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Fiscal Externalities and Optimal Unemployment Insurance†

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A common finding of the optimal unemployment insurance (UI) literature is that the optimal replacement rate is around 50 percent; however, a key assumption is that UI is the only government spending activity. I show that optimal UI levels may be dramatically reduced when UI is a small part of overall spending: the negative impact of UI on income tax revenues implies added welfare costs, a mechanism that I call a fiscal externality. Using both a standard calibrated structural job search model and a "sufficient statistics" method, I find that the optimal replacement rate is zero when fiscal externalities are incorporated. (*JEL* E24, H24, J64, J65)

A large literature studies the optimal provision of unemployment insurance, using a variety of approaches including calibrated structural models (Hansen and İmrohoroğlu 1992, Hopenhayn and Nicolini 1997) and reduced-form "sufficient statistic" analyses (Baily 1978, Chetty 2008). The central trade-off studied in this literature is between the consumption-smoothing benefits of UI, and the moral hazard costs of longer durations of unemployment repeatedly found in papers such as Meyer (1990) and Chetty (2008). A common finding of this literature is that the optimal UI replacement rate is around 50 percent, implying that current levels in the United States are close to optimal: Acemoglu and Shimer (2000), Wang and Williamson (2002), and Chetty (2008) all argue that welfare gains from increasing UI from the current level are small. However, a key assumption in the existing literature is that unemployment benefits are the only spending activity of the government that needs to be financed with taxes on labor income. In this paper, I show that recommendations for optimal UI levels may decline dramatically when one incorporates the fact that UI spending is a small part of overall government spending.

The economics behind this finding are simple and intuitive. When the government makes UI benefits more generous, the average duration of unemployment spells increases due to moral hazard, thereby lowering the steady-state level of employment and the tax base used to finance non-UI spending. Even if the tax rate

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is increased enough to cover the higher UI payments, the decrease in the tax base means that the revenues used to finance non-UI spending are no longer sufficient, implying either that this spending must decrease or that additional taxes must be levied. It follows that there is an added welfare cost associated with higher UI benefits relative to the case in which non-UI spending is zero.

I refer to these effects on the non-UI budget as fiscal externalities. An alternative interpretation is that individuals do not internalize the cost of reduced-tax revenues when making their job search decisions. Fiscal externalities can thus be thought of as an application of the Theory of the Second Best, in which optimal policy must be considered in the context of a job search decision that is already distorted by income taxes. The logic is similar to Feldstein (1997), who considered the effect of inflation—as an implicit tax on savings—added to an already-large explicit tax on savings: when UI lengthens durations of unemployment, this increases an already large distortion, and the classic Harberger deadweight loss triangle becomes a trapezoid, amplifying the welfare costs of UI.

I explore the quantitative implications of fiscal externalities for optimal UI using the two most popular approaches found in the literature. First, I calibrate a structural job search model to match a set of real-world moments under two scenarios: the first uses an estimate of total government spending, while the second ignores all government spending other than UI. I simulate the model and solve numerically for the optimal replacement rate in each case, permitting a comparison of the results across the two scenarios.

The second approach is a "sufficient statistics" method that relies on reduced-form elasticities: I solve a simple two-period model as in the seminal work of Baily (1978), deriving an expression for the optimal level of benefits that can be written in terms of a few empirical values, which are therefore sufficient statistics for welfare. I then use a statistical extrapolation of the sufficient statistics, approximating their values at alternative UI replacement rates, to calculate numerical results for the optimal replacement rate.

I find that the effect of incorporating fiscal externalities into the analysis is large. In my benchmark specification that ignores non-UI spending, the optimal replacement rate is 33 percent using the structural approach and 46 percent using the sufficient statistics approach, values that are broadly in line with the existing literature. However, when I introduce empirically reasonable fiscal externalities, the optimal replacement rate drops to zero in both cases. A decline in UI generosity reduces unemployment and thus increases the tax base, with a larger effect on consumption when fiscal externalities are accounted for: in my structural model, a reduction in the replacement rate from 40 percent to 5 percent has an effect on mean consumption that is 40 percent larger with fiscal externalities.

My analysis complements the important contribution by Chetty and Finkelstein (2013), who identify the possibility that several types of fiscal externalities can affect optimal social insurance, and who derive a sufficient statistics condition for optimal UI when UI affects savings that are subject to taxation. Chetty and Finkelstein (2013) argues that fiscal externalities could have important effects on welfare, but they do not perform a numerical analysis. My paper analyzes the effect of externalities from income taxes and provides, to my knowledge, the first numerical evaluation of the welfare implications of fiscal externalities from income taxes for optimal UI.

My contribution is to show that fiscal externalities are of first-order importance for optimal UI, and that, in a standard class of job search models, fiscal externalities can make UI a counterproductive policy. However, this should not be interpreted as definitive evidence of overwhelming distortions from UI; Appendix B demonstrates that the results could be reversed if UI has significant positive effects on subsequent wages, and the existence of interactions between UI and other margins could also restore a welfare-enhancing role for UI. Rather, the message of this paper is that fiscal externalities are of quantitative significance, and should be taken seriously in future work on UI. My companion paper (Lawson 2017b), which appears following the present paper, performs a similar function in the context of college education, by demonstrating the importance of fiscal externalities for optimal tuition subsidy policy.

The rest of the paper is organized as follows. Section I presents the structural job search model and discusses the calibration and the results. In Section II, I describe a two-period model based on Baily (1978), solve for the welfare derivative and optimal UI equation, and present numerical results. Section III concludes, and two appendices present sensitivity analyses and extensions; additional results are collected in a supplementary online Appendix.

I. Calibrated Job Search Model

In this section, my analysis will be based on the model from Lentz (2009), which is a typical and intuitive single-agent search model, incorporating endogenous search intensity and private asset accumulation. My only modifications are the introduction of government spending outside of UI and a simplified functional form for the effort cost of job search. The first subsection describes the model, while the second explains the calibration; I then present the numerical results, and discuss the effects of fiscal externalities on the estimated optimal benefit level. I conclude with a discussion of the robustness of the results.

A. *Model Setup*

The model features a representative infinitely-lived risk-averse agent who makes stochastic transitions between states of employment and unemployment. When unemployed, the agent receives an after-tax UI benefit equal to b, with infinite potential duration,[1] and chooses search intensity s subject to a convex disutility function $e(s)$, where s is the probability of receiving a job offer.[2] All jobs have an identical wage y, where labor income is taxed at marginal rate τ, and jobs end exogenously at a constant rate of δ per period. All individuals receive an exogenous lump-sum transfer of L in each period, either from the government or from home production, as

[1] By assuming that benefits are constant and never expire, I keep the analysis simple and focus on only one dimension of the optimal UI problem, namely the optimal level of benefits.

[2] This simplified specification allows a closed-form first-order condition for s.

will be discussed shortly. Agents cannot borrow, but they can make savings that earn interest at a rate of i per period, and they face a discount factor of β. Finally, agents receive utility from consumption $U(c)$ in each period.

In all periods and states, agents decide on their level of net saving, while unemployed agents also choose how hard to search for a job. It is convenient to formulate the worker's optimization problem using recursive methods; therefore, let $V_e(k)$ represent the maximum present value of being employed with assets equal to k, while $V_u(k)$ will be the analogous value of unemployment, and let k' represent next period's assets. The worker's problem can then be written as

$$V_e(k) = \max_{k' \in \Gamma_{y(1-\tau)}(k)} \left[U((1+i)k + y(1-\tau) + L - k') + \beta[(1-\delta)V_e(k') + \delta V_u(k')]\right],$$

$$V_u(k) = \max_{k' \in \Gamma_b(k),\, s \geq 0} \left[U((1+i)k + b + L - k') - e(s) + \beta[sV_e(k') + (1-s)V_u(k')]\right],$$

where $\Gamma_z = (k' \in \mathbb{R} \mid 0 \leq k' \leq (1+i)k + L + z)$ is the set of permissable asset values.

The agent is representative of a continuum of ex ante identical agents, and therefore, I can consider the economy-wide steady-state.[3] I consider two different fiscal environments. In the first—the "fiscal externality scenario"—along with UI benefits, the government must finance both the lump-sum transfer L and an exogenous quantity of public good G,[4] leading to the following government budget constraint:

$$(1) \qquad (1-u)y\tau = ub + G + L,$$

where u is the unemployment rate.

In the second fiscal environment—the "benchmark scenario"—there is no public good G, and L is available exogenously as costless household production rather than needing to be financed by the government, and thus the government budget constraint is

$$(2) \qquad (1-u)y\tau = ub.$$

In each scenario, the government chooses b and τ subject to their budget constraint to maximize steady-state expected utility, and the wage will be calibrated in each case so that baseline consumption is identical in the two scenarios. I will compare the results when the best estimates of G and L are used with the results obtained when I assume that the government only needs to finance UI benefits, so that the only difference between the two scenarios is the effect of UI on the government's

[3] The vast majority of the optimal UI literature performs a steady-state analysis; see Appendix A.A4 for an analysis with transitional dynamics, in which the optimal replacement rates are higher but the effect of fiscal externalities remains strong.

