The Macroeconomic Consequences of Unemployment Scarring

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Abstract

Unemployment leaves scars in earnings that remain after 10 years. This paper evaluates the macroeconomic consequences of these scars. I build a heterogeneous agent New Keynesian model with labor market frictions and human capital dynamics that is calibrated to match the microeconomic evidence on persistent earnings loss following job displacement. Unemployment scarring offers an alternative explanation for macroeconomic hysteresis and increases the pressure that recessions place on the fiscal deficit. Contractionary fiscal multipliers are significantly larger and fiscal consolidation is self defeating as it raises debt while contracting GDP. When estimating the model to replicate the path of unemployment from the beginning of The Great Recession until 2019, the model successfully matches the sluggish recovery of GDP, consumption, and hourly labor compensation from The Great Recession. Without scarring, The Great Recession would have exhibited a 'V' shaped recovery where GDP returns to its pre-recessionary trend by 2015. In a counterfactual simulation, had the US pursued a fiscal consolidation equivalent to 2% of GDP, debt to GDP would have permanently risen by 1.3%.

Keywords Macroeconomics, Unemployment Scarring, Heterogeneous Agents, Fiscal Policy

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1 Introduction

Since the seminal work of Jacobson, LaLonde, and Sullivan (1993), job displacement from stable employment is understood to cause large and persistent earnings losses[1]. These long term earnings losses are on average 10 to 15% after 10 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 find reemployment in lower paying occupations (Huckfeldt, 2022)[2] . While a growing *microeconomic* literature seeks to explain the origins of these 'scars', few *macroeconomic* papers examine the impact of unemployment scarring on business cycle dynamics and fiscal policy. This paper bridges this gap by evaluating the macroeconomic consequences of this microeconomic phenomenon. In particular, I demonstrate that accounting for the microeconomic evidence on unemployment scarring in a macroeconomic framework provides an alternative micro foundation for hysteresis, a quantitative rationale for why fiscal consolidations can fail, and a reconciliation for the sluggish recovery from The Great Recession.

To quantify the macroeconomic role of unemployment scarring, I build a heterogeneous agent New Keynesian (HANK) model with search and matching frictions augmented with human capital dynamics to capture scars in earnings. To account for the empirical fact that only those who are permanently layoffs suffer from scarring[3] [4], the model differentiates unemployment between permanent layoffs, temporary layoffs, and other types of unemployment. During a permanent layoff, human capital erodes leading to a lower wage upon reemployment. In aggregate, an increase in the unemployment rate leads to a persistent decline in labor productivity. I calibrate the model to match the estimates of earnings loss following job displacement in Davis and Wachter (2011) and show that these microeconomic scars that follow job displacement lead to macroeconomic hysteresis in output, consumption, and labor income without a prolonged increase in the unemployment rate. Persistent losses in income translate to tax revenues, which in turn necessitate a larger in increase in debt to sustain government expenditures. As a result, unemployment scarring increases the pressure that recessions place on the fiscal deficit.

The transmission of fiscal policy differs significantly in the presence of unemployment scarring. Contractionary fiscal multipliers are 0.4 to 1 dollar larger per dollar spent by the government from persistent losses in output that stem from lost labor productivity. Furthermore, persistent losses in tax revenues that arise from scarring

[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 **?** 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. 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.

are severe enough to raise debt in response to a negative government spending shock. This increase in debt combined with larger fiscal multipliers lead to self defeating fiscal consolidation.

To confront the model to data, I estimate the model to match the path of unemployment from the beginning of The Great Recession until the COVID Pandemic and compare the model's untargeted simulated paths of output, consumption, and hourly labor compensation against the data. The model successfully matches the path of consumption and output from 2008 to 2015 while accounting for the path of hourly labor compensation for the whole sample period. The model attributes 10% of the rise in debt to GDP during this period to human capital losses from unemployment scarring. Half of this increase in debt to GDP is attributed to increased debt from losses in tax revenues while the other half stems from losses in GDP. Without unemployment scarring, the model can only account for the first year of the sluggish recovery from The Great Recession, a symptom of any model that cannot generate hysteresis in income without a persistent response in unemployment. Further, in the absence of unemployment scarring, consumption and GDP recover to its pre-recessionary trend by 2015 and exhibit a 'V' shaped response.

Finally, I simulate a counterfactual where the US engages in fiscal consolidation equivalent to 2% of GDP that begins in 2010. This fiscal policy is captured by adding negative spending shocks to the estimated demand and monetary policy shocks used to replicate the path of unemployment during The Great Recession. In response to this shock, debt to GDP permanently rises by 1.3% and debt rises by 0.7%. Without human capital losses from unemployment scarring, debt to GDP and debt would have fallen by 2%.

