) = \max_{\{\mathbf{c}_{it}, \mathbf{a}_{it}\}} \{U\left(\mathbf{c}_{it}\right)) + \beta_i(1-D)\mathrm{E}_{\mathrm{t}}\left[v_{t+1}\left(\mathbf{m}_{t+1}, \mathbf{p}_{it+1}, h_{it+1}, n_{it+1}, X_{it+1}\right)\right]\}$$

subject to the budget constraint

$$\begin{aligned} \mathbf{a}_{it} &= \mathbf{m}_{it} - \mathbf{c}_{it} \\ \mathbf{a}_{it} + \mathbf{c}_{it} &= \mathbf{z}_{it} + (1 + r^a_t)\mathbf{a}_{it-1} \\ \mathbf{a}_{it} &\geq 0 \end{aligned}$$

where $\mathbf{m}_{it}$ denotes market resources to be expended on consumption or saved into government bonds. $\mathbf{c}_{it}$ is the level of consumption and $\mathbf{a}_{it}$ is the value of government bonds where the return is r^a_{t+1}. $\mathbf{m}_{it}$ is determined by labor income, $\mathbf{z}_{it}$, and the gross return on assets from the last period, $(1 + r^a_t)\mathbf{a}_{it-1}$. 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 ξ_{it}.

$$\mathbf{z}_{it} = \mathbf{p}_{it}\theta_{it}\xi_{it}h_{it}$$

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

$$\mathbf{p}_{it+1} = \mathbf{p}_{it}\psi_{it+1}$$

Both θ_{it} and ψ_{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 $E \rightarrow E$, 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

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

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 c_t. 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 $MC_t = \frac{c_t}{Z_t}$

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.

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

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 $X_{it} \in$ {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, Küster, and Nakajima (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, Straub, and Rognlie (2019), the tax rate adjusts to stabilize the debt to GDP ratio:

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

where ϕ_B governs the speed of adjustment.

2.6 Monetary Policy

The central bank follows the Taylor rule:

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

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, $\epsilon^m_t = \rho_v \epsilon^m_{t-1} + \varepsilon_t$ are innovations to the Taylor rule.

2.7 Equilibrium

An equilibrium in this economy is a sequence of:

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

- Prices $\left(r_t, r^a_{t+1}, i_t, q^b_t, w_t, c_t, \pi_t, \tau_t\right)^\infty_{t=0}$

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

Such that:

$(c_{it}(m))^\infty_{t=0}$ solves the household's maximization problem given $(w_t, \eta_t(X), r^a_t, \tau_t)^\infty_{t=0}$.

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 $C_t \equiv \int_0^1 \mathbf{p}_{it} c_{it} \, di$

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

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

3 Parameterizing the Model

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, Huckfeldt, and Trigari (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

[6]Note if profits were not held by firms then the goods market condition would be $C_t + G_t = Y_t$. In particular, since firm profits are $D_t = Y_t - w_t \int_0^1 h_{it} n_{it} \, di$, then the goods market condition would become $C_t + G_t = w_t \int_0^1 h_{it} n_{it} \, di + G_t + D_t. = Y_t$

2007 SCF and a quarterly MPC of 0.21. 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, Huckfeldt, and Trigari (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, Huckfeldt, and Swanson (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 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

[7] Gertler, Huckfeldt, and Trigari (2022) estimate the E to U probability of entering a permanent separation and a temporary layoff while Graves, Huckfeldt, and Swanson (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.

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 $\Delta_L = .1$ 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, Slacalek, Tokuoka, and White (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, Küster, and Nakajima (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, Slacalek, Tokuoka, and White (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, Violante, and Weidner (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 3 presents the estimated discount factors. [8].

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, den Haan, and Watson (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, Eichenbaum, and Trabandt (2016)[9]. The elasticity of substitution is set to 6. The price adjustment cost 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, Straub, and Rognlie (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].

[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 .74 to .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)

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

Description	Parameter	Value	Source/Target
CRRA	ρ	2	Standard
Real Interest Rate	r	$1.03^{.25}-1$	3% annualized real rate
Probability of Death	D	0.00625	40 Year Work Life
$\frac{\text{Liquid Wealth}}{\text{Quarterly Permanent Income}}$	$\frac{A}{\Phi}$	4.407	2007 SCF
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, Moll, Violante (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	$\frac{\text{HH income w. UI}}{\text{pre job loss income}} = .76$
Non UI income parameter 2	ω_2	0.294	$\frac{\text{HH income w.o. UI}}{\text{pre job loss income}} = .55$
Gov. transfers	T_s	0.091	$\frac{\text{SNAPS and Soc. Security Inc}}{\text{Pre Job Loss Income}} = .13$
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 1 Household Calibration

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, Huckfeldt, and Trigari (2022)
Job Finding Prob. of temp. layoff	$\eta_t(T)$	0.82	Gertler, Huckfeldt, and Trigari (2022)
Job Finding Prob. of quit/other	$\eta_t(O)$	0.51	Gertler, Huckfeldt, and Trigari (2022)
Prob. of perm. layoff in steady state	λ^P_{ss}	0.35	35% of EU from perm. layoffs
Prob. of temp. layoff in steady state	λ^T_{ss}	0.31	31% of EU from temp. layoffs
Prob. of quit/other in steady state	λ^O_{ss}	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 2 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, den Haan, and Watson (2000)
Matching Elasticity	α	0.65	Ravn and Sterk (2017)
Real Wage Rigidity parameter	ϕ_w	0.837	Gornemann, Küster, and Nakajima (2021)
Vacancy Cost	κ	0.056	$\frac{\kappa}{w\phi} = .071$
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, Straub, and Rognlie (2019)

Table 3 Rest of Economy Calibration

Discount Factors		
.937	.964	.991

Table 4 Discount factor estimates

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.

[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.

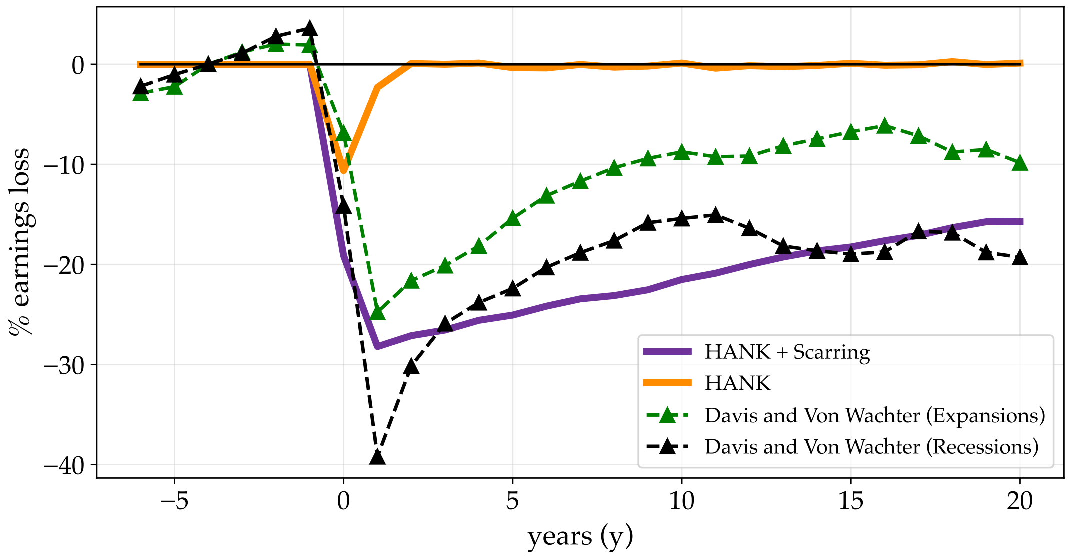

Figure 2 Earnings loss following job loss in $y = 0$: Model vs Data

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.

5 Consumption Response to an Increase in Unemployment

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.

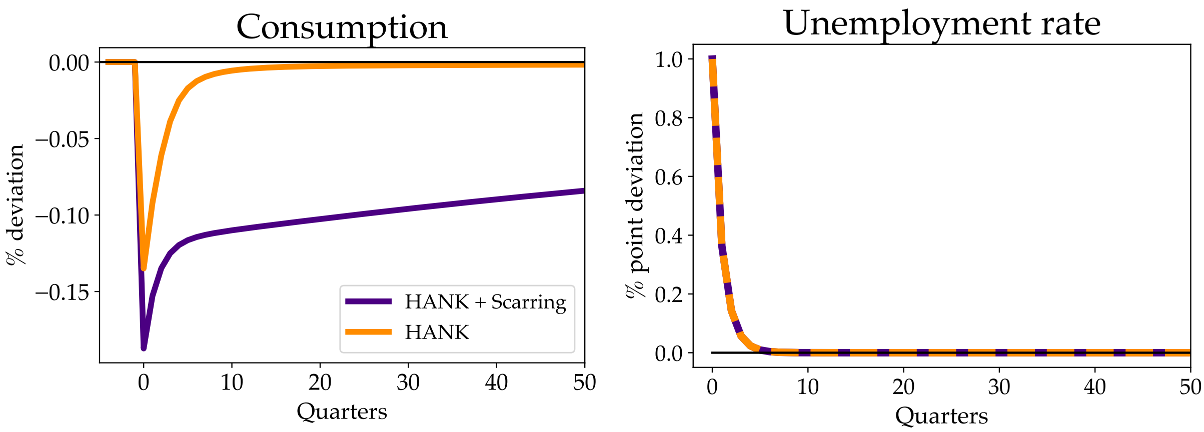

Figure 3 Consumption response to a transitory increase in the unemployment rate

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 to consumption, output, debt, and 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.