[4] The underlying assumption is that the public good is valued very highly by individuals up to a quantity G, and not at all beyond G. Being constant, it does not need to be accounted for in the utility function. Results are nearly identical if G is made endogenous with a continuous marginal value and chosen optimally, as demonstrated in Appendix A.A3.

fiscal system: in (1), the tax rate τ is a large income tax that pays for G and L as well as UI spending, and so, if more generous UI raises unemployment and reduces the tax base, the loss in tax revenue will be greater than in (2).

The variable G represents a quantity of mandatory government expenditures, which is a simplified way of capturing the variety of expenditures made by governments on programs such as national defense, law and order, and health care, among others. Meanwhile, the lump-sum transfer L represents a variety of transfers and social benefits provided to low-income households, as well as the fact that low incomes are taxed at a lower marginal rate; including L in the analysis provides a first-order approximation to the real-world tax system, which features marginal tax rates which may deviate significantly from average tax rates.[5] I take the tax system as given and consider the optimal UI benefit in this setting, given that the government must raise tax revenues to finance both the exogenous G and the fixed lump-sum transfer L.[6]

B. *Calibration of the Model*

Calibration requires choosing functional forms and parameter values, in order to be able to simulate the model. For functional forms, I assume constant relative risk-aversion utility with risk-aversion parameter R, so $U(c) = \frac{c^{1-R}}{1-R}$, and I borrow the search cost function from Chetty (2008): $e(s) = \frac{(\theta s)^{1+\kappa}}{1+\kappa}$, until $s = \bar{s}$, beyond which the marginal cost is infinite.[7]

As is standard in the literature, when looking at optimal UI benefits, I focus on the UI replacement rate r, or the percentage of previous earnings received as benefits, rather than the dollar amount b. The model features infinite-potential-duration UI for simplicity, but not all unemployed individuals actually receive UI, either because their benefits have expired or because they do not take up benefits. Therefore, I follow the approach of Fredriksson and Holmlund (2001) in deflating benefits in my model to be equal in expectation to real-world finite-duration benefits.[8] That is, I multiply the replacement rate by 0.8, which is the approximate take-up rate over 1990–2005 found by Ebenstein and Stange (2010),[9] and by 15.8/24.3, which is the ratio of mean compensated unemployment duration to mean total duration in the Mathematica sample of Chetty (2008).[10] I also account for taxation of benefits

[5] Assuming a proportional tax keeps the government budget constraint simple, but a progressive tax would actually strengthen my results, as reductions in UI benefits would reduce unemployment and move individuals to higher tax brackets, with even larger fiscal gains.

[6] As pointed out by an anonymous referee, an interesting topic for future research would be an analysis of the joint optimality of UI and the progressivity of income taxation. However, my goal in this paper is simply to show that accurately modeling the basic structure of the existing tax system leads to fundamentally different results for optimal UI.

[7] Thus, $\bar{s}$ is the maximum feasible search intensity; in the simulations, this upper limit never appears to be binding.

[8] Assuming that everyone receives UI would imply a much larger size of the UI program than is the case in reality, and the relative size of UI spending and other programs defines the size of fiscal externalities.

[9] This accounts for the fact that the empirical quantities used later are defined for the entire population that is eligible for UI, regardless of whether they take up benefits; Gruber (1997) argues that this is in fact the policy-relevant population, because government can control benefit eligibility but not benefit receipt.

[10] Fredriksson and Holmlund (2001) makes a slightly different adjustment, finding the average replacement rate for all unemployed individuals whether eligible for UI or not, across both UI and social assistance, accounting for UI benefit exhaustion.

TABLE 1—PARAMETERS SELECTED FROM LITERATURE AND DATA

Parameter	Definition	Value(s)
δ	Weekly job separation rate	$\frac{1}{260}$
i	Weekly real interest rate	0
R	Coefficient of relative risk aversion	2
$\overline{s}$	Maximum weekly search intensity	0.9
r_0	Baseline replacement rate	0.46
y	Weekly (i.e., per period) wage	$\{1, 0.7293\}$
τ_0	Baseline marginal tax rate	$\{0.282, 0.0155\}$
τ_b	Tax rate on UI benefits	0.17
L	Lump-sum transfer	0.1529

Note: When two values are listed, the first is for the fiscal externality scenario, while the second is for the benchmark scenario.

at rate τ_b, and so if r is the real-world replacement rate and y is normalized to one as it will be in the fiscal externality scenario, $b = r(1-\tau_b)(0.8)\left(\frac{15.8}{24.3}\right)$ is the corresponding value of the infinite-duration benefit in my model. In Appendix A.A2, I show that, while less simple to implement numerically, results are similar if UI benefits expire after six months.

The selected parameter values are summarized in Table 1; an extensive series of sensitivity analyses on these parameters can be found in Appendix A.A1. A period represents a week, and so the job separation rate is set to $\delta = 1/260$ to correspond with a median job duration of five years measured by the Bureau of Labor Statistics in January 2006 for high school graduates, a group which is a reasonable proxy for UI recipients. I follow Hansen and İmrohoroğlu (1992) and Chetty (2008) in setting the interest rate to zero.[11] I use $R = 2$ for the coefficient of relative risk-aversion, as this is a standard value in studies of UI,[12] and I use $\overline{s} = 0.9$ for the upper limit of search intensity. I assume that the baseline replacement rate is 0.46, which is the mean effective replacement rate over 1988–2010 reported by the US Department of Labor; I denote this baseline replacement rate as r_0 to differentiate it from other values considered in my search for the optimum.

In the fiscal externality scenario, the wage y is normalized to one, whereas in the benchmark scenario, I take the baseline marginal tax rate τ_0 from the fiscal externality scenario and set $y = 1 - \tau_0 + \frac{ub}{1-u}$. This ensures that the baseline after-tax income is the same in the two scenarios, with y scaled down in the benchmark scenario to reflect the loss of income to pay for G and L in the fiscal externality scenario, and thus the two scenarios are identical in terms of their baseline values of consumption.[13] Note that b is defined as $r(1-\tau_b)(0.8)\left(\frac{15.8}{24.3}\right)$ regardless of the value of y, and so the value of UI benefits is identical as well. This minimizes

[11] Chetty (2008) finds that unemployed individuals have little long-term savings, and Hansen and İmrohoroğlu (1992, 123) argues that previous findings of near-zero average real returns on "highly liquid short-term debt" justify the assumption of a non-interest-bearing asset.

[12] For example, Chetty and Saez (2010) uses $R = 2$, and Lentz (2009) estimates a value of 2.21. Sensitivity analyses in online Appendix E consider alternative values of R.

[13] Alternative benchmark calibrations in which $y = 1$ and L is exogenously provided, and in which $y = 1$ and L is not provided, lead to even larger gaps between optimal UI in the fiscal externality and benchmark scenarios; results are available upon request.

the differences between the two scenarios and ensures that the only difference is the responsiveness of tax revenues to UI: in the benchmark scenario, L is provided exogenously and the value of G is automatically deducted from earnings, so that the only action of government is to raise a small amount of tax revenue to pay for UI. This eliminates the main fiscal externality channel that occurs when higher UI reduces the tax revenues available to pay for G and L.[14]

To calibrate the tax system for the fiscal externality scenario, I estimate tax rates applying to UI recipients from a variety of sources. Marginal income taxes are taken from a sample of unemployed workers from the 2008 March CPS (Flood et al. 2015): I use the 2007 tax code to impute marginal tax rates for each individual, and averaging the imputed tax rates across the sample, I find that the average individual who received UI in 2007 faced a 14.3 percent marginal federal tax rate, a 0.5 percent EITC tax-back rate, and a 3.9 percent marginal state tax rate.

For average taxes, the Institute on Taxation and Economic Policy (Davis et al. 2009) estimates that the average individual in the the second quintile of household earnings (taken as an approximation to UI recipients) paid 1.5 percent of their income in state income taxes, while a Congressional Budget Office (CBO 2010) publication reports that the average second-quintile individual paid 1.1 percent in federal income taxes. The latter CBO publication also finds that second-quintile individuals paid 9.5 percent of their income in social insurance taxes, which are calculated as the sum of the employee and employer payroll taxes.[15] This estimate applies to average payroll taxes, but 9.5 percent is also a good estimate of the marginal social insurance tax faced by the typical UI recipient, based on estimates in Cushing (2005), and so I will use 9.5 percent as both the average and the marginal rate.[16]

Together, this implies that the average unemployed individual faces a marginal tax rate of $\tau = 0.143 + 0.005 + 0.039 + 0.095 = 0.282$, and an average tax rate of $0.095 + 0.011 + 0.015 = 0.121$. Meanwhile, UI benefits are subject to federal income taxation, and state taxes in some but not all states; using the 2008 March CPS data, I find that, on average, the marginal state tax rate applied to UI is 2.7 percent, meaning that the tax rate applied to UI is $\tau_b = 0.17$. Further details on the tax rate estimation can be found in online Appendix F, and while the results that follow are sensitive to the fiscal parameters, sensitivity analyses in Appendix A.A1 show that the main results are robust to a variety of modifications. As described in online Appendix F, these tax rates allow me to back out values of $L = 0.1529$ and $G = 0.1032$, and I will solve for optimal UI subject to these values.