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

The first is the theoretical literature on hysteresis that largely emphasizes endogenous innovation and R&D as potential mechanisms in explaining hysteresis (Comin and Gertler, 2006; Moran and Queralto, 2018; Bianchi, Kung, and Morales, 2019). Although this literature has long discussed unemployment scarring as a potential mechanism for the sluggish recovery in macroeconomic aggregates following recessions (Cerra, Fatás, and Saxena, 2023), this paper formalizes this discussion by quantifying the effects of unemployment scarring in macroeconomic model that matches the microeconomic evidence on unemployment scarring.

This paper also contributes to the literature on heterogeneous agent New Keynesian (HANK) models with search and matching (SAM) frictions. This literature emphasizes the interaction between nominal rigidities, search and matching frictions, and incomplete markets to generate counter-cyclical unemployment risk, and thus countercyclical precautionary saving, that amplify changes in aggregate demand (McKay and Reis, 2016; Ravn and Sterk, 2017; Den Haan, Rendahl, and Riegler, 2018). I contribute to this literature by augmenting a HANK and SAM model with human capital dynamics to evaluate the implications of unemployment scarring.

Finally, this paper is most closely related to the small but emerging literature on the implications of unemployment scarring on business cycle fluctuations and macroeconomic policy. Most closely related to this paper is the work of Alves and Violante (2023) and Alves (2022). Alves and Violante (2023) investigate the implications of unemployment scarring in the transmission of monetary policy while 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 sluggish recovery from The Great Recession.

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 9 concludes.

2 The Model

I present an 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 $\gamma(X)$ 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 model is illustrated in figure 1

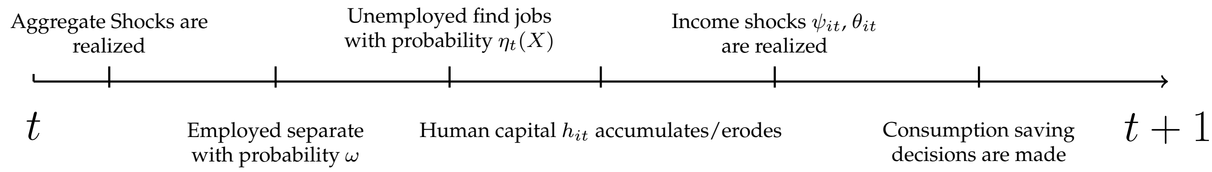

Figure 1 Timing of model

The Bellman problem is:

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

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 raise the 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

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

The first order condition leads to demand for good j

$$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\epsilon_p} Y_t \tag{1}$$

and the price index

$$P_t = \left(\int_0^1 P_{jt}^{1-\epsilon_p} \, dj \right)^{\frac{1}{1-\epsilon_p}} \tag{2}$$

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 firm hires labor L_t from a labor agency at cost c_t. Given the cost of labor, each firm 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.

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

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 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 a household's individual productivity, only the average productivity $\int_0^1 h_{it} \, di$ of all households.

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

s.t.

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

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 steady state, the probability of entering each state is γ_X where X indicates the type of unemployment. 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 allow the transition probability from employment to one of the respective unemployment states to follow:

$$EU_t^P = \gamma_P EU_{ss} + \zeta_P dEU_t$$

$$EU_t^T = \gamma_T EU_{ss} + \zeta_T dEU_t$$

$$EU_t^O = \gamma_O EU_{ss} + \zeta_O dEU_t$$

where $\gamma_P + \gamma_T + \gamma_O = 1$, $\zeta_P + \zeta_T + \zeta_O = 1$, and $dEU_t = EU_t - EU_{ss}$.

ζ_{perm}, ζ_{temp}, ζ_{quit} provide freedom to parsimoniously 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:

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

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

- 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:

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

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 replicate 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 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 literature.

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)[5]. 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 55%, 25%, and 20%, 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 each recession. During recessions, their estimates indicate that the average increase in unemployment that is attributed to temporary layoffs is 25%. For increases in the unemployment rate attributed to quits/others, The Bureau of Labor Statistics provides time series of unemployment by reason. Some of these categories include those such as temporary layoff, job leaver, reentrant, or permanent separation. I calculate that on average, 20% of increases in the unemployment rate 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.

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 17 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). Finally, the magnitude of human capital erosion, Δ_U, is set to 0.2 and the probability of human capital accumulation during employment, π_L, is set to $.085$ to match the earnings loss following job displacement during expansions estimated by Davis and Wachter (2011)[6].

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. 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

[5] 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 into as a quitter/other, or as a layoff. Their estimates both use the CPS from 1976 to 2019. I use estimates of both papers to deduce the E to U probability of permanent layoffs, temporary layoffs, and quits/others.

[6] I target the earnings loss following job displacement estimates in expansions as this is in line of the earnings loss estimates from survey data (Huckfeldt (2022).)

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 be uniformly distributed across the population. I estimate the mean and standard deviation of the discount factor distribution to target the aggregate liquid wealth to aggregate quarterly permanent income ratio and an aggregate quarterly MPC of 0.21 as in Kekre (2023), respectively. 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. [7].