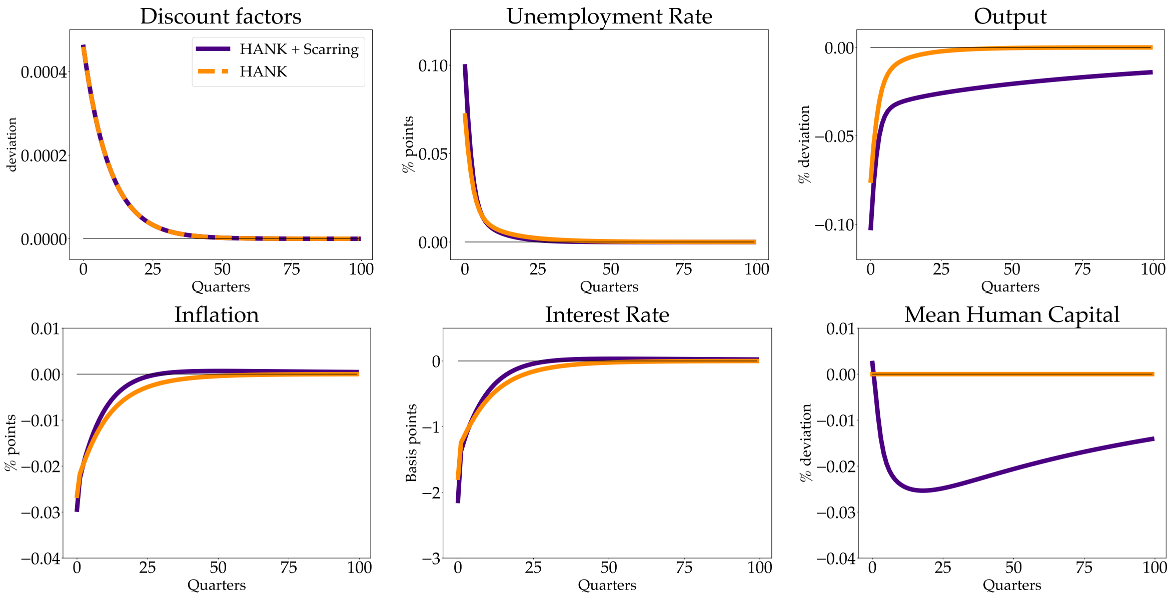

Figure 4 Impulse responses to a negative demand shock

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.

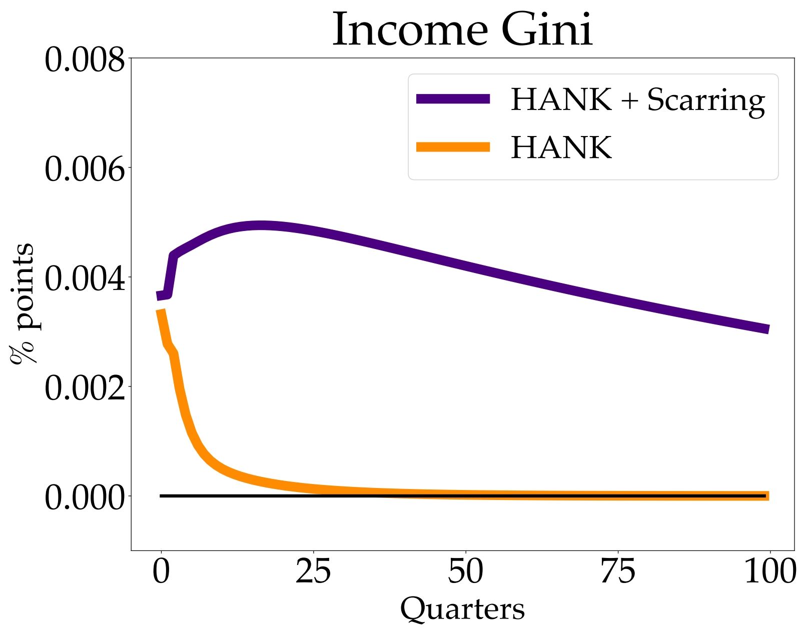

Figure 5 Response of income Gini index to negative demand shock.

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.

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

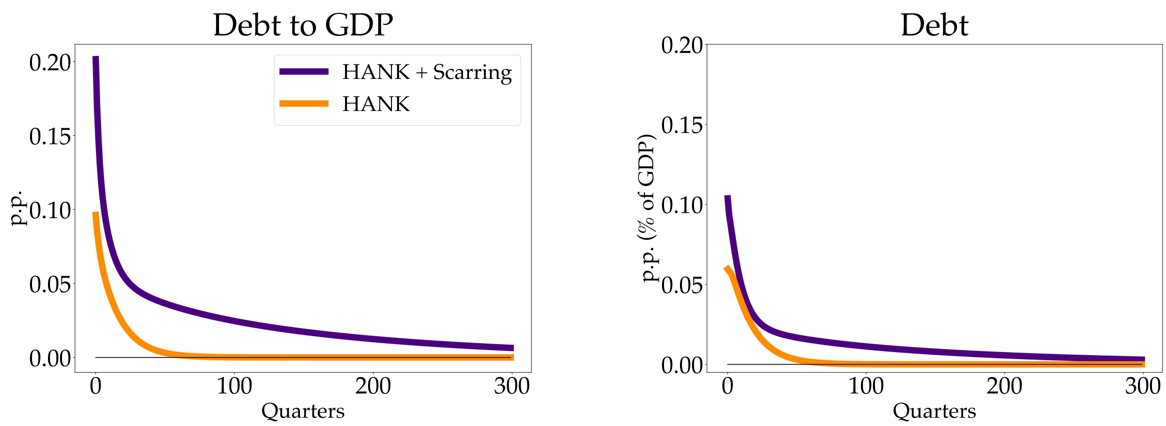

Figure 6 Responses of debt and debt to GDP to negative demand shock

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

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 to persist long after the government spending shock recovers.

7.2 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. In this section, I show that fiscal consolidation is substantially less effective at decreasing debt to GDP in a model that is calibrated to the 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 8 plots responses of relevant variables to

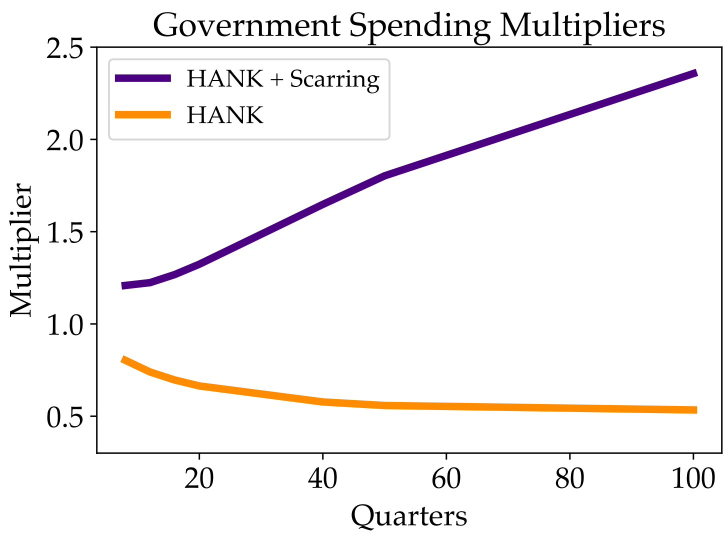

Figure 7 Fiscal Multipliers to a negative government spending shock.

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: $\frac{\Sigma_{t=0}^{20} \frac{1}{R^t} \Delta Y_t}{\Sigma_{t=0}^{20} \frac{1}{R^t} \Delta G_t}$.

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.

8 Simulating The Great Recession

8.1 Model vs Data

This section demonstrates that unemployment scarring can reconcile the sluggish recovery from The Great Recession. To illustrate this, I simulate The Great Recession by estimating a sequence of negative demand shocks to match the unemployment rate during this period. I then compare the untargeted paths of consumption, output, and

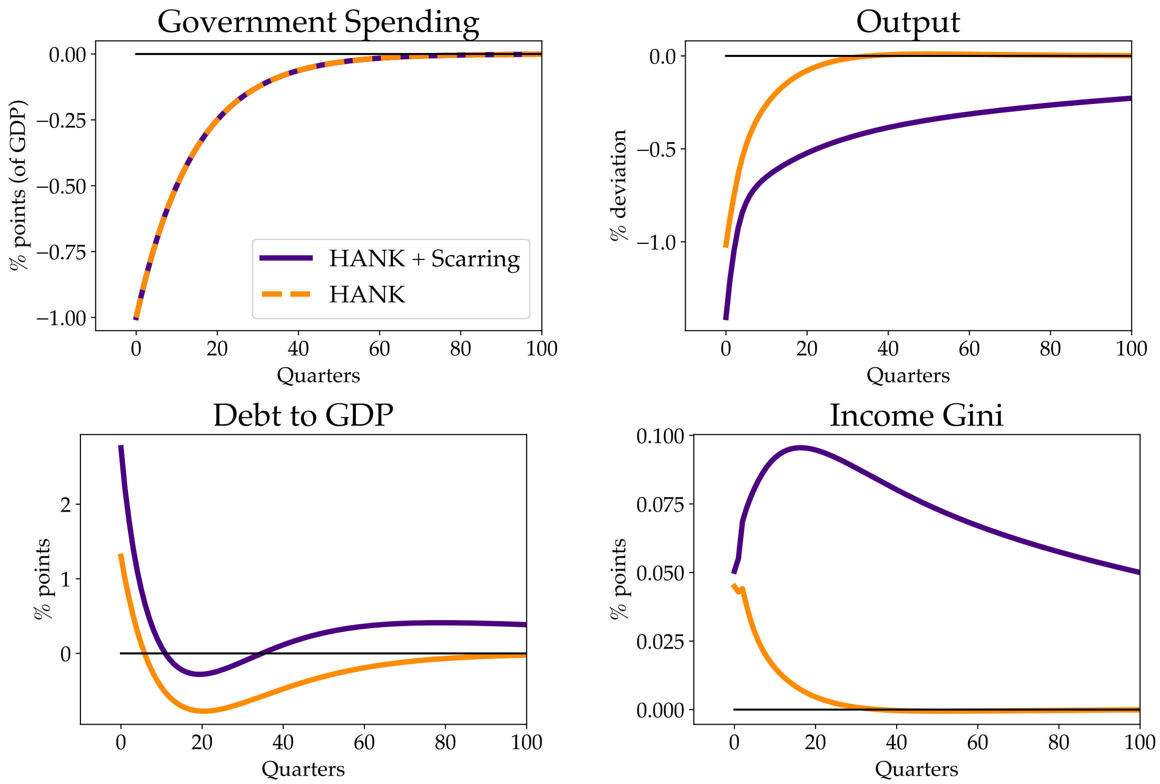

Figure 8 Responses to a negative government spending shock

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

labor compensation 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.