[14] In a sense, the fiscal externality from income taxes is eliminated in the benchmark scenario by assuming that a worker's marginal product is $1 - \tau_0 + \frac{ub}{1-u}$, rather than a larger marginal product of 1 that is distorted downward to $1 - \tau_0 + \frac{ub}{1-u}$ by income taxes.

[15] As the CBO (2010, 4) publication explains, the employer share of payroll taxes are assumed to be "passed on to employees in the form of lower wages than would otherwise be paid. Therefore, the amount of those taxes is included in employees' income, and the taxes are counted as part of employees' tax burden."

[16] The marginal FICA payroll tax is 15.3 percent, but Cushing (2005) estimates net marginal tax rates accounting for marginal benefits in the form of expected retirement and disability benefits. The mean age of UI recipients in the SIPP sample of Chetty (2008) is 37, and averaging Cushing's results for middle-income 35- and 40-year-olds without Social Security dependents (and adding the 2.9 percent Medicare tax, which is ignored by Cushing), the estimated marginal social insurance tax is 8.0 percent to 11.5 percent for men and 6.2 percent to 10.6 percent for women, depending on the discount rate. Online Appendix F provides further detail.

Table 2—Moments for Calibration

Moment	Definition	Value
u	Unemployment rate	0.054
$\frac{E(c_e) - E(c_u)}{E(c_e)}$	Consumption gap between employment and unemployment	$0.222 - 0.265 r_0 = 0.1001$
$E_b^u = \frac{b}{u}\frac{du}{db}$	Elasticity of u with respect to b	$0.946 \times 0.48 \times 0.53 = 0.2407$

Note: These three moments are used to calibrate the values of θ, κ, and β.

The remaining parameters, θ, κ, and β, are set to make the model match a set of moments from the real world. The moments used are the unemployment rate u, the percentage gap between average consumption when employed and unemployed $\frac{E(c_e) - E(c_u)}{E(c_e)}$, and the elasticity of the unemployment rate with respect to benefits, which I denote as $E_b^u = \frac{b}{u}\frac{du}{db}$. While all three moments jointly determine the parameter values, u is especially informative about the level of the search cost function, which is primarily determined by θ. Meanwhile, E_b^u is informative about the curvature parameter κ. Finally, the consumption gap is closely related to workers' ability to maintain a buffer stock of assets, so $\frac{E(c_e) - E(c_u)}{E(c_e)}$ primarily identifies the discount factor.[17] These three moments are also closely related to the sufficient statistics that will be used later in the paper.

The specific values used for the moments are summarized in Table 2,[18] and are as follows. The unemployment rate u is set to 0.054 to match the average unemployment rate among high school graduates during 1992–2010. Gruber (1997) estimates a relationship of $\frac{E(c_e) - E(c_u)}{E(c_e)} = 0.222 - 0.265r$,[19] which implies a value of 0.1001 at baseline. Finally, Chetty (2008) estimates an elasticity of unemployment durations with respect to benefits of 0.53,[20] though this estimate is based on a sample of UI recipients, whereas the consumption estimates in Gruber (1997) are from a sample of unemployed workers who were initially eligible for UI, regardless of whether they were actually receiving benefits. Therefore, as with the benefit level, I need to adjust for benefit nonreceipt, and I follow Gruber's recommendation and multiply the elasticity by 0.48, the derivative of benefit receipt with respect to benefit

[17] The standard approach is simply to choose a "reasonable" value for the discount factor; however, there is no consensus on the right "reasonable" value. An annual discount rate of around 4–5 percent is typical, but to take opposite extremes, Acemoglu and Shimer (2000) use an annual rate of nearly 11 percent, whereas Coles (2008) produces results for a zero discount rate. Lentz (2009) finds that his results are very sensitive to the gap between the interest and discount rates, motivating my attempt to use data to pin down this parameter.

[18] Alternative values are considered in Appendix A.A1.

[19] Gruber's data is on food consumption from the PSID; he estimates the year-to-year drop in consumption for individuals who were employed in year $t - 1$ and unemployed in t.

[20] This estimate is close to the middle of the typical range of estimates in the literature; Chetty (2008) describes the usual range of estimates as 0.4 to 0.8, while Fredriksson and Holmlund (2001, 388) claim that their own value of 0.5 is "in the middle range of the available estimates." I assume that this elasticity is the general equilibrium value, if there are any general equilibrium adjustments by firms; it is plausible that Chetty's estimate captures this as it uses state-level variation in UI benefits over time.

TABLE 3—CALIBRATED PARAMETERS

Parameter	Definition	Fiscal externality	Benchmark
ρ	Annual discount rate	0.0105	0.0105
θ	Search cost level	19.5	19.5
κ	Search cost curvature	0.869	0.8705

Note: In the first row of the table, I present the value for the annual discount rate $\rho = \beta^{-52} - 1$.

eligibility in his sample.[21] If the average duration of unemployment is D, this gives $E_b^D = \frac{b}{D}\frac{dD}{db} = 0.53 \times 0.48 = 0.2544$, and the fact that $u = \frac{D}{D+\frac{1}{\delta}}$ means that $E_b^u = (1-u)E_b^D = 0.946 \times 0.2544 = 0.2407$.

I calibrate the model twice, once for each of the two scenarios; in each of these, the calibration will produce the same labor market outcomes, though in economies with different fiscal systems. In this way, given each set of starting assumptions about the size of government, I find the parameters that match the real-world moments, which are presented in Table 3; for easier interpretation, I present the annual discount rate ρ rather than the weekly discount factor β, where $\rho = \beta^{-52} - 1$. Finally, in the section to come, I will find the level of UI that is optimal in each case,[22] allowing me to compare the results with fiscal externalities to those from the usual approach.

C. *Numerical Results*

To numerically solve the model, I use value function iteration, and the parameters used are displayed in Table D.1 in online Appendix D.1; the details of the numerical methods and the resulting moments are also presented in online Appendix D.1.[23] The results for the optimal replacement rates and estimated welfare gains can be found in Table 4; the column labeled "Welfare Gain" expresses the gain from moving from $r = 0.46$ to the optimum as a welfare-equivalent increase in consumption, or the percentage increase in all individuals' consumption which would raise average utility by the same amount from the baseline level.

In the benchmark scenario, when G and L are ignored in the government budget constraint, the optimal replacement rate is 33 percent, and the welfare gain from moving from 46 percent to 33 percent is very small. Previous results from the existing literature that implicitly make this same assumption are summarized

[21] 0.48 is also very close to my value of $0.8 \times \frac{15.8}{24.3} \simeq 0.52$ for the fraction of time that initially eligible unemployed individuals receive benefits, a closely related quantity.

[22] This is not a comparative statics exercise; I am studying the effect of fiscal externalities on optimal UI *calculations*, not the impact on optimal UI of increasing the size of government. Governments' fiscal activities have always been much more extensive than just UI, but this has been ignored by the optimal UI literature, and I want to know how much the estimated optimum changes if this fact is no longer ignored.

[23] An overidentifying moment can be generated from the asset distribution, by comparing my simulated steady-state distribution to the asset distribution in the SIPP data of Chetty (2008). My model does not contain motives for saving other than self-insurance against unemployment, and I also restrict assets to be nonnegative, so I cannot match the long left and right tails of a real-world distribution, but the median level of assets generated by the model amounts to between 38 percent and 52 percent of a year's pretax labor income in my two scenarios. If I assume that half of housing equity can be counted as liquid wealth, I find that the median liquid wealth in Chetty's sample is about 40 percent of mean annual income; if all of housing equity is counted, then median wealth is about 70 percent of mean income. Therefore, the center of the asset distribution is on the right order of magnitude.

TABLE 4—OPTIMAL REPLACEMENT RATES AND WELFARE GAINS

Scenario	Replacement rate r	Welfare gain
Fiscal externality	0.00	0.23 percent
Benchmark	0.33	0.01 percent

TABLE 5—NUMERICAL RESULTS FROM STRUCTURAL STUDIES OF OPTIMAL UI

Paper	Optimal replacement rate
Hansen and İmrohoroğlu (1992)	0.15* (with moral hazard)/0.65 (without)
Davidson and Woodbury (1997)	0.66*/1.30**
Hopenhayn and Nicolini (1997)	> 0.94* (with optimal tax)
Acemoglu and Shimer (2000)	> 0.4**
Fredriksson and Holmlund (2001)	0.38–0.42*
Wang and Williamson (2002)	0.24*/0.56**
Coles and Masters (2006)	0.76*
Lentz (2009)	0.43–0.82*

Note: * corresponds to infinite-duration UI, ** to finite-duration (typically 26 weeks).

in Table 5, which shows that 33 percent is within the existing range of estimates, though toward the low end. However, once the government needs to finance G and L with income taxes, the optimal replacement rate declines dramatically to zero, as the added revenue cost of providing UI completely outweighs the gains from consumption-smoothing. The welfare gain obtained from moving to the optimum is equivalent to a 0.23 percent increase in consumption; since UI spending represents only 1.27 percent of mean consumption at baseline, this welfare gain is economically quite significant, equivalent to a saving of 17.7 percent of the total expenditure on UI. During 2001–2010, average UI spending was \$59 billion, and so my results imply a welfare gain of about \$10.5 billion per year.