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 7.1% of the real wage, near the 7% target calibrated in Christiano, Eichenbaum, and Trabandt (2016) and within the range of plausible values of this statistic reported by Silva and Toledo (2009)[8]. The elasticity of substitution is set to 6. The price adjustment cost parameter is set to 120 to target a slope of 0.05 for the Phillips Curve. 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[9].

[7] 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.

[8] The range of plausible values lie between 4% and 14%

[9] 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	0.2	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, Slacalek, Tokuoka, and White (2017)
Std Dev of Log Transitory Shock	σ_θ	0.2	Carroll, Slacalek, Tokuoka, and White (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	γ_P	0.35	35% of EU from perm. layoffs
Prob. of temp. layoff	γ_T	0.31	31% of EU from perm. layoffs
Prob. of quit/other	γ_O	0.33	33% of EU prob. quit/other layoffs
Perm. layoff deviation param.	ζ_P	0.6	55% of Δ Urate from perm layoffs
Temp. layoff deviation param.	ζ_T	0.3	25% of Δ Urate from temp layoffs
Quits/other layoff deviation param.	ζ_O	0.1	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	120	Slope of Phillips Curve = 0.05
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	1.0	Fixed Real Wage
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 Persistence earnings loss from job displacement

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[10]. 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 illustrates the path of earnings loss following displacement for the baseline model and the model where there is not scarring. 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

[10] 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.

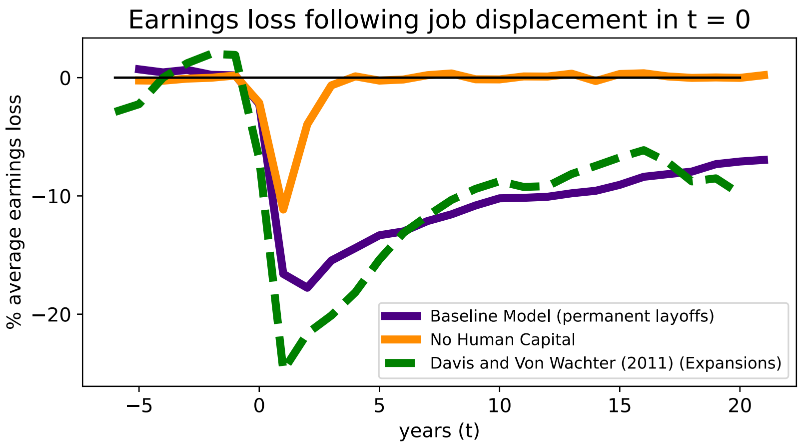

Figure 2 Earnings loss following job displacement in $t = 0$: Model vs Data

years.

5 Consumption Response to 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.

6 Macroeconomic 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,

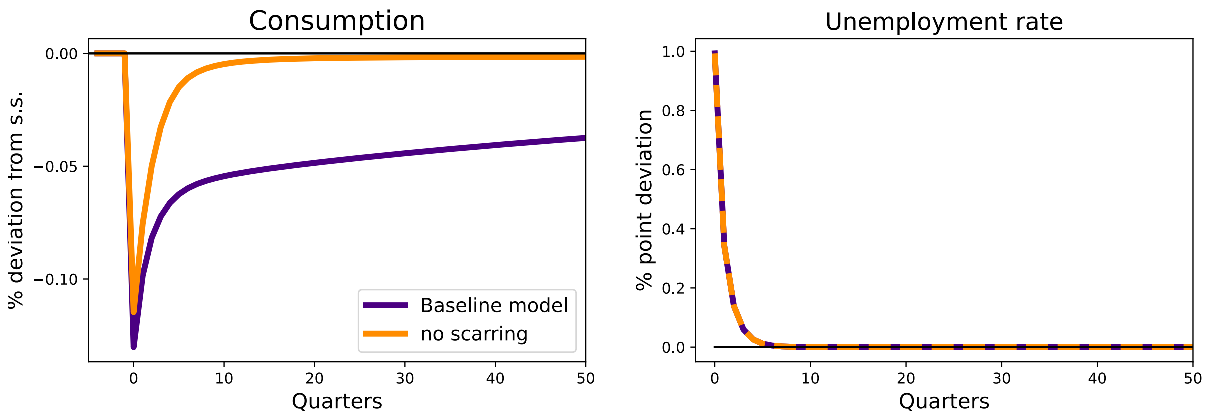

Figure 3 Consumption response to a transitory increase in the unemployment rate

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.