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].

[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.

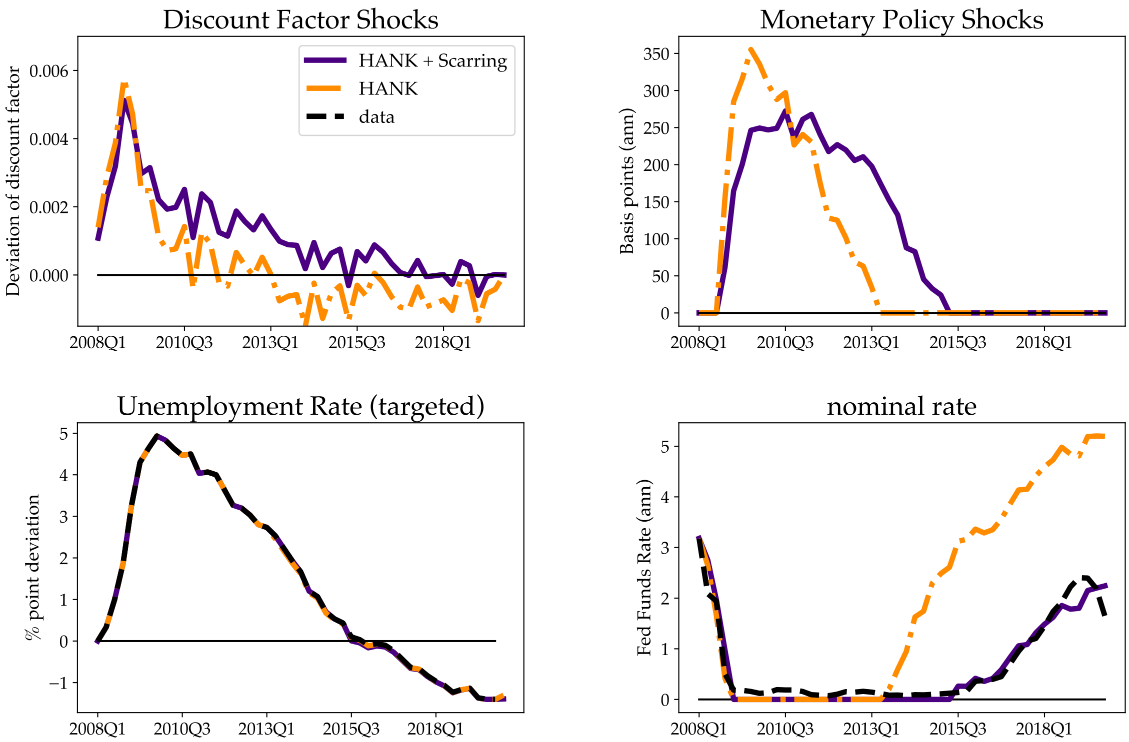

Figure 9 Estimated shocks to discount factor and nominal rate

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, Straub, and Rognlie (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 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 plots the estimated shocks, the unemployment rate, and the nominal rate against the data under the baseline model and the model without scarring. Figure 10 plots the key aggregate variables against their detrended observed counterpart in the data and 11 plots the model responses against the data without detrending. Only the unemployment rate and price index are targeted. Overall, unemployment 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 12 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.

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 13 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.

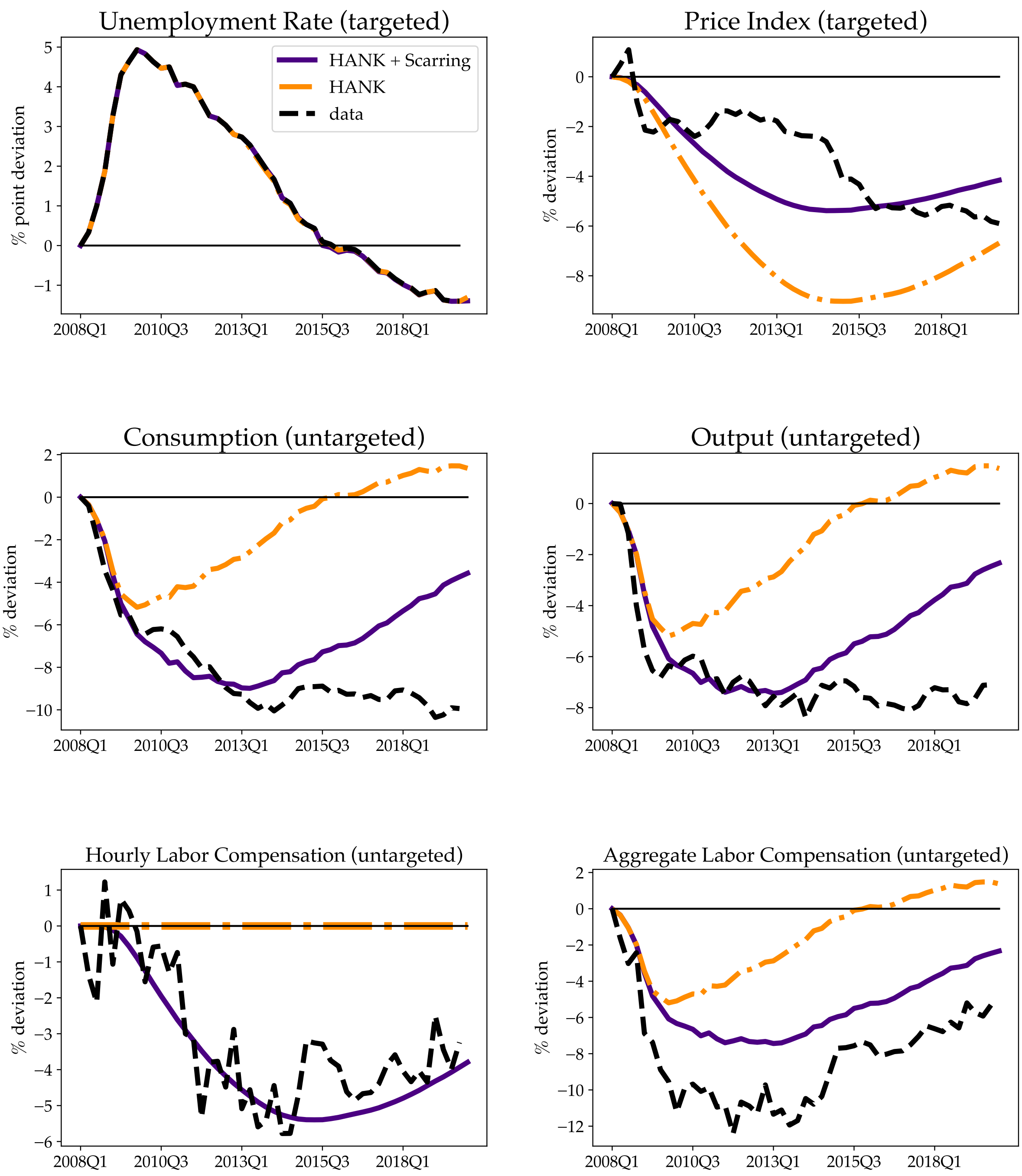

Figure 10 Great Recession: Model vs Data (detrended)

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.