Figures 1 through 3 illustrate graphically the implications of changing UI generosity. Figure 1 shows how the employment rate $1 - u$ varies with the replacement rate r, while Figure 2 shows total UI spending as a function of r; because the two scenarios are calibrated to the same moments, the results are nearly identical. However, Figure 3 demonstrates that the effect of UI spending on the budget-balancing tax rate is significantly different in the two scenarios: taxes rise much more rapidly with r in the fiscal externality scenario than when I assume that government does not need to finance G and L. The intuition can be understood as follows: an increase in UI benefits leads to increased unemployment and reduced-tax revenues, but the loss in tax revenues is much larger when the tax rate is large to begin with. Therefore, in the fiscal externality scenario, the disincentive effects of UI leave a bigger budgetary shortfall, requiring a larger tax increase to compensate, which generates larger distortions on job search and larger welfare costs.

An alternative explanation of the intuition of the fiscal externality comes from the fact that individuals make their search decisions based on the private return, which depends on the after-tax income and consumption received, but when the government needs to finance G and L, that after-tax income is a smaller fraction of

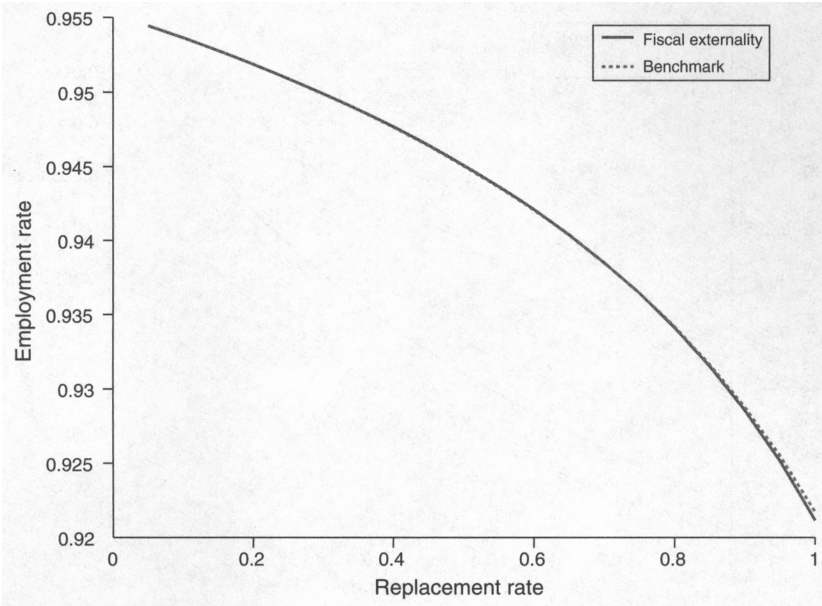

Figure 1. Employment Rate

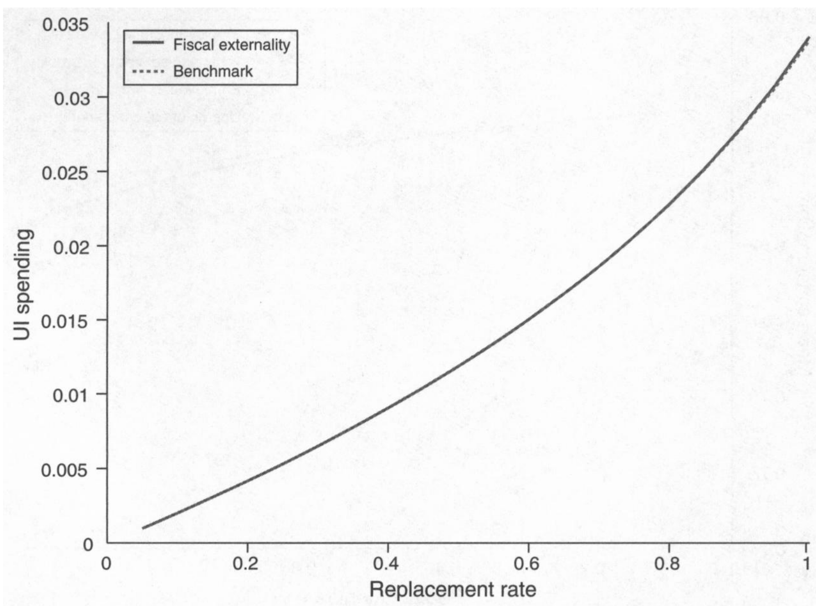

Figure 2. UI Spending

the total output generated. Individuals treat the gain in future consumption as the private return to search, but the public return is considerably larger in the presence of distortionary taxation.

Figures 4 and 5 present additional graphical evidence on consumption and welfare. Consumption starts at the same level at $r = 0.46$, but is noticeably steeper

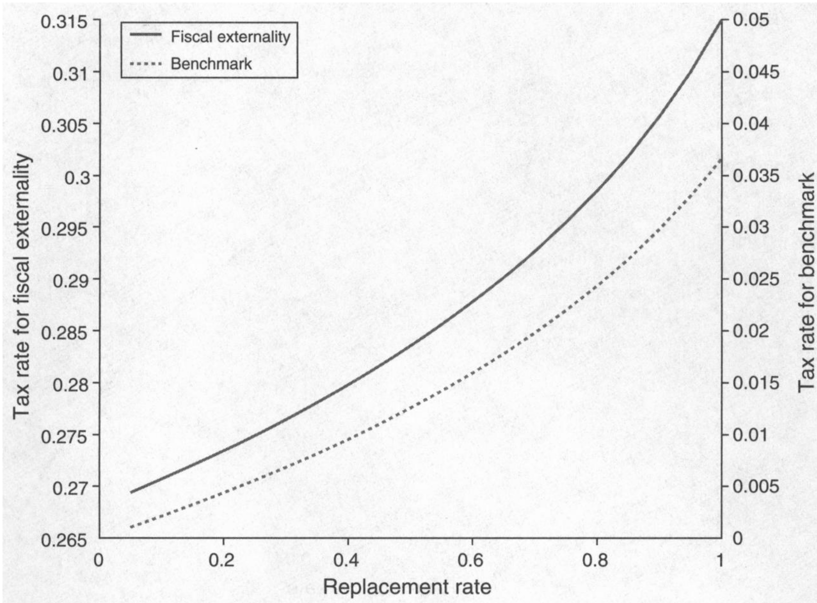

FIGURE 3. BUDGET-BALANCING TAX RATES

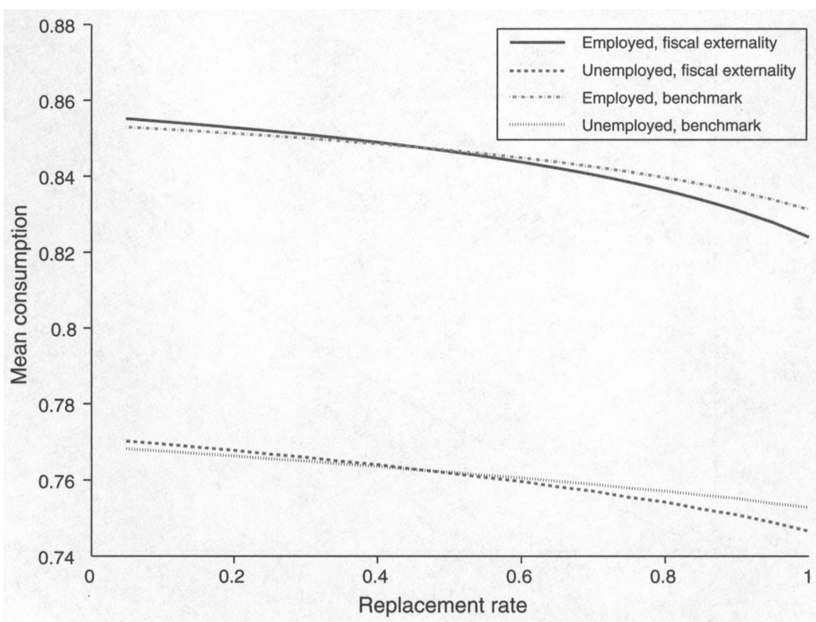

FIGURE 4. MEAN CONSUMPTION

with respect to r in the fiscal externality case, for the reason explained above: the preexisting distortion caused by income taxes exacerbates the fiscal costs of UI, leading to faster declines in consumption as r increases. As a result, Figure 5 shows that the welfare gain from lowering r is substantially higher in the fiscal externality scenario.