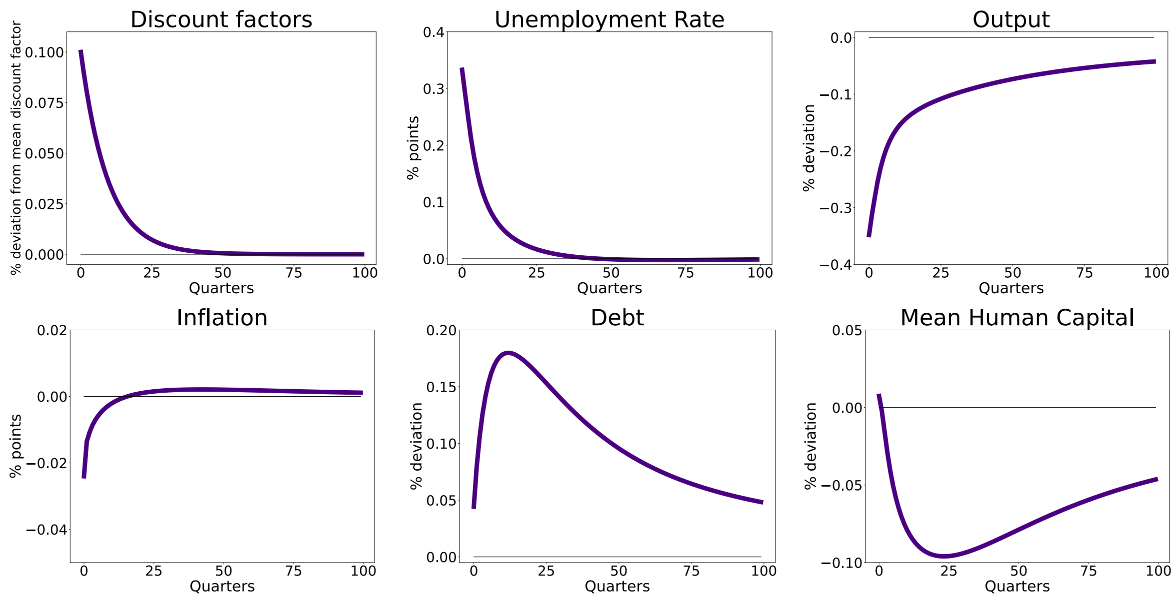

Figure 4 Impulse responses to a negative demand shock

To quantify the extent to which losses in human capital explain the hysteresis in the impulse responses, figure 5 plots the decompositions of the response of output and debt to the negative demand shock with and without the human capital loss channel. The plots show that losses in human capital explain all of the hysteresis in the responses of these aggregate variables.

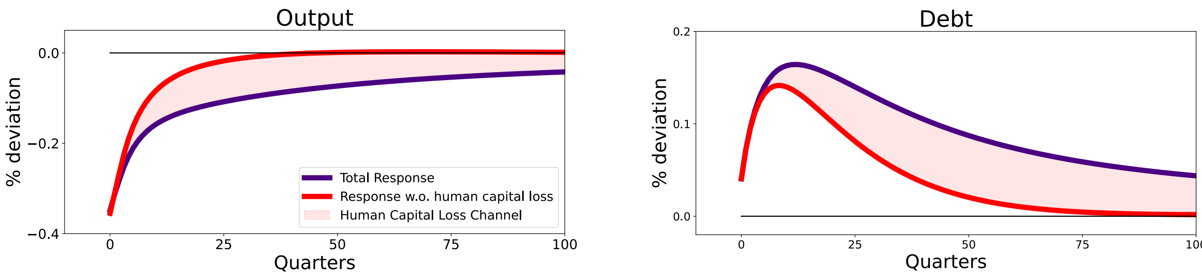

Figure 5 Human capital loss channel of impulse responses to demand shock

6.2 Contractionary 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 significantly larger due to unemployment scarring. To do so, I consider negative government spending shocks in the baseline model and the model where scarring turned off in the same manner described in section 6 and compute the cumulative multipliers. In particular the multiplier is defined as:

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

Figure 6 plots the fiscal multipliers to a contractionary government spending shock across varying shock persistences under the baseline model with a fixed real wages ($\phi_w = 1$) at a horizon of $H = 20$ quarters and $H = \infty$. At both horizons, the multipliers are much larger with scarring.

6.3 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 document that fiscal consolidation is indeed self defeating in a model that is calibrated to the microeconomic evidence on unemployment scarring. I consider a negative sending shock and recalibrate the speed of fiscal adjustment ϕ_b to 0.015, the bottom range of estimates Auclert, Straub, and Rognlie (2019), for a clear sense of the effects of this