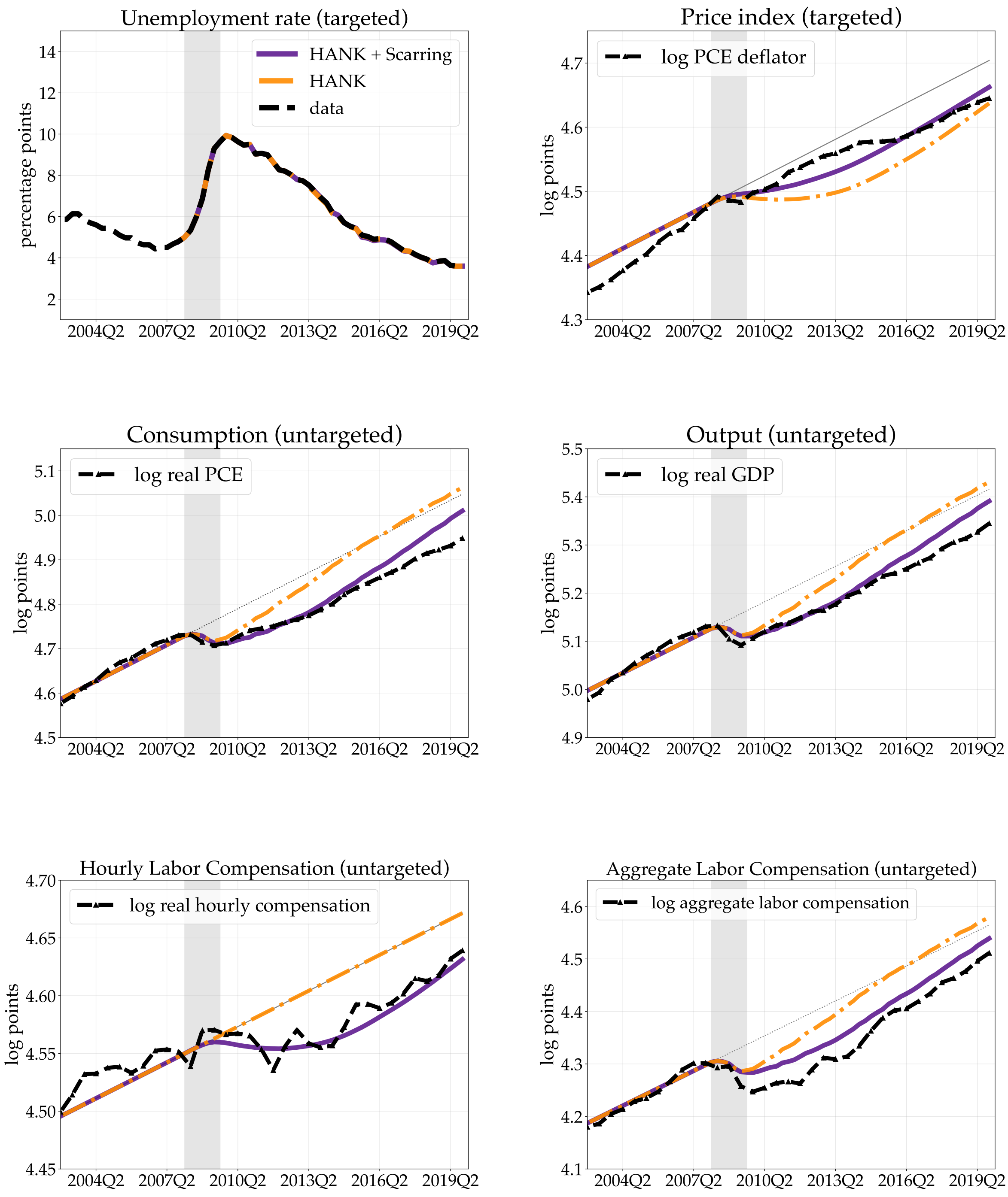

Figure 11 Great Recession: Model vs Data (with trend)

Note: This figure plots the responses from figure 10 with the trend.

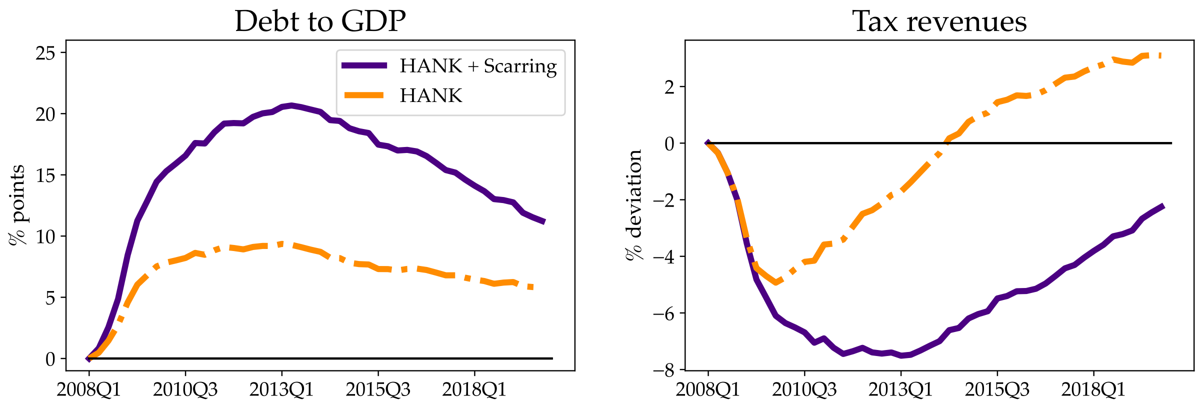

Figure 12 The response of debt to GDP and tax revenues

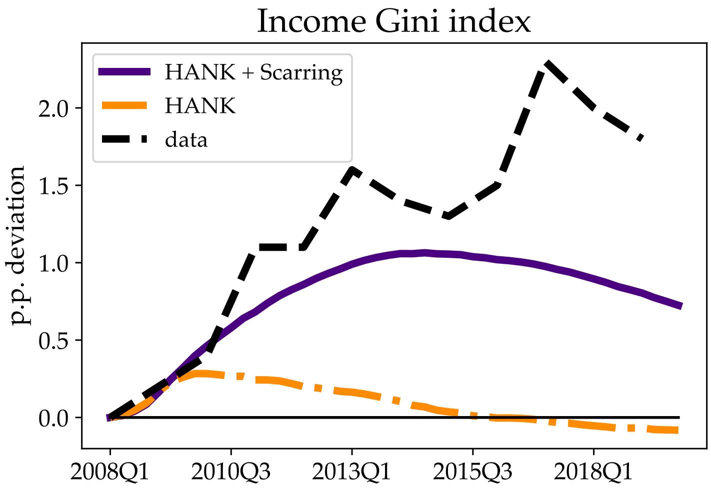

Figure 13 Gini Coefficient: Model vs Data

9 The COVID Recession

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 97.7% of the increase in the unemployment rate was attributed to temporary layoffs (Gertler, Huckfeldt, and Trigari, 2022). In this section, I show that it is the absence of scarring that explains the quick recovery of consumption and output during the COVID recession. 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]. At best, the model can attribute 78.5% of an increase in the unemployment rate to temporary layoffs. Figure 25 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 the Return to Trend

During the COVID Recession, temporary layoffs played a key role in allowing GDP to return to its pre-2020 trend. To demonstrate 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 15 compares the path of output under the original calibration (from section 9.1) with the counterfactual scenario with a large mass of permanent layoffs. In both cases, the path of unemployment remains identical and instead only differ in the composition of the unemployment rate. The figure 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 initial drop in GDP — the percentage deviation of the counterfactual from the trend reaches 2 % by the second quarter of

[13] Gertler, Huckfeldt, and Trigari (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.

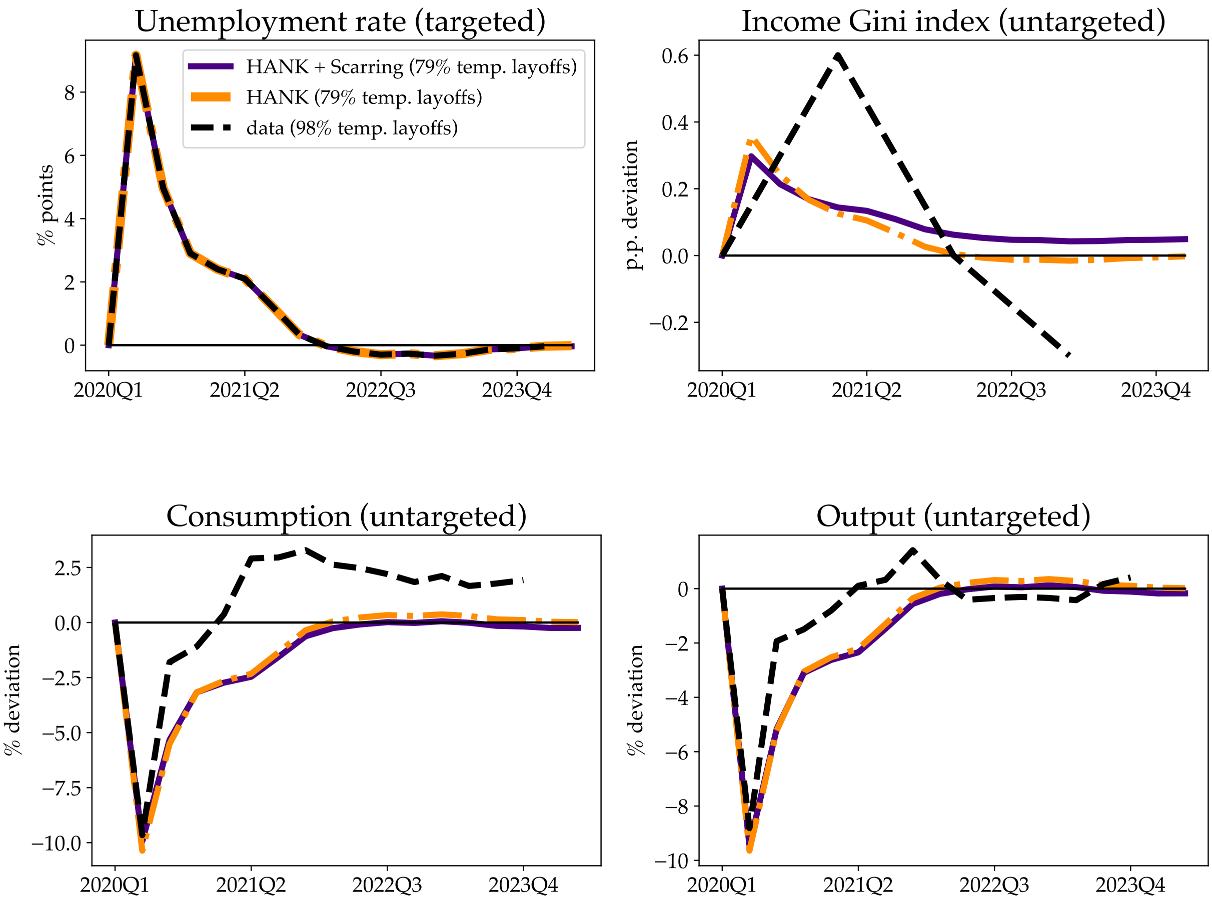

Figure 14 Model vs data: The COVID Recession

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.