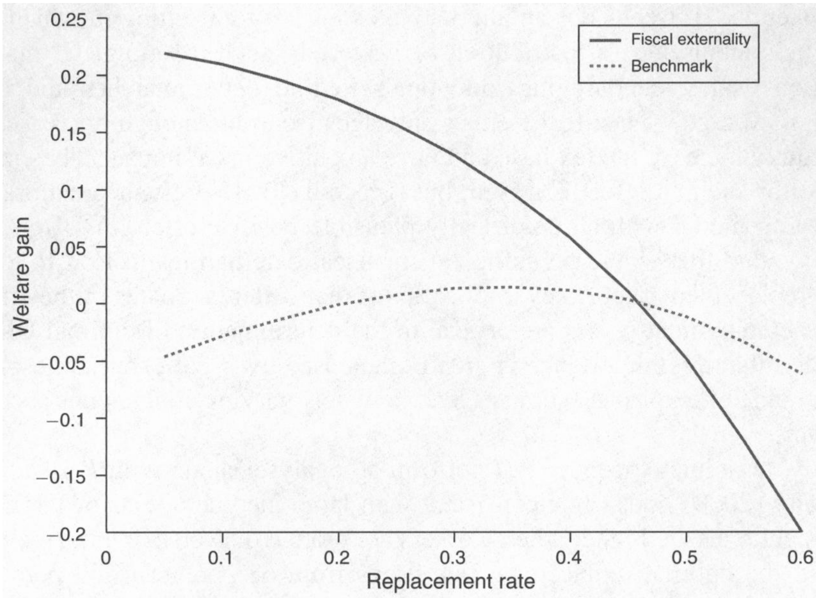

Figure 5. Welfare

D. *Robustness Analysis*

To confirm the robustness of my results, I have performed an extensive series of sensitivity analyses, with results that are displayed in Appendix A.A1. I show that the effects of fiscal externalities remain strong for a variety of alternative calibrations of the fiscal system and of other parameters and moments, with two partial exceptions: the effects are somewhat weaker if the marginal tax rate is reduced to 12.1 percent to be equal to the average tax rate, and a positive interest rate significantly reduces the optimal benefit level, all the way to zero even in the absence of fiscal externalities.[24]

In Appendix A.A2, I have also extended the model to feature benefits that expire after six months; the results are very similar to the baseline, indicating that my conclusions hold with a more realistic (but less simple) approach to modeling unemployment benefits. Appendix A.A3 shows that results are nearly identical if G is endogenous and chosen optimally conditional on the value of b. Finally, Appendix A.A4 moves beyond a steady-state analysis and considers transitional dynamics; optimal replacement rates rise because increases in UI allows individuals to consume savings along the transition path, but r still drops by 0.31 with fiscal externalities. These findings all indicate that the overall results of the analysis are robust to many modifications: the addition of non-UI spending to a standard search model dramatically affects optimal UI calculations, leading to a significant drop in the optimal replacement rate.

[24] Even in the latter case, the welfare gain from reducing UI benefits is considerably larger in the fiscal externality scenario.

In Appendix B, I consider an alternative extension to a setting in which unemployed individuals face a distribution of wages. In such a setting, UI may raise reservation wages, encouraging individuals to find better matches and thereby increasing average wages. If the effect on wages is strong enough, increases in UI may actually increase the tax base and have a positive fiscal impact. The empirical evidence for such an effect is mixed, but Appendix B.B1 presents a calibration of a job search model with an empirically plausible positive effect of UI on wages, and shows that this would be sufficient for fiscal externalities to lead to a higher optimal replacement rate. A key implication is that better estimates of the effects of UI on re-employment wages are critical to the determination of optimal UI generosity—and that this importance is greatly increased by fiscal externalities—as the existing range of empirical estimates lead to widely varying conclusions about optimal policy.

Finally, in online Appendix E, I perform all analyses again with $R = 5$, a value that Chetty (2008) finds to be consistent with large income effects of UI. Optimal replacement rates are higher when workers are more risk averse, but the main result is robust: the optimal replacement rate drops from 68 percent to 39 percent due to fiscal externalities in the baseline analysis. Meanwhile, the sensitivity analyses again fail to alter the main qualitative finding.

II. Sufficient Statistics Approach

The structural approach has numerous strengths, but it is difficult to present a clear demonstration of the mechanisms at work in this framework,[25] and so I now switch my focus to a simpler and more reduced-form model of unemployment in the sufficient statistics tradition. This approach will permit a more detailed, step-by-step analysis of fiscal externalities in the context of UI, and will generate an analytical solution as an intuitive function of observable empirical quantities. The sufficient statistics approach has been used recently by Chetty (2008) and Shimer and Werning (2007), but I will focus on Martin Baily's (1978) original seminal paper in optimal UI; the formula generated by his two-period model of unemployment is used by Gruber (1997), and Chetty (2006) demonstrates that it applies to a wide range of job search models.

The first subsection presents the model and derives a general version of the optimal benefit equation, while the second explores this equation in further detail and provides the equations needed to perform the numerical analysis. The third subsection presents numerical results, and the final subsection considers the robustness of my findings.

[25] Shimer and Werning (2007, 1149) argue that structural models "rely heavily on the entire structure of the model and its calibration, which sometimes obscures the economic mechanisms at work and their empirical validity."

A. *Baily (1978) Model and Optimal Benefit Equation*

The only modification that I make to Baily's model is to add G and L to the analysis; the notation from Baily's paper is also altered to make it more compatible with the notation used earlier. The model is more reduced-form than the structural model, but captures many of the same features, and the simplicity of the model makes it well suited to an exposition of the effects of fiscal externalities.

In Baily's model, time is finite and consists of two periods,[26] with the interest and discount rates both set to zero. In the first period, the representative worker is employed at an exogenous wage y,[27] and between periods they face a risk of unemployment: with exogenous probability δ, the worker loses their job and becomes unemployed, whereas they keep their initial job at the same wage for the entire second period with probability $1-\delta$. If the worker becomes unemployed, they choose search effort e (normalized into income units) and a desired wage y_n. They then spend a fraction $1-s$ of the second period unemployed and the remaining $s \in (0,1)$ at a new job at wage y_n, where s is a deterministic function of e and y_n:[28]

$$s = s(e, y_n), \qquad \frac{\partial s}{\partial e} > 0, \qquad \frac{\partial s}{\partial y_n} < 0.$$

Individuals receive utility from consumption in each period according to the continuous function $U(c)$, where $U' > 0$ and $U'' < 0$. The variable k represents first-period savings, so overall expected utility is given by

$$V = U(c_1) + (1-\delta)U(c_e) + \delta U(c_u), \tag{3}$$

where $c_1 = y(1-\tau) + L - k$ is first-period consumption, $c_e = y(1-\tau) + L + k$ is second-period consumption if the worker keeps their job, and $c_u = (1-s)(b-e) + sy_n(1-\tau) + L + k$ is second-period consumption if the worker loses their job.[29] Here, τ remains the marginal income tax rate, L the lump-sum transfer, and b the after-tax UI benefit.

The government budget constraint over the two periods is

$$[(2-\delta)y + \delta s y_n]\tau = \delta(1-s)b + 2P, \tag{4}$$

where P is new notation for total non-UI government spending, to allow me to perform algebraic analysis covering both the fiscal externality and benchmark scenarios: $P = G + L$ in the fiscal externality scenario, whereas $P = 0$ in the benchmark scenario, as in the structural analysis. Again, G represents per period exogenous

[26] Baily meant this to represent a two-year time horizon, but the model could also stand for a world with a longer time horizon divided into two halves.

[27] In an extension in online Appendix N.4, I consider the effect of allowing choice over initial labor supply.

[28] y_n is also assumed to be deterministic, such that a worker defines the wage level that they will search for, and will eventually find such a job, with it taking longer to find high-wage jobs. In online Appendix N.1, I examine the consequences of a stochastic s.

[29] The assumption that, if the worker loses their job, utility in the second period is defined over total consumption implies no credit constraints within a period: the worker can borrow as much as necessary to smooth consumption during the second period. I consider a relaxation of this assumption in online Appendix N.2.

provision of a public good, and online Appendix N.5 shows that the effects of fiscal externalities would be at least as large if G were allowed to be endogenous.