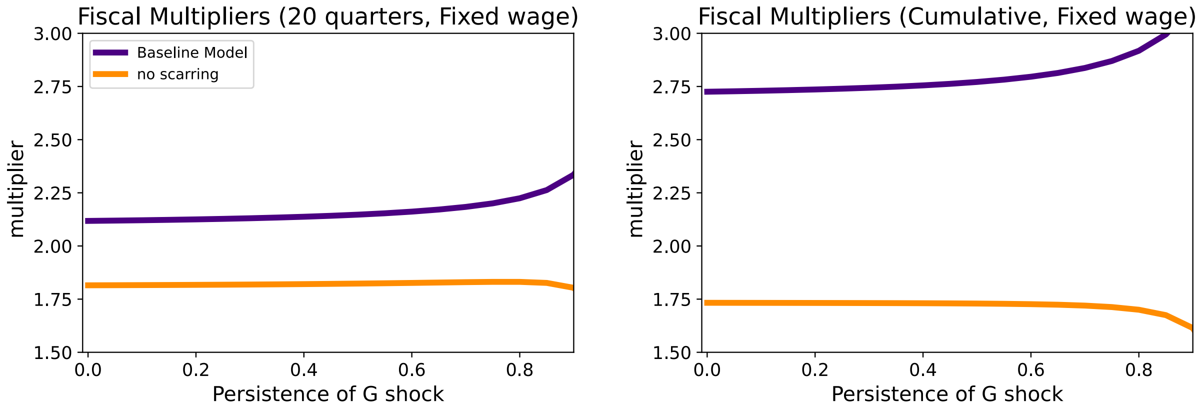

Figure 6 Fiscal Multipliers out of negative spending shocks

shock on debt. The size of the shock is 1% of GDP and the persistence of the shock is 0.9. To capture the extent to which unemployment scarring explains the responses to this shock, I decompose the responses with and without human capital. Figure 7 plots the impulse responses to debt and debt to GDP with their decompositions. With unemployment scarring, debt to GDP and debt both rise in response to a decrease in government spending. The initial rise in debt to GDP even when removing human capital losses is due to the model featuring realistic aggregate MPCs and that this shock is deficit financed. For debt, the decomposition illustrates that it is the human capital loss channel that persistently decreases tax revenues that leads to a persistent increase in debt. For debt to GDP, human capital loss drives both persistent losses in output as well as the increase in debt therefore raising debt to GDP.

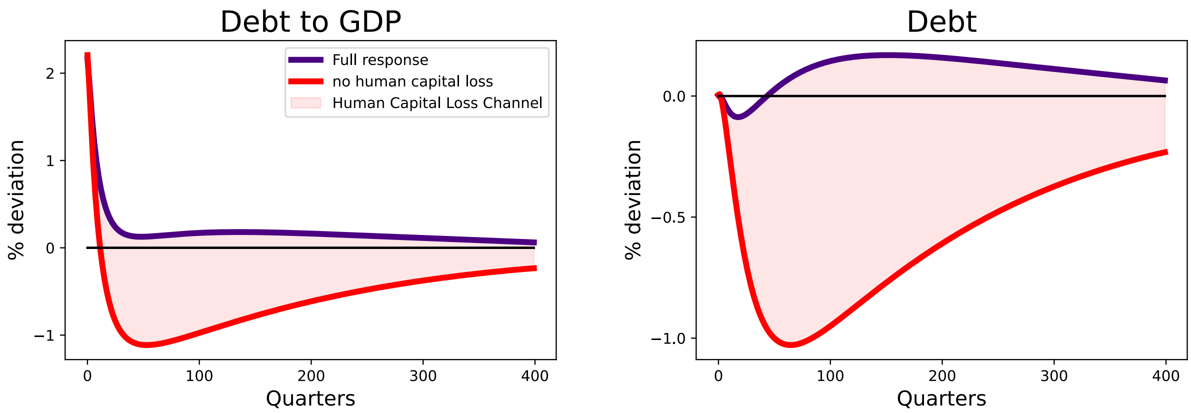

Figure 7 Responses to negative government spending shock

7 Simulating The Great Recession

7.1 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 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.

To ensure that the model's steady state is comparable to the first quarter of 2008, I recalibrate the model such that the unemployment rate and the nominal interest are equal to their corresponding values at the beginning of 2008. Furthermore, I recalibrate the human capital parameters of the model to match the microeconomic estimates of earnings losses following job displacement in recessions. In particular, I rescale the the labor market transition probabilities to target a steady state unemployment rate or 5% and the steady state real interest rate is set to 3.18%, their respective values 2008Q1. To capture the earnings losses in a recession, I first recalibrate the magnitude of human capital erosion during unemployment Δ_U to match the earnings loss following job displacement in recessions estimated in Davis and Wachter (2011). Setting $\Delta_U = 0.3$ yields a good fit of the data. I then re-estimate the discount factors to match the same moments from the calibration section. Lastly, I set the Taylor rule coefficient on output to $\phi_y = \frac{1}{12}$ as in Kekre (2023).