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 measures 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.

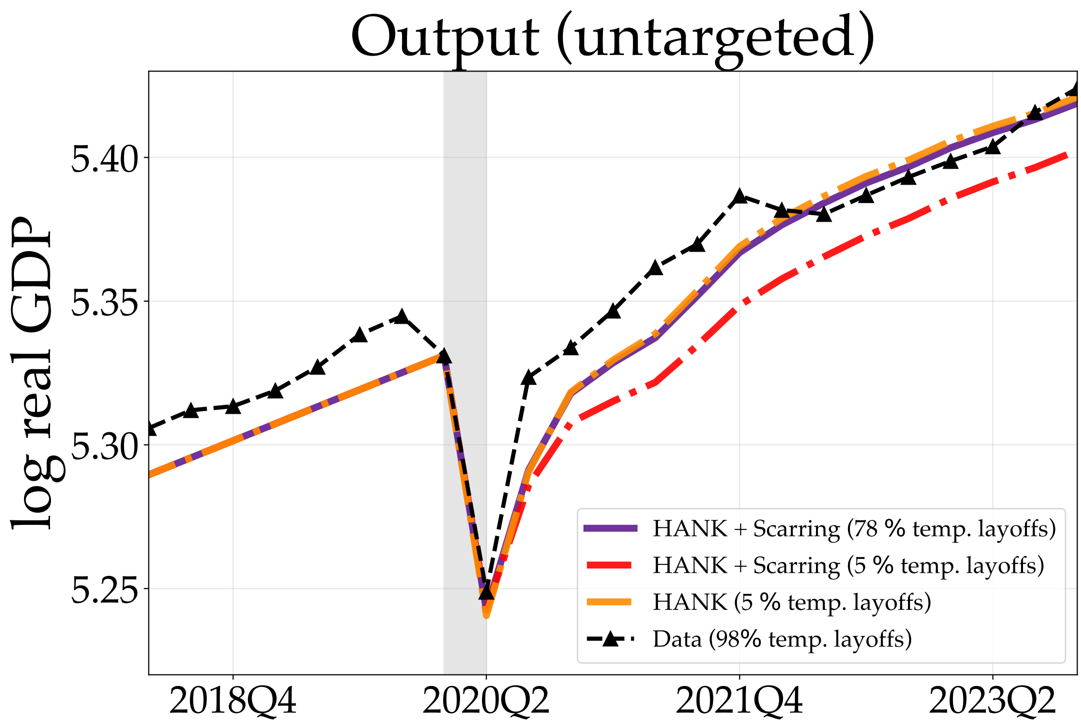

Figure 15 Counterfactual: What if permanent layoffs captured the rise in unemployment during the pandemic?

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, Proebsting, and Tesar, 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

[15] Bertheau, Acabbi, Barceló, Gulyas, Lombardi, and Saggio (2023)

the US economy had it engaged in similar austerity measures. I augment the simulation in the previous section by simulating a counterfactual 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

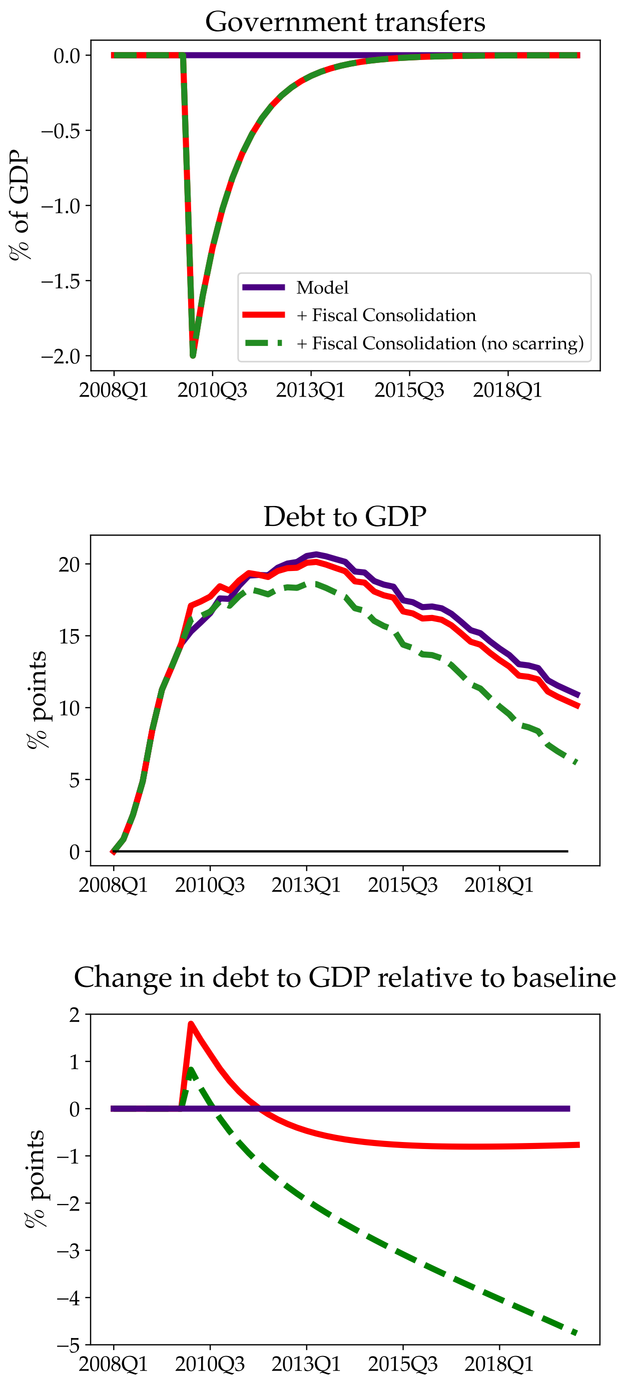

Figure 16 Counterfactual: Fiscal Consolidation in the US

Note: This exercise plots the simulated paths of of macro aggregates during the Great Recession from figure 10 with a fiscal consolidation shock that begins in 2010Q1 under the baseline model and the model without scarring.

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 evaluates 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 determines the speed of 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 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 the rise in unemployment during the COVID Recession been attributed to permanent layoffs, then the recovery of GDP would not have returned to its pre-2020 trend.

In addition, the transmission of fiscal austerity changes considerably in the presence of these scars. Given a reduction in government spending, scarring erodes future tax revenues, increasing pressure on the fiscal deficit. Quantitatively, the decline in debt to GDP from a consolidation if four times smaller because of unemployment scarring and leads to a near permanent rise in income inequality as scarring increases the dispersion in wages.

There are many future avenues of research on the role of unemployment scarring for business cycle dynamics and macroeconomic policy. To begin, the root cause of these scars are still being understood. An evaluation that incorporates the origins of this microeconomic phenomenon would provide a clearer sense of how policy can be designed to mitigate scarring. Furthermore, unemployment scarring as a driver of sluggish recoveries motivates future research on job retention schemes as those pursued in Europe during the COVID recession. As noted in Lachowska, Mas, and Woodbury (2020) and Jacobson, LaLonde, and Sullivan (1993), "something intrinsic to the employment relationship itself... is lost when workers are displaced.". Job retention policies may provide the best hedge from scarring because finding a good match with an employer is just so difficult. I leave these interesting questions to future research.