The next step is to evaluate the derivative of social welfare with respect to UI benefits. From (3), the worker's lifetime expected utility can be written generally as $V = V(e, y_n, k; b, \tau)$; the government sets the values of b and τ, and the worker chooses $\{e, y_n, k\}$ to maximize V taking $\{b, \tau\}$ as given. The government planner has equally-weighted utilitarian preferences, and therefore wants to maximize V at the individual's optimum, choosing b and τ to satisfy the government budget constraint. Since the individual chooses $\{e, y_n, k\}$ to maximize V, the partial derivatives with respect to these individual choices are zero, and behavioral responses to b have no first-order effect on welfare: $\partial V/\partial e = \partial V/\partial y_n = \partial V/\partial k = 0$. The envelope theorem then implies that the welfare derivative can be written as a function of the two partial derivatives $\partial V/\partial b$ and $\partial V/\partial \tau$ and the derivative of the government budget constraint:

$$\frac{dV}{db} = \frac{\partial V}{\partial b} + \frac{\partial V}{\partial \tau}\frac{d\tau}{db}. \tag{5}$$

Loosely speaking, $\partial V/\partial b$ represents the marginal benefit of increased UI, which is equivalent in utility terms to a marginal increase in consumption while unemployed. The second term represents the marginal cost in the form of higher taxes, with $d\tau/db$ identifying the size of the tax increase needed to pay for higher benefits and $\partial V/\partial \tau$ the welfare cost of higher taxes in terms of lost consumption. The partial derivatives are

$$\frac{\partial V}{\partial b} = \delta(1-s)U'(c_u), \tag{6}$$

$$\frac{\partial V}{\partial \tau} = -yU'(c_1) - (1-\delta)yU'(c_e) - \delta s y_n U'(c_u). \tag{7}$$

Therefore, the welfare derivative is

$$\frac{dV}{db} = \delta(1-s)U'(c_u) - \left[yU'(c_1) + (1-\delta)yU'(c_e) + \delta s y_n U'(c_u)\right]\frac{d\tau}{db}. \tag{8}$$

At the optimal level of UI, the right-hand side of (8) must be equal to zero. As in Baily's analysis, the goal is to express the right-hand side in terms of observable empirical quantities, to provide a simple mapping from these empirical quantities into the optimal value of the replacement rate.

I begin by replacing $U'(c_1)$ and $U'(c_e)$ using the individual's first-order condition for saving and a first-order Taylor series expansion of first-period marginal utility $U'(c_1)$ around $U'(c_u)$, specifically $U'(c_1) = U'(c_u) + \Delta c U''(\theta)$, where $\Delta c = c_1 - c_u$ and θ is between c_u and c_1. As demonstrated in online Appendix H.1, this allows the welfare derivative to be written in terms of $U'(c_u)$ and $U''(\theta)$:

$$\frac{dV}{db} = -2y\Delta c U''(\theta)\frac{d\tau}{db} - \left[(2-\delta)y + \delta s y_n\right]U'(c_u)\left[\frac{d\tau}{db} - \omega\right], \tag{9}$$

where $\omega = \frac{\delta(1-s)}{(2-\delta)y + \delta s y_n}$. To further simplify this expression, I follow Baily in making two additional assumptions, which are summarized below.

ASSUMPTION 1: *I assume that the wage distribution is degenerate with* $y_n = y$.

ASSUMPTION 2: *I assume that* $c_1 U''(\theta) = c_u U''(c_u)$.

Given these two assumptions,[30] and setting dV/db equal to zero, the following proposition characterizes the optimal level of UI benefits.

PROPOSITION 1: *Given Assumptions 1 and 2, the equation defining the optimal value of b is*

$$\frac{\Delta c}{c_1} R = (1-u) \frac{\frac{d\tau}{db} - \omega}{\frac{d\tau}{db}}, \tag{10}$$

where $R = \frac{-c_u U''(c_u)}{U'(c_u)}$ *is the coefficient of relative risk aversion and* $u = \frac{\delta(1-s)}{2}$ *is the unemployment rate. Equivalently, using elasticities, the optimal UI equation is*

$$\frac{\Delta c}{c_1} R = (1-u) \frac{E_b^\tau - \psi}{E_b^\tau}, \tag{11}$$

where $E_b^\tau = \frac{b}{\tau}\frac{d\tau}{db}$ *is the elasticity of* τ *with respect to b, and* $\psi = \frac{\omega b}{\tau} = \frac{ub}{ub + P}$ *is the fraction of total government expenditures allocated to UI.*

PROOF:

The proof of this result can be found in online Appendix H.1.

These equations state the condition that must hold at the optimum; even though b does not appear explicitly, only a value of b that causes (10) and (11) to hold can be optimal.

B. *Analysis of Optimal Benefit Equation*

In order to be able to use either of the equations derived above, I need to evaluate the response of taxes to benefits. Total differentiation of the government budget constraint (4) gives

$$\frac{d\tau}{db} = \frac{\delta(1-s) - \delta b \frac{ds}{db} - \delta \tau y \frac{ds}{db}}{(2 - \delta + \delta s) y}. \tag{12}$$

The three terms in the numerator represent three separate components of the response of taxes to benefits. I call the first the "mechanical effect": even if there is

[30] Assumption 1 replicates the standard assumption of no effects of UI on wages, as in Section I. Assumption 2, meanwhile, is necessary if I am to translate the second derivative of utility into an observable empirical quantity, specifically a coefficient of relative risk aversion. Online Appendix H.1 describes this assumption in greater detail.

no behavioral response to UI, if b increases, the tax rate must increase to compensate, and $\frac{\delta(1-s)}{(2-\delta+\delta s)y}$ represents the size of this increase. The second component is the "duration effect," and captures the fact that, if higher benefits increase the duration of unemployment, this increases the total amount of benefits paid, requiring a further tax increase. Finally, I refer to the third component as the "revenue effect": longer unemployment durations also reduce the amount of taxes paid on labor income, raising the required tax increase further still. Notice that while the magnitude of the duration effect doesn't depend on the size of government, the revenue effect is multiplied by τ; this highlights the importance of the standard assumption that τ is a small payroll tax, rather than a large marginal income tax, which leads to a significant understatement of the revenue effect of UI.

Writing in terms of elasticities, I can use (12) to solve for E_b^{τ}:

$$E_b^{\tau} = \psi + \left(\psi + \frac{u}{1-u}\right) E_b^D, \tag{13}$$

where $E_b^D = \frac{b}{1-s}\frac{d(1-s)}{db}$ is the elasticity of unemployment durations with respect to b. The three components of the tax response are apparent here as well: the first ψ is the mechanical effect, while the ψ and $\frac{u}{1-u}$ multiplying E_b^D represent the duration effect and the revenue effect, respectively.

I can now explain (11) as an intuitive representation of the trade-off between marginal benefits and costs of increased UI (the interpretation of (10) is equivalent). The left-hand side represents the welfare gain from increased UI in the form of consumption-smoothing, which is increasing both in the magnitude of risk aversion and the consumption shock upon unemployment. On the right-hand side, ψ is exactly equal to what I labeled as the mechanical effect, which is a lump-sum transfer of income between employed and unemployed states, and thus not a cost to society. The term $\frac{E_b^{\tau}-\psi}{E_b^{\tau}}$ is the fraction of the total response of taxes to benefits generated by the duration and revenue effects, or the cost of increased UI in terms of behavioral distortions. This, in turn, is weighted by the size of the tax base, $1-u$.

Combining (11) and (13), the equation for the optimum is

$$\frac{\Delta c}{c_1} R = (1-u)\frac{\left(\psi + \frac{u}{1-u}\right) E_b^D}{\psi + \left(\psi + \frac{u}{1-u}\right) E_b^D}. \tag{14}$$

This is the equation that I will use to solve for the optimal value of b, and the quantities that appear in (14) are the sufficient statistics.

However, even without a numerical analysis, I can draw some important lessons from (14). The standard assumption that $P = 0$ means $\psi = 1$; $\frac{u}{1-u}$ is likely to be a small number, so the mechanical and duration effects are large compared to the revenue effect, because the taxes that induce the revenue effect are so small.[31]

[31] Baily (1978) implicitly assumes $P = 0$, and adds an additional assumption, which is equivalent to assuming that $\psi + \left(\psi + \frac{u}{1-u}\right) E_b^D = 1$ in the denominator of (14); then the result simplifies to $\frac{\Delta c}{c_1} R = E_b^D$. The same result is found in Chetty (2006), motivating his conclusion that $\frac{\Delta c}{c_1}$, R, and E_b^D are the three sufficient statistics for optimal unemployment insurance.

However, if P is large, ψ will be small, meaning that the revenue component will be at least on the same order of magnitude as the mechanical and duration components.

The significance of a larger revenue component can be shown formally by examining the effect of non-UI spending P on the welfare derivative. In online Appendix H.2, I evaluate a derivative normalized into dollar terms, $\frac{dW}{db} \equiv \frac{\frac{dV}{db}}{U'(c_u)}$, and show that, under standard assumptions,[32] this welfare derivative is decreasing in P if and only if $E_b^D > 0$, as is overwhelmingly found in the empirical literature. This means that if two researchers estimate a baseline welfare derivative, one using $P = 0$ and the other a positive value of P, the latter will necessarily find a less positive welfare gain from increasing b.

The researcher with the positive P will also necessarily find a lower level of optimal UI if they assume strict quasi-concavity of welfare and use the method of statistical extrapolation recommended by Chetty (2009) and previously used by Baily (1978) and Gruber (1997): for each sufficient statistic in the optimal benefit equation, the available data is used to select the best functional form of that statistic with respect to b, allowing for an extrapolation of dW/db out of sample to find the optimum. If the same statistical extrapolations are used when $P = 0$ and when $P > 0$, then at the value of b that is optimal for $P = 0$, the welfare derivative with $P > 0$ will necessarily be negative, implying by quasi-concavity that the optimal b is lower with higher P.