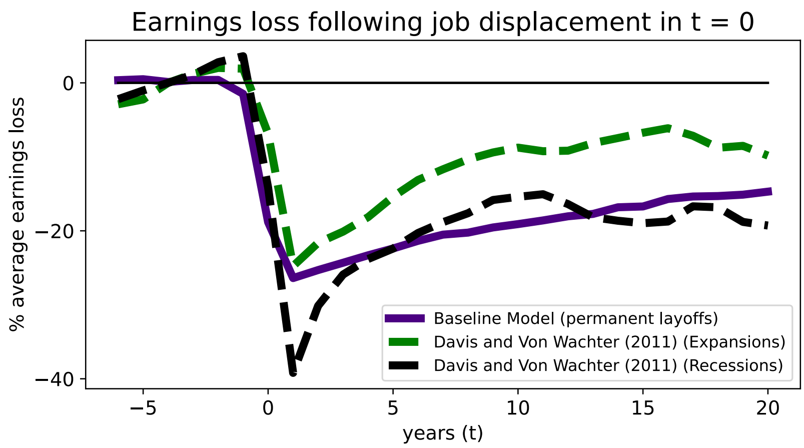

Figure 8 Earnings following job displacement

For the estimation, I follow Kekre (2023) and jointly estimate a sequence of dis-

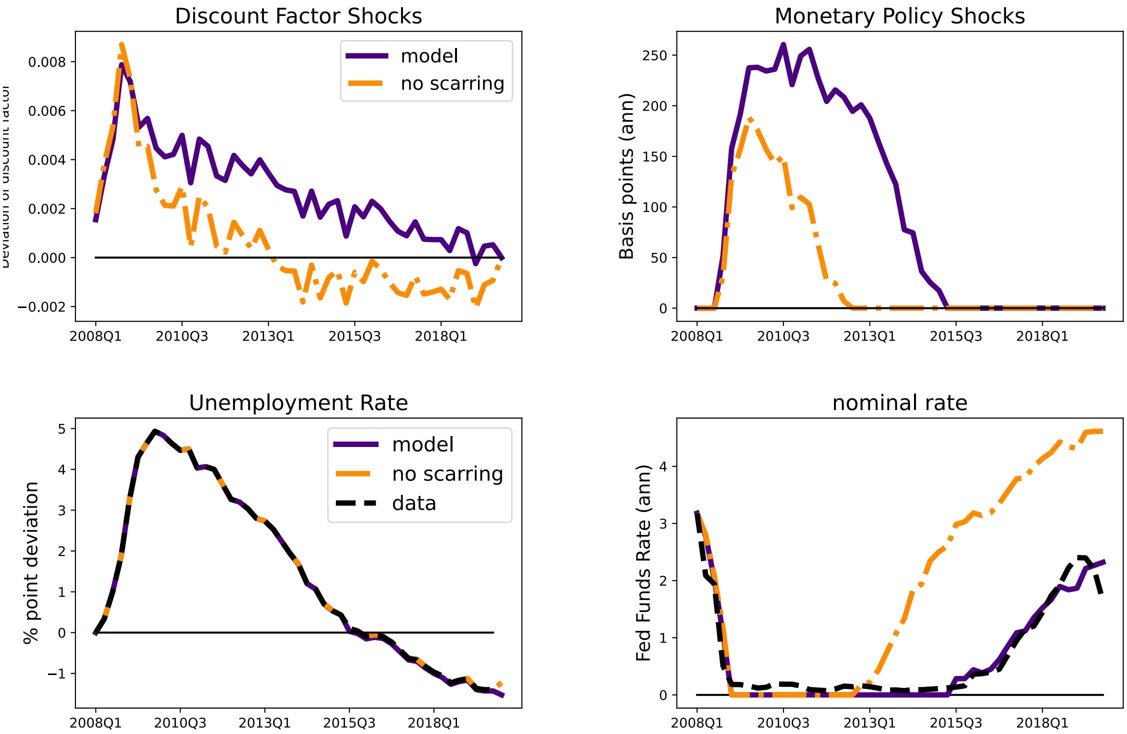

Figure 9 Estimated shocks to discount factor and nominal rate

count 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[11]. When calibrating these discount factor shocks, I assume all discount factors follow an AR(1) with quarterly persistence 0.9. As mentioned 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

[11]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.

10 plot the key aggregate variables against their observed counterpart. 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.

7.2 Debt to GDP during the Great Recession

Having showing 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 the sample period. Figure 11 plots the simulated path of debt to GDP (purple) as well as its decomposition without human capital losses (red) and without tax revenue losses that stem from losses in human capital (green). I also plot the observed path of debt to GDP as a reference. Given the model does not account for the fiscal stimulus of various sectors of the economy during The Great Recession, it is no surprise that the model does not replicate debt to GDP as seen in the data. The model suggests that human capital losses from unemployment scarring account for 10% of the increase in debt to GDP, half of which stemming from lost tax revenues.

7.3 What if the US had pursued fiscal consolidation?

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[12]. 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 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 2015[13]. 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 12 plots the

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

[13] I assume the effects of this shock passes almost entirely through debt, as opposed to taxes, by setting $\phi_b = 0.015$, the lower bound of the estimates provided by Auclert, Straub, and Rognlie (2019). 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.