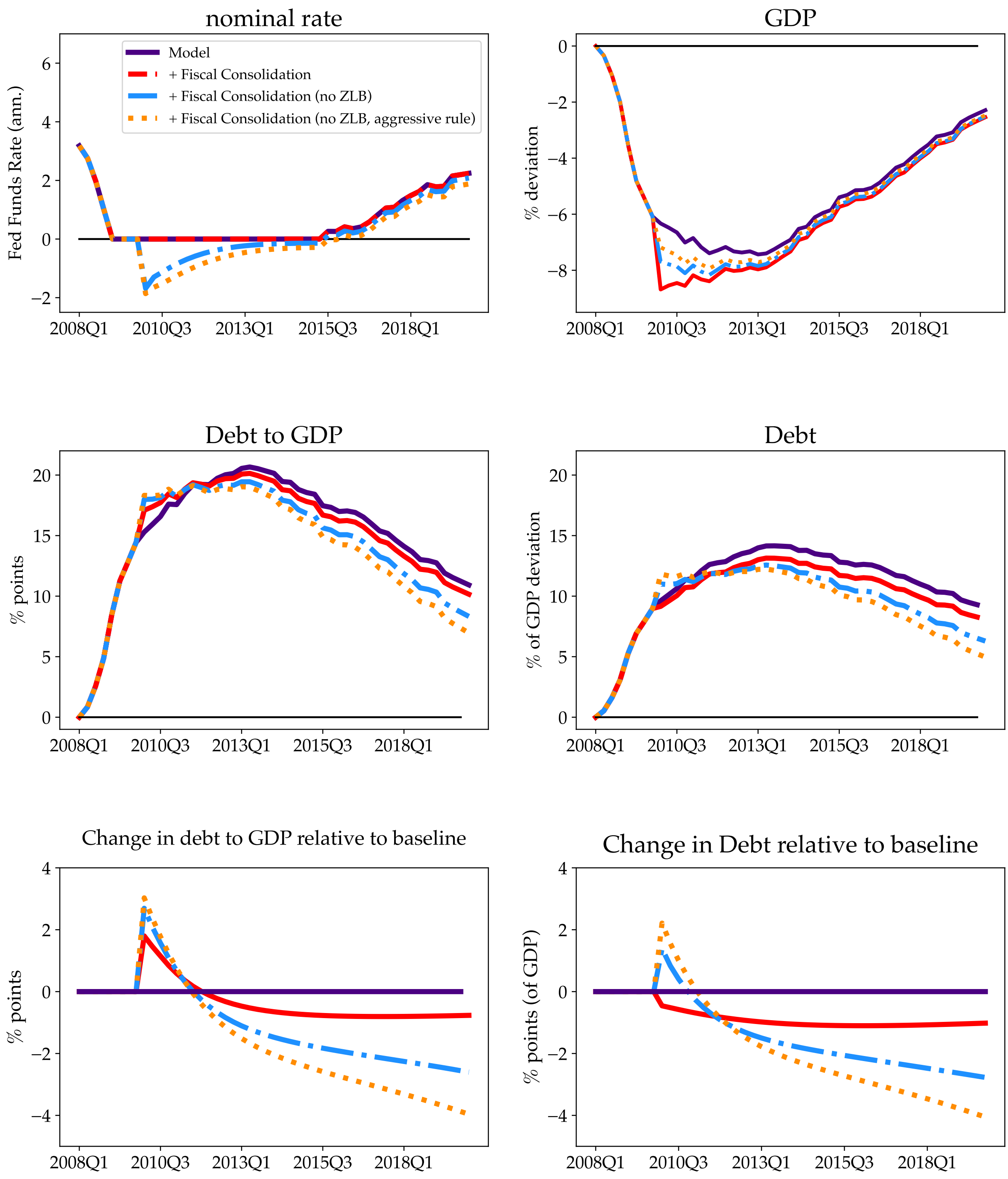

Figure 17 Counterfactual: Fiscal Consolidation in the US and the effects of the zero lower bound

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A 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, Huckfeldt, and Trigari (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 **??** 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.

A.2 The 1990-1991 Recession

According to the model, scarring plays an important role in explaining the recovery from the 1990s recession. Figure **??** 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

[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.

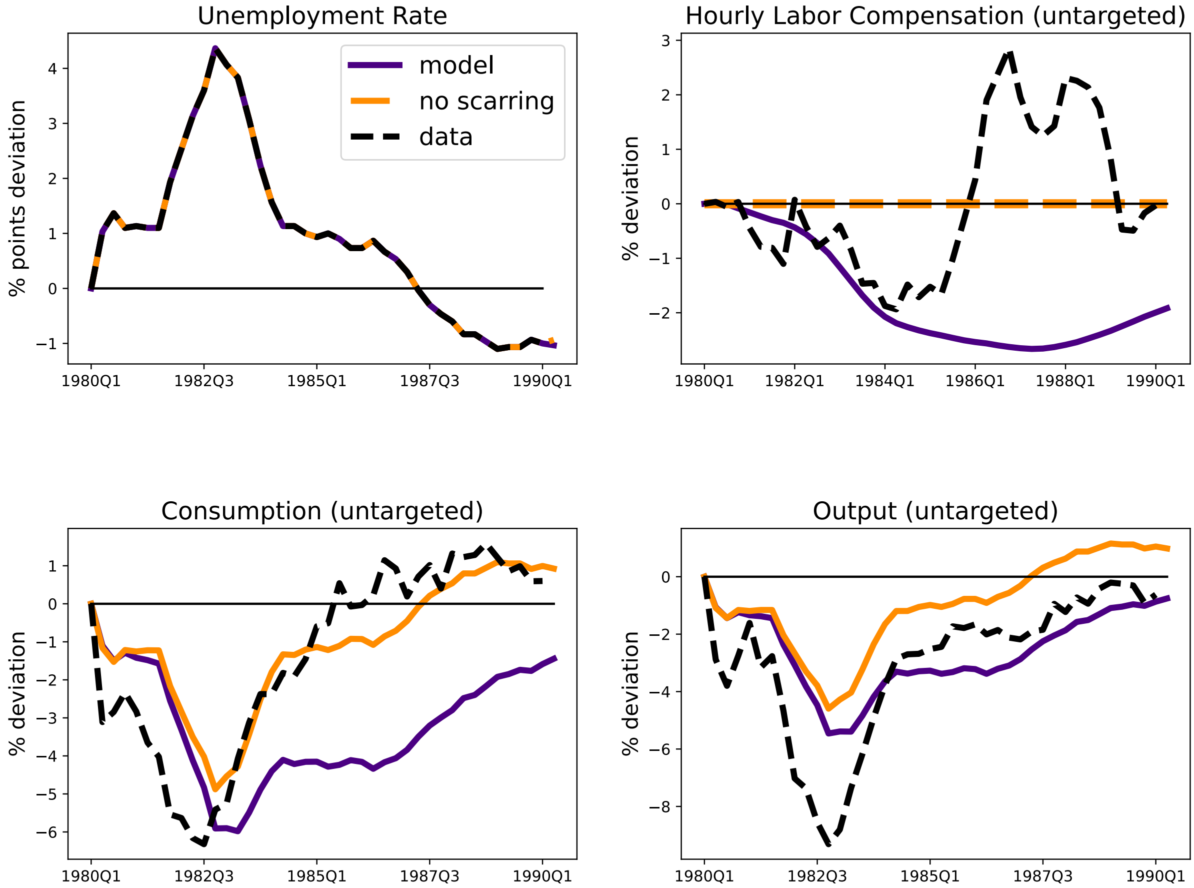


Figure 18 Model vs data: 1980s

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.

A.3 The 2001 Recession

Similar to the 1990-1991 recession, scarring can help explain the recovery from the 2001 recession. Figure **??** 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.

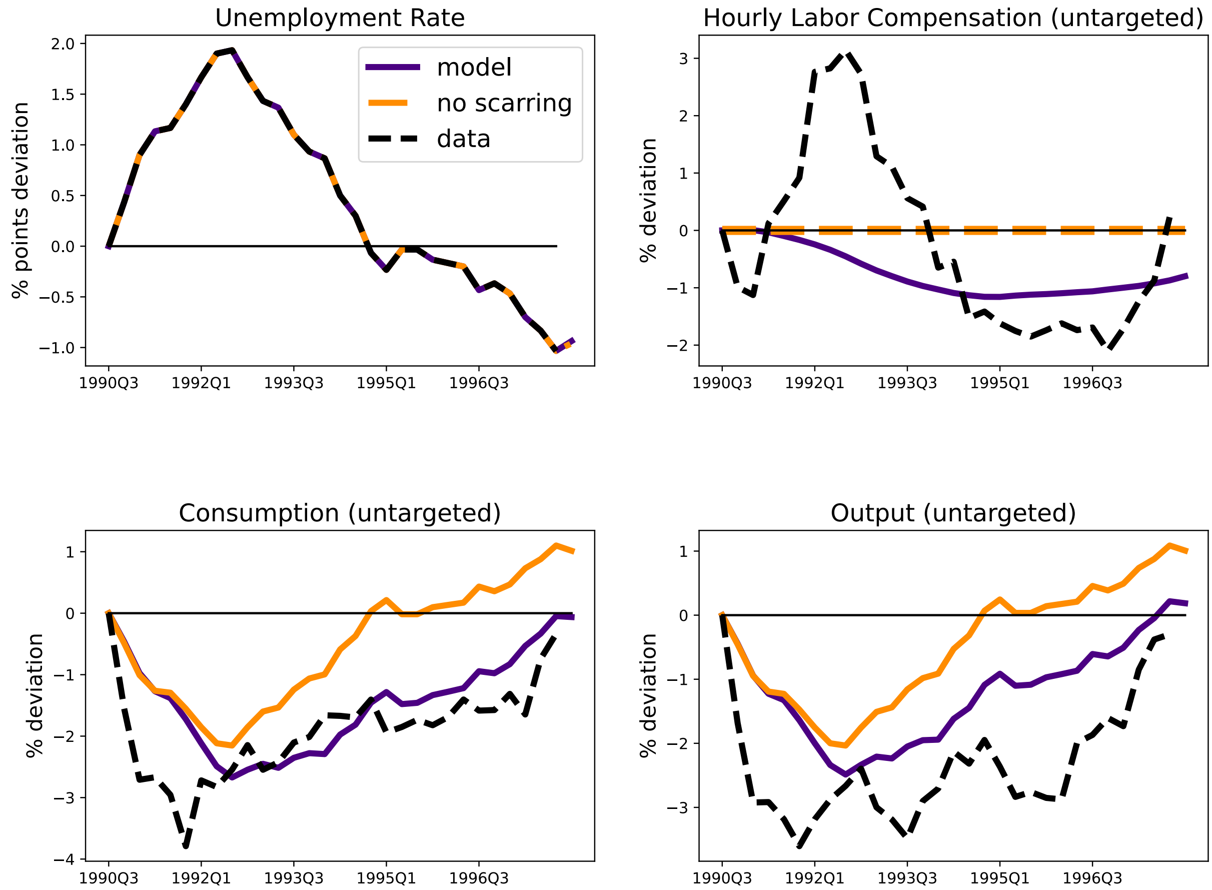


Figure 19 Model vs data: 1990-1991 recession

B Monetary Policy and Unemployment Scarring

This section illustrates that monetary policy has persistent effects on output, aggregate labor productivity, and income inequality in the presence of unemployment scarring. Figure 21 plots the impulse responses to a 25 basis point shock to the Taylor rule and shows that monetary policy induces persistent responses in output, mean human capital, and the Gini index for income. For this exercise, I augment the Taylor rule such that it is inertial:

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

where the inertial parameter ϕ_{ev} is calibrated to 0.8. These impulse responses are consistent with Jorda, Taylor, and Singh (2023), who document that monetary contractions has permanent effects on output without induces a persistent effect on

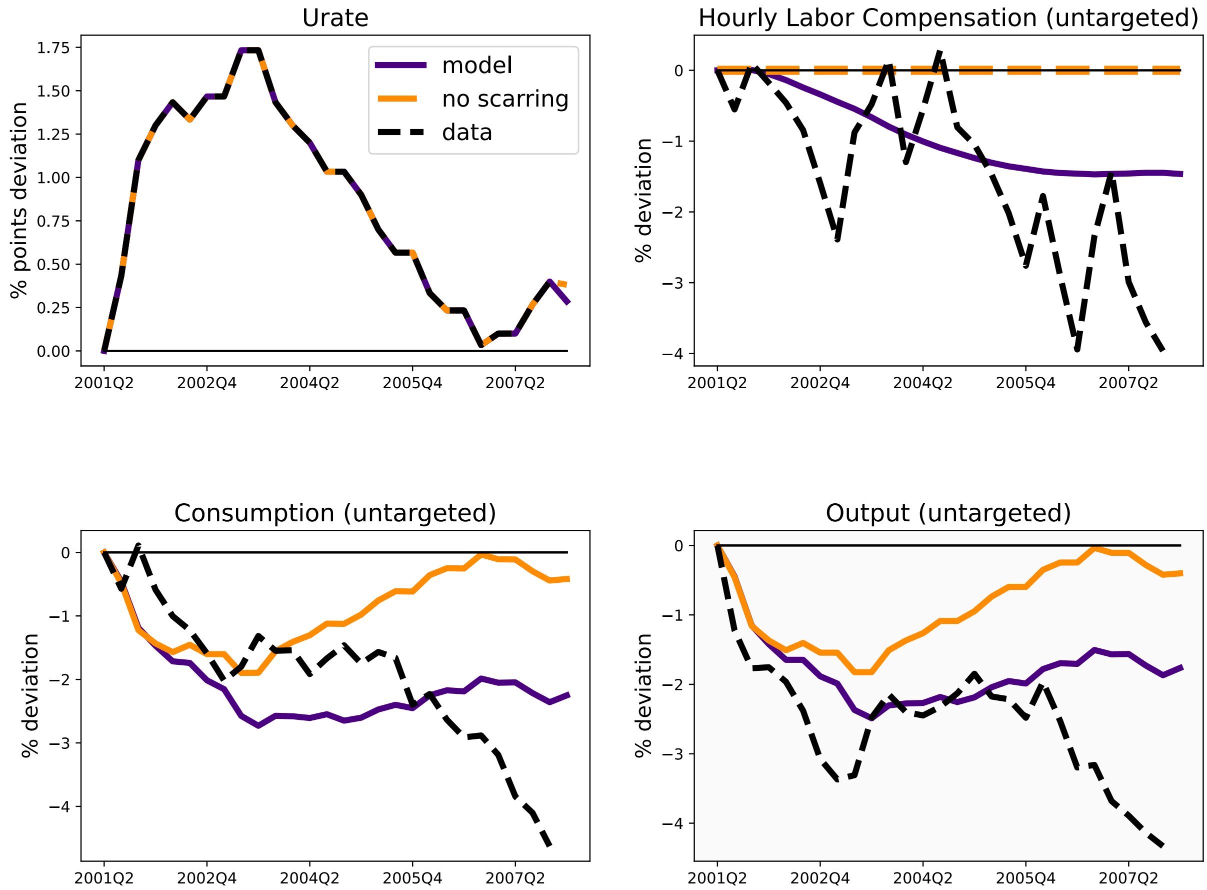


Figure 20 Model vs data: 2000s

unemployment or labor hours. The key insight is that unemployment scarring affects the firm specific human capital of a worker. Therefore, unemployment scarring does not lead to a prolonged rise in the unemployment rate. Overall, unemployment scarring can provide an alternative rationale for the results in Jorda, Taylor, and Singh (2023).

C 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 22 (baseline calibra-

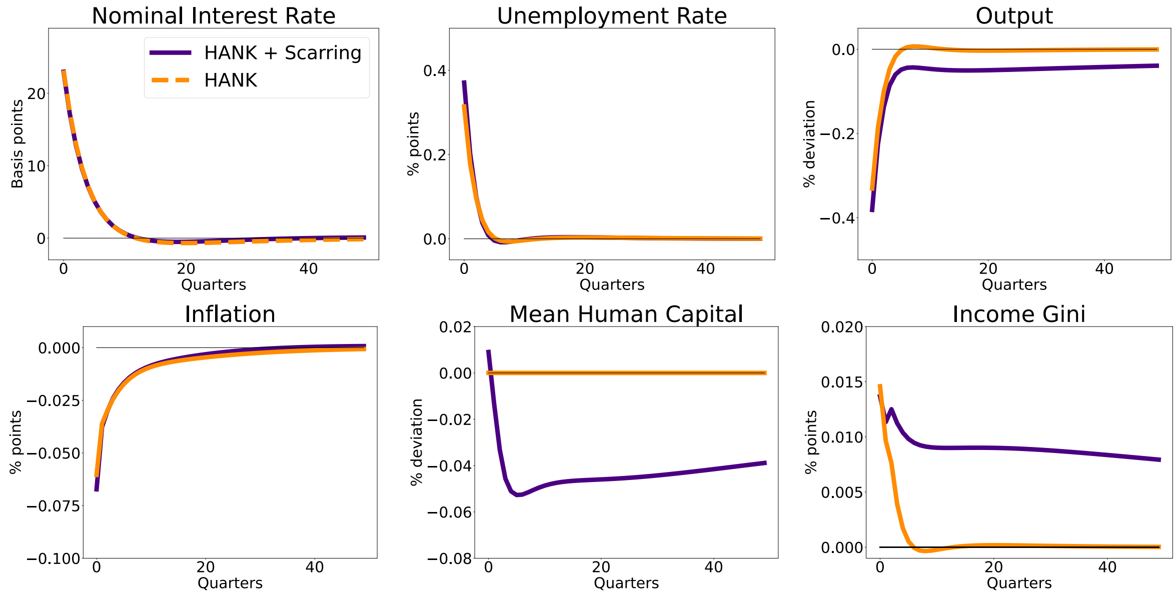


Figure 21 Impulse responses to a monetary policy shock

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)

tion) and figure 23 (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,

D 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 9 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 24 plots the responses of consumption and output when either shock process is estimated to match the unemployment rate during the Great Recession.

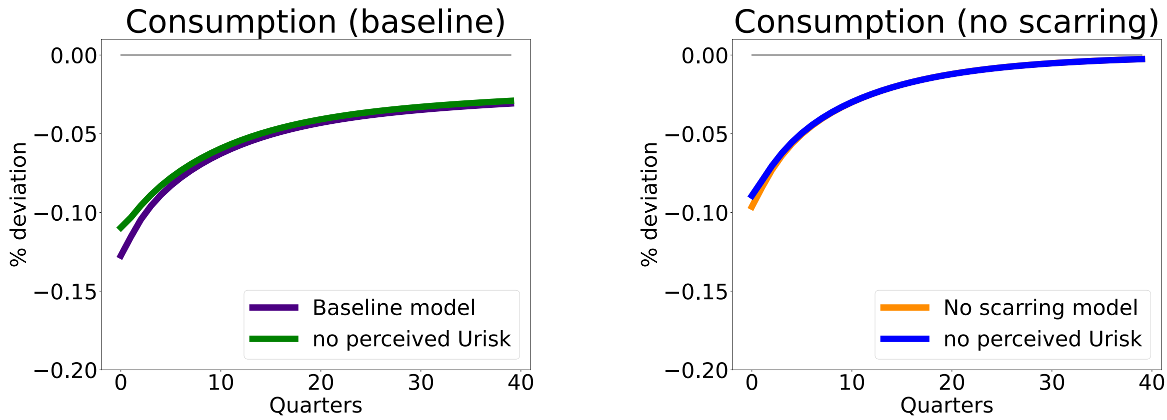


Figure 22 Responses of Consumption to demand shock with and without perceived unemployment risk.

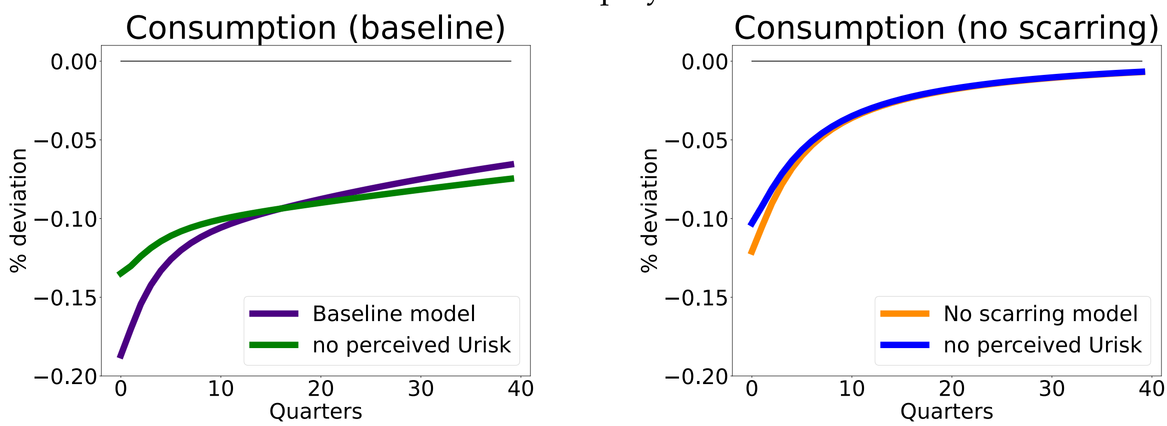


Figure 23 Responses of Consumption to demand shock under a fixed real wage with and without perceived unemployment risk.