C. *Numerical Results*

In this subsection, I will numerically evaluate (14) to find the optimal replacement rate r, by selecting baseline values for the sufficient statistics and then using the method of statistical extrapolation mentioned above. Online Appendix I provides a detailed explanation of the precise method used for extrapolation: the basic idea is to select functional forms and parameters for each of the quantities in (14) with respect to r, to provide the best approximation to how each will change as r is changed.

Many of the quantities for the sufficient statistics have already been used earlier in the paper, so the discussion will be kept brief. Starting with the functional form for the consumption drop, I use $\frac{\Delta c}{c_1} = 0.222 - 0.265r$ as in Gruber (1997). I also continue to use $E_b^D = 0.48 \times 0.53 = 0.2544$ and $R = 2$. As before, the baseline value of r is set to 0.46, and I use an initial unemployment rate of $u_0 = 0.054$. Then, let $u = \phi r^{E_b^D}$, where I can solve for $\phi = 0.0658$, allowing me to extrapolate u out of sample. Finally, with the tax rate on UI equal to $\tau_b = 0.17$, $\psi = \frac{ub}{(1-u)\tau y} = 0.83\frac{12.64}{24.3}\frac{ur}{(1-u)\tau}$, which equals 0.0402 at baseline. The parameter values are summarized in Table 6.[33]

[32] Specifically, I assume that $\frac{\Delta c}{c_1}R < 1 - u$; it is clear from (7) that $\frac{\partial V}{\partial \tau} < 0$, and then $\frac{\Delta c}{c_1}R < 1 - u$ follows immediately if Assumptions 1 and 2 are accurate, as those assumptions imply that $\frac{\partial V}{\partial \tau} = -2yU'(c_u) \times \left[(1-u) - \frac{\Delta c}{c_1}R\right]$.

[33] These quantities encode all relevant information from underlying structural parameters, making the welfare equations robust to many modifications of the model; Chetty (2006) shows that the results from Baily (1978) are applicable to a far more general class of models.

Table 6—Sufficient Statistics and Parameters

Statistic	Definition	Value/extrapolation
$\frac{\Delta c}{c_1}$	Employment/unemployment consumption gap	$0.222 - 0.265r$
E_b^D	Elasticity of D with respect to b	0.2544
R	Coefficient of relative risk aversion	2
r_0	Baseline replacement rate	0.46
u_0	Baseline unemployment rate	0.054
ϕ	Constant in unemployment rate function	0.0658
ψ	UI as fraction of government spending	$0.83 \frac{12.64}{24.3} \frac{ur}{(1-u)\tau}$

Table 7—Optimal Replacement Rates and Welfare Gains (*sufficient statistics*)

Scenario	Replacement rate r	Welfare gain
Fiscal externality	0.0000	0.62 percent
Benchmark	0.4595	0.00 percent

I solve the nonlinear first-order condition (14) for the optimal value of $r \in [0, 2]$,[34] and Table 7 presents the optimal r for my parameter values, as well as the results when I set $P = 0$ so that $\psi = 1$.[35]

The results for the optimal replacement rate are remarkably similar to those from the structural analysis: once again, fiscal externalities cause the optimal replacement rate to drop to zero, and the drop is more dramatic now, from about 46 percent. In other words, the usual analysis would indicate that the current average generosity of UI in the United States is optimal, but adding fiscal externalities is enough to make abolishing UI the optimal policy.

Meanwhile, I estimate the welfare gain by adding up dW/db—which is already expressed in consumption terms—from $r = 0.46$ to the optimum and dividing by mean consumption. Estimated welfare gains from the sufficient statistics method tend to be larger than those from the structural model, largely due to differences in models and assumptions about elasticities. The estimated welfare gain of 0.62 percent in the fiscal externality scenario—nearly 50 percent of initial UI spending—may be implausibly large, and is due to the assumption that unemployment goes to zero as r approaches zero.[36]

The results confirm that fiscal externalities can alter the nature of the optimal UI problem and significantly change the numerical results; the efficiency costs of UI are larger than previously recognized, and taking that into account can reduce the optimal level of UI all the way to zero.

[34] I assume that the government is not interested in extracting payments from unemployed workers, so a zero represents a corner solution.

[35] The latter case does not perfectly reproduce Baily's results; to do so, I also need to make an extra assumption made by Baily (1978). Specifically, I need to assume that $\psi + \left(\psi + \frac{u}{1-u}\right) E_b^D = 1$ in the denominator of (14), and then the result is $r = 0.3577$.

[36] If, instead of allowing dW/db to become very negative as $r \rightarrow 0$, I hold it constant at its $r = 0.303$ value (which is the peak of dW/db), the welfare gain drops to 0.27 percent of consumption, very similar to the 0.23 percent result from the structural analysis.

D. *Robustness Analysis*

I conclude this section by reporting additional results from the sufficient statistics approach to confirm the robustness of my conclusions. First of all, in Appendix B.B2, I consider the possibility that UI may affect the wages received by re-employed individuals. I show that fiscal externalities continue to lead to lowered optimal replacement rates if the elasticity of wages with respect to UI is small, but that the opposite conclusion holds with a sufficiently high wage elasticity: it is possible that fiscal externalities could lead to a significant increase in the optimal benefit level.

I then present an extensive series of sensitivity analyses in online Appendix K. I begin with the baseline model when $R = 5$, and show that the results are less dramatic in this case, though fiscal externalities continue to significantly reduce the optimal replacement rate. I also show that, when $R = 5$, effects of UI on wages have an effect on optimal replacement rates that is qualitatively similar to that with $R = 2$, though less quantitatively dramatic.

The rest of online Appendix K presents further sensitivity analyses for both $R = 2$ and $R = 5$. I try alternative values of E_b^D, specifically $0.48 \times \{0.3, 0.8\}$, and the optimal replacement rates move up in the former case and down in the latter; the effects of fiscal externalities remain significant in both cases. I then try two alternative baseline tax rates, $\tau_0 = \{0.15, 0.35\}$, and the effects of fiscal externalities are less severe in the former case and more so in the latter, but zero UI remains optimal when there is no effect of UI on wages even in the low τ_0 case. I also consider complete take-up of benefits, and I use a larger value of the initial unemployment rate, $u_0 = 0.064$; both changes slightly reduce the effect of fiscal externalities on optimal replacement rates, but I still obtain zeros for $R = 2$.

In online Appendix L, I report the baseline values of dW/db, for comparison with results from Chetty (2008). The results are qualitatively similar to those elsewhere in the paper, as values of dW/db cluster around zero in the benchmark scenario but range from -0.08 to 0.18 in the fiscal externality scenario.

I also examine equation (B2) and the underlying equation for dW/db analytically in online Appendix M, where I produce a series of results that are more general than the specific numerical estimates above. Among other results, I show that fiscal externalities increase the welfare derivative and b^* if and only if higher UI increases the tax base, or $d(sy_n)/db > 0$, and that if there is an effect of UI on wages, the effect of fiscal externalities on the optimal b^* follows a single-crossing property in that wage effect.

Finally, I also perform a number of extensions to the model in online Appendix N. I allow for stochastic duration of unemployment, and restrictions on borrowing during unemployment, which both tend to move the optimal replacement rate closer to one, and I use a second-order Taylor series expansion of marginal utility, and allow for variable labor supply on the initial job, which both reduce the optimal benefit level. However, the results are still quite similar, and the qualitative conclusions are unchanged: the pairwise comparisons of optimal replacement rates in the two scenarios are nearly identical in each case. I also show that, if G is endogenous and chosen optimally by the government, the impact of fiscal externalities on the welfare derivative and the optimal level of UI is either unchanged or larger, depending on which elasticities we can actually observe empirically.

III. Conclusion

The optimal UI literature has explored many aspects of the design and generosity of unemployment insurance systems, but the numerical impact of fiscal externalities on optimal policy has not previously been studied, and I have demonstrated in this paper that this is an important omission. My results demonstrate how substantial an impact fiscal externalities resulting from income taxes can have on optimal UI calculations, while the sensitivity analyses indicate the previously unrecognized importance of parameters such as the elasticity of post-unemployment wages with respect to UI benefits.

I present results from both of the main approaches in the existing optimal UI literature, specifically the macro-based structural approach and the sufficient statistics method. The baseline results from both approaches, using the most typical set of parameters including a zero elasticity of wages with respect to benefits, feature an optimal replacement rate of zero. These results indicate that the efficiency costs of UI are likely to be more severe than has previously been recognized. However, appropriate parameter values—including the effect of UI on wages and the coefficient of relative risk aversion—remain uncertain, and my analysis abstracts from a variety of potential secondary impacts of UI, such as impacts on human capital accumulation,[37] or interactions of UI with other government programs. For example, in Lawson (2015), I examine how the welfare analysis of UI is further complicated by substitution of individuals between UI and programs such as Disability Insurance. As such, it would certainly be premature to conclude that UI should be abolished; further empirical and welfare analysis is needed.