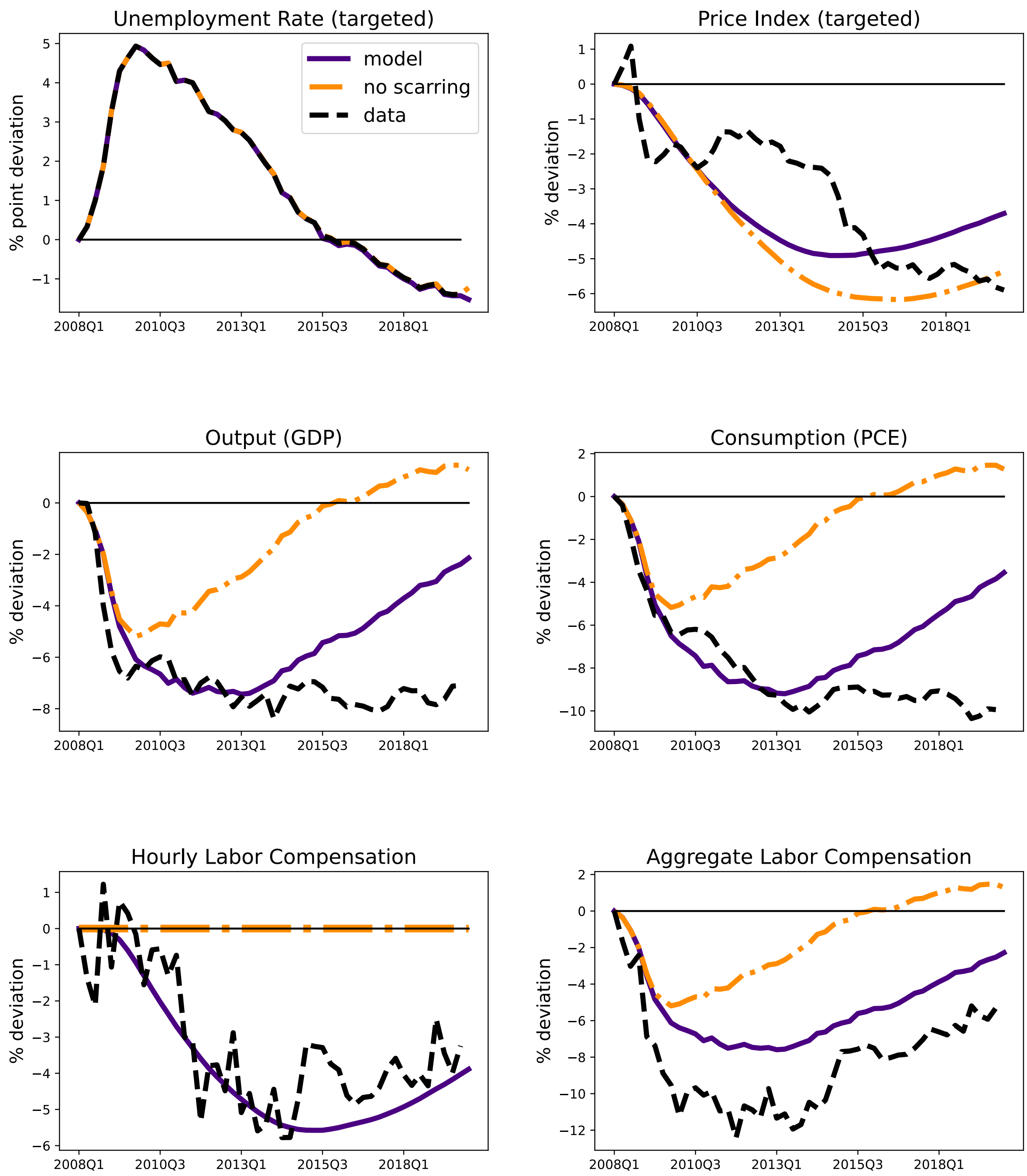

Figure 10 Great Recession: Model vs Data

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 (dashed green). Figure 12 demonstrates that fiscal consolidation would have caused a persistent decline in GDP while raising

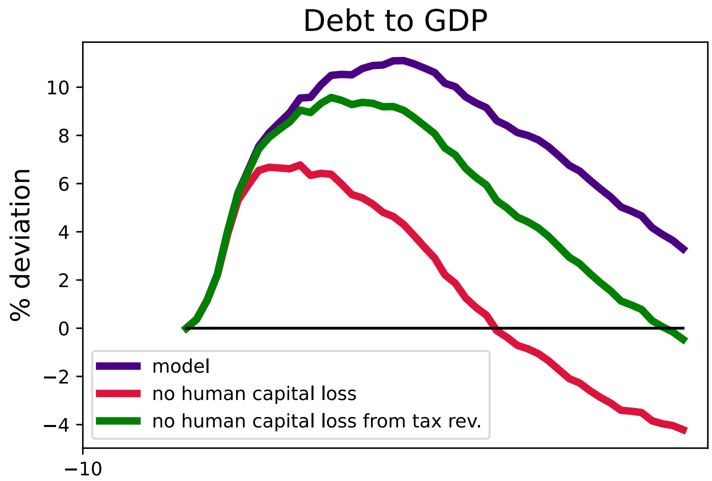

Figure 11 Decomposing the response of debt to GDP

debt and debt to GDP. In the absence of human capital losses, the effects of fiscal consolidation on GDP would have been transitory with GDP returning to its pre-shock path in 2013. Further, without losses to tax revenues from lost human capital, debt would have permanently declined. Instead, debt increases slightly because of unemployment scarring. This increase in debt in combination with persistent losses to output leads to a permanent increase in debt to GDP.