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.

E Overview of the Model

F COVID Recession Counterfactual

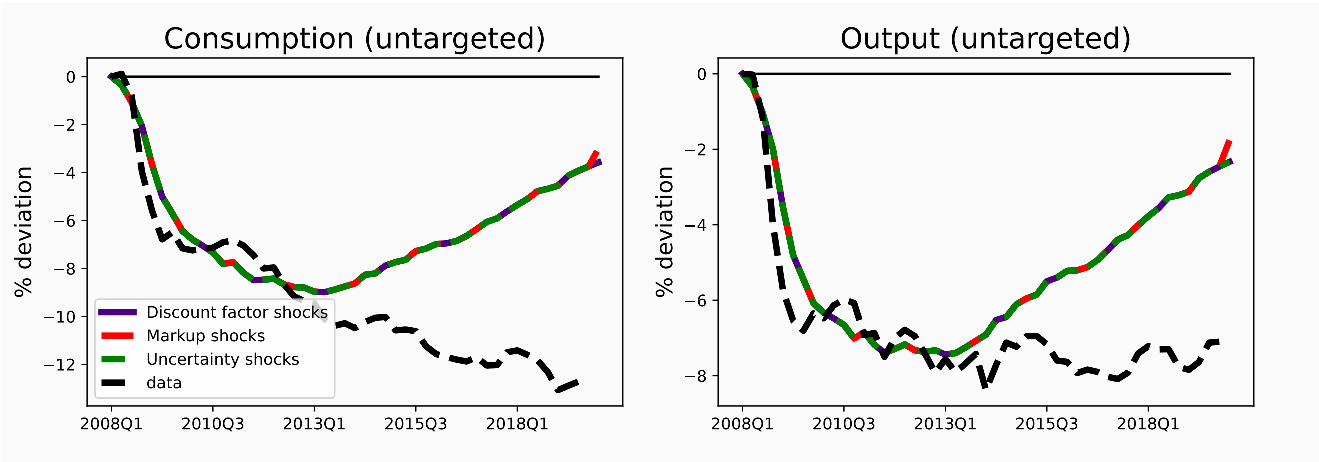
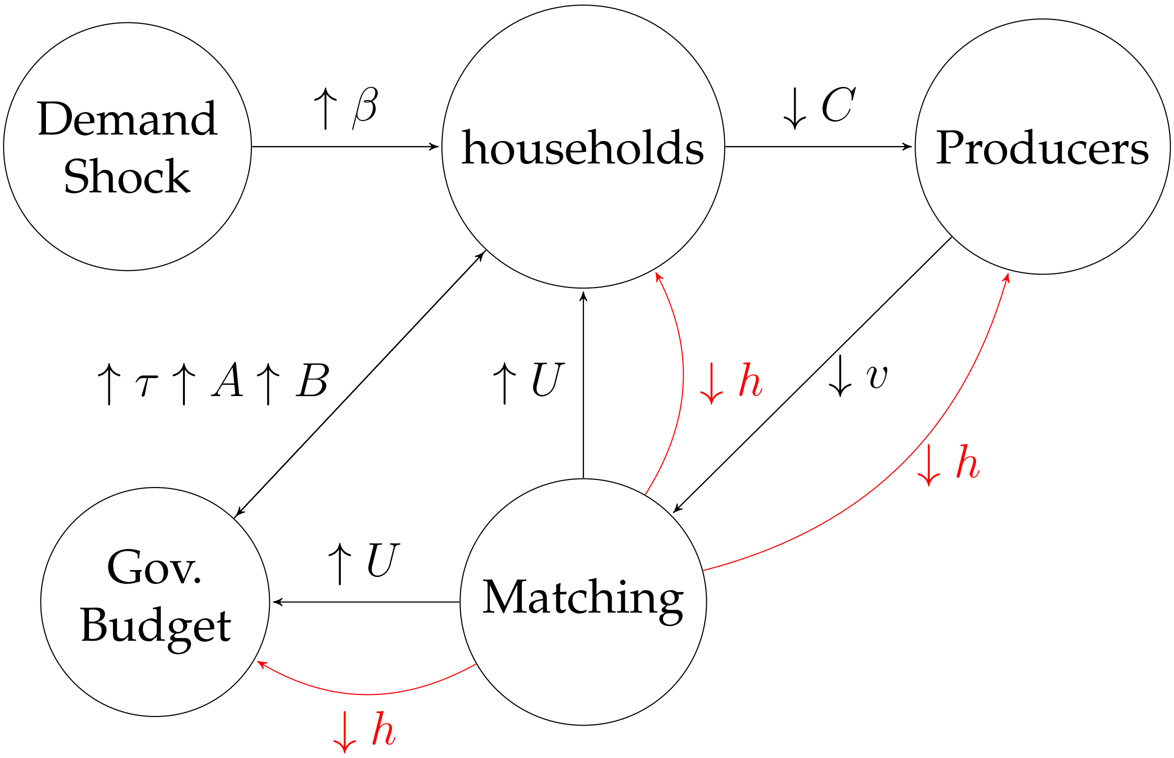


Figure 24 Simulation of Great Recession Using different shocks.



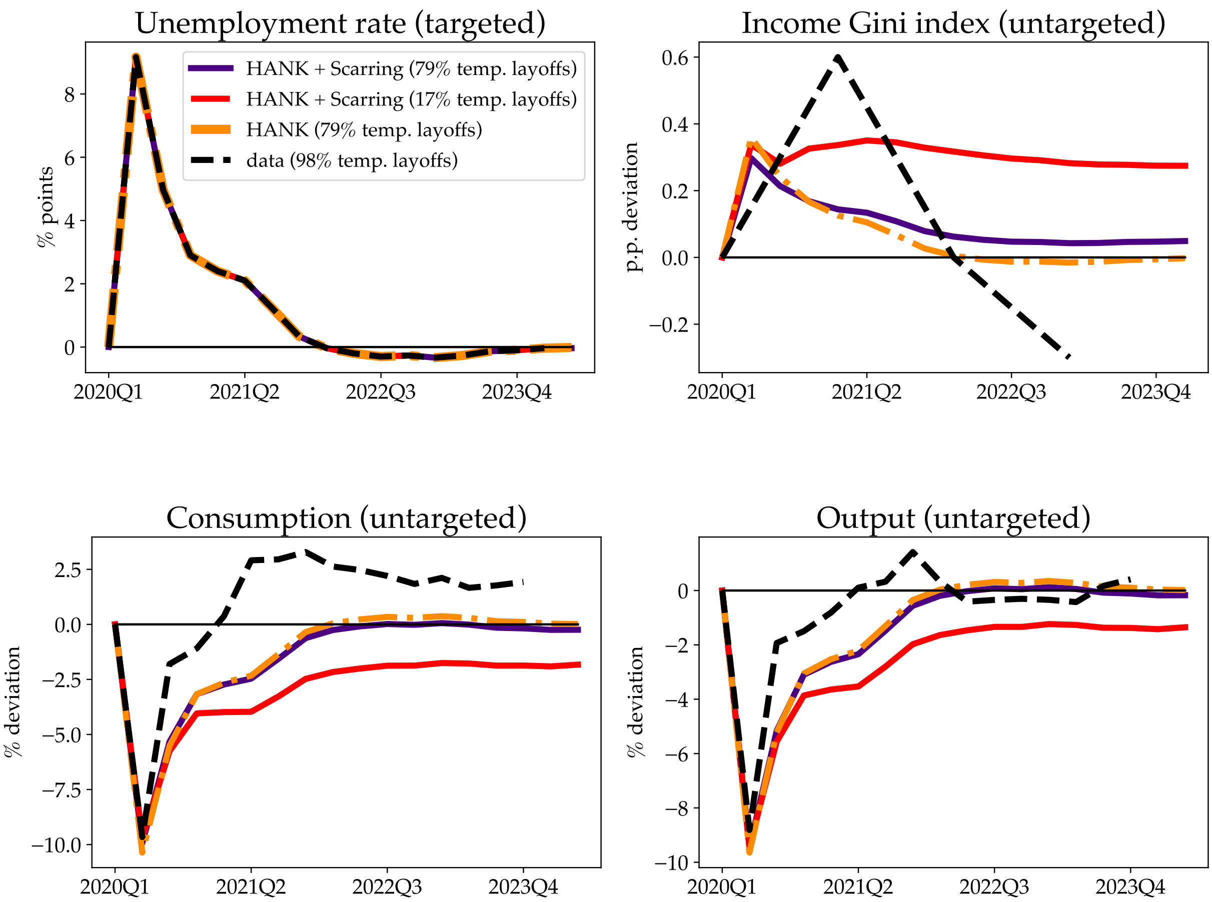


Figure 25 Model vs data: The COVID Recession

Note: In this exercise, the effects unemployment scarring are eliminate because 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.