This paper also raises a number of new questions, about how past work on UI policy over the business cycle may be affected by fiscal externalities, and about the role of active labor market programs in reducing durations of unemployment and facilitating better matches. One lesson of this paper is that relatively small improvements in labor market efficiency can provide significant welfare benefits when the labor market is already highly distorted, suggesting that any benefits provided by active labor market programs might be larger than previously realized.

Finally, the insights in this paper can also be generalized into other areas of government policy. In Lawson (2017b), a companion paper which follows the current paper, I apply to college tuition subsidies an analysis that is similar to the current paper. Meanwhile, substantial literatures examine the effects of other social insurance programs on labour market outcomes, including disability insurance, old age security, and health insurance policy. As in the area of UI, welfare analyses of these programs typically abstract away from other roles of government (for example, Feldstein 1985 on social security, Golosov and Tsyvinski 2006 on disability insurance, and the analysis of public health insurance in Chetty and Saez 2010), thus ignoring fiscal externalities and leaving room for future work which addresses their consequences.[38]

[37] Brown and Kaufold (1988) suggest that UI could encourage investment in education, if it reduces the riskiness of the return to education.

[38] Parry and Oates (2000) recognizes the importance of interactions between environmental policies and the tax system, and argues that this will apply to other programs and institutions that raise the cost of living, but they restrict their discussion to areas of trade, agriculture, occupational licensing, and monopolies. Some studies of the

Appendix A: Sensitivity Analyses and Extensions of Structural Model

A1. *Sensitivity Analyses*

I have performed a wide range of sensitivity analyses, to examine how the results change when the parameters or moments used in calibration are altered. First, I present the results of a variety of alternative calibrations of the fiscal system in Table A1. In the cases when I ignore all social insurance taxes, or set them to 2.9 percent (to reflect only the Medicare tax), or use a 5.5 percent federal average tax rate (the historically low value for the second quintile in 2010), the effect on the optimal replacement rates is modest: the effect of fiscal externalities remains large. The same is true when I drop individuals with weekly wages above twice the maximum UI benefit from my CPS sample; those individuals will tend to face capped benefits and thus might be less responsive to UI, and without them the estimated tax rates decline, but omitting them makes little difference to the optimal replacement rates. Finally, if L is omitted entirely from the analysis and the average tax rate of 12.1 percent is used as a single tax rate applying to all income, the effect of fiscal externalities is significantly reduced, but still large enough to reduce the optimal r by 0.17. To summarize, the importance of fiscal externalities to my analysis is robust across each specification, and the results are numerically similar to the baseline analysis unless the marginal tax rate declines significantly; the value of the average tax rate is relatively unimportant in the analysis of the optimal replacement rate.

Next, the results of a series of sensitivity analyses on the model parameters are presented in Table A2. It is striking how robust the baseline results are to the changes considered. A smaller job separation rate and a larger unemployment rate both leave the results essentially unchanged, as does allowing for perfect take-up or utility from leisure when unemployed. Matching 0.1001 to the drop in consumption at the moment of job loss rather than the average consumption gap raises the optimal benefit levels, but a significant effect of fiscal externalities remains. Allowing for lower and higher values of E_b^u leads to higher and lower optimal replacement rates respectively, but the effect of fiscal externalities remains significant in each case.

The only cases in which the results are dramatically altered are when a positive interest rate is used, and when I allow for two types of individuals. In the former case, the optimal replacement rate is significantly lowered in the benchmark case, perhaps so much as to eliminate the gap in optimal policy, but even then the welfare gain is much larger when fiscal externalities are considered, suggesting that the zero lower bound is "more binding" in that case. Meanwhile, the two-type analysis assumes that half of the population fits my model, with a baseline unemployment rate of 10.8 percent, while the other half is never unemployed and receives wages

programs I discuss do take income taxes that pay for other spending into account, including Laitner and Silverman (2012) in the area of social security and Bound et al. (2004) on disability insurance, but even in these cases, there is no mention of the importance of this component or the fact that including it represents a departure from the rest of the literature. A recent paper, Hendren (2016), also points out the central importance of behavioral effects on the government budget constraint when performing welfare analysis of a government program: the government must weigh the fiscal externality (a term also used by Hendren) against net changes in transfers and net willingness to pay for the goods or services provided.

Table A1—Fiscal Sensitivity Analyses

(τ_0, ATR, τ_b)	Scenario	Rep. rate r	Welfare gain (*percent*)
No social insurance taxes	Fiscal externality	0.07	0.11
(0.187, 0.026, 0.17)	Benchmark	0.36	0.01
5.5 percent Federal ART	Fiscal externality	0.00	0.22
(0.282, 0.070, 0.17)	Benchmark	0.34	0.01
2.9 percent social insurance tax	Fiscal externality	0.02	0.14
(0.216, 0.055, 0.17)	Benchmark	0.36	0.01
$L = 0$	Fiscal externality	0.21	0.06
(0.121, 0.121, 0.121)	Benchmark	0.38	0.01
Drop high wages	Fiscal externality	0.00	0.19
(0.247, 0.122, 0.142)	Benchmark	0.34	0.01

Table A2—Model Parameter Sensitivity Analyses

	Scenario	Rep. rate r	Welfare gain (*percent*)
$(1+i)^{52} = 0.03$	Fiscal externality	0.00	0.77
	Benchmark	0.00	0.47
$\delta = \frac{1}{364}$	Fiscal externality	0.00	0.23
	Benchmark	0.34	0.01
$E_b^u = 0.1362$	Fiscal externality	0.07	0.09
	Benchmark	0.44	0.0004
$E_b^u = 0.3633$	Fiscal externality	0.00	0.37
	Benchmark	0.30	0.04
Perfect take-up	Fiscal externality	0.02	0.22
	Benchmark	0.32	0.03
$u = 0.07$	Fiscal externality	0.00	0.29
	Benchmark	0.35	0.02
Consumption drop	Fiscal externality	0.22	0.06
	Benchmark	0.55	0.01
Utility from leisure	Fiscal externality	0.00	0.21
	Benchmark	0.34	0.01
Two types	Fiscal externality	0.46	0.00
	Benchmark	0.75	0.13

32 percent higher (to roughly represent college graduates with an 8 percent wage bonus for each year of college). In this setting, UI benefits allow for significant redistribution to the lower income group, and accordingly optimal replacement rates are significantly higher, but the effect of fiscal externalities remains strong.

In online Appendix E, I perform all of these sensitivity analyses again for a case in which $R = 5$, and I find that while optimal replacement rates are higher, the results are qualitatively similar.

A2. *Extension to Finite-Duration Benefits*

I now attempt to model more realistically the finite duration of UI benefits; specifically, a period now represents a month rather than a week, and benefits expire after 6 months. I ignore the question of take-up and simply define the benefit level for UI recipients as $b = r(1 - \tau_b)$, which will tend to bias downwards the importance of fiscal externalities; however, for comparability with the baseline analysis, I calibrate L in the same way as before. To capture duration dependency and ensure that a reasonable proportion of unemployment spells are of long duration and involve exhaustion of benefits, I allow θ_t to increase with time t spent out of work according to experimental results in Kroft, Lange, and Notowidigdo (2013).[39]

Parameters and moments are in Tables D.5 and D.6 in online Appendix D.2, and the numerical results are in Table A3. This more realistic modeling choice has little effect on the results; the optimal replacement rates are essentially identical, and the welfare gain in the fiscal externality scenario is actually larger. I conclude that my results are robust to alternative specifications of UI benefits.

A3. *Results with Endogenous G*

Throughout the main analysis, I assume that G is an exogenous quantity; in this Appendix, I instead consider a case in which G is set to maximize social welfare conditional on the value of b. Specifically, to per period utility of both the employed and unemployed, I add $(1-\beta)\alpha\ln(G)$; multiplying by $(1-\beta)$ means that $\alpha\ln(G)$ can be added directly to the value functions. Since I assume that the government chooses G optimally, I find the α at which the baseline value of $G = 0.1032$ is optimal, which is $\alpha = 0.1448$. Then I search for the optimal replacement rate while, at each candidate value for r, finding the optimal value of G.

The results are presented in Table A4; the results for the benchmark scenario are simply reproduced from Table 4, since G does not feature there. The optimal replacement rates and welfare gains are effectively identical to the baseline results. Locally, it makes no difference to welfare whether or not the government can adjust G, since they are indifferent between raising G and cutting taxes.[40] Meanwhile, as b is reduced, the government balances tax reductions with an increase in G to 0.1047, and so the welfare gains must be at least as high as in the baseline case, because the government still has the option of keeping G constant and just lowering taxes. Additionally, since endogenous G means that the government doesn't cut taxes quite as dramatically when b decreases, the fiscal externality is even a bit stronger now at low b, reinforcing the case for low UI benefits.

The same general results would follow if G was a redistribution program like L rather than a public good: as long as the government sets G and L so that their marginal value to society is equal to that of a tax reduction, it makes no difference to welfare which is adjusted. The results for the optimal replacement rate would naturally change if redistribution changed at low b, i.e., if less generous UI affected eligibility for other transfer programs. This could go in either direction, depending on whether the alternative programs are substitutes or complements for UI, and

[39] Kroft, Lange, and Notowidigdo