8 Conclusion and extensions

This paper shows that accounting for the microeconomic evidence on unemployment scarring in a macroeconomic framework provides an alternative explanation for macroeconomic hysteresis. I build a heterogeneous agent model with search and matching friction extended to include human capital dynamics to capture the realistic earnings loss faced by households after losing a job. In the model, unemployed households experience human capital erosion that leads to lower effective wages upon reemployment. When calibrated to match the estimated earnings loss following job displacement in the microeconomic literature, this channel can quantitatively explain macroeconomic hysteresis as well as why fiscal consolidation can be disastrous in recessions. Finally, the model accounts for the sluggish recovery from The Great Recession.

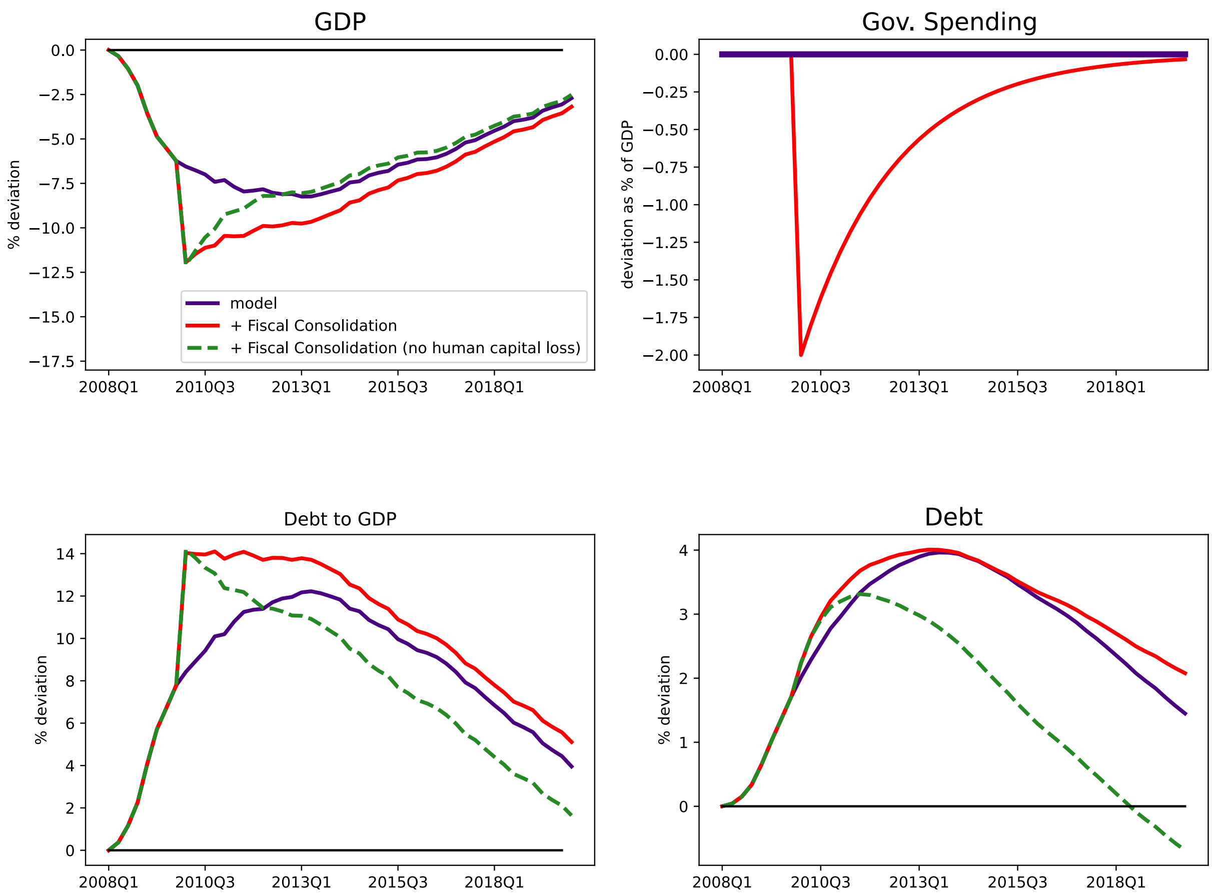

Figure 12 Counterfactual: Fiscal Consolidation in the US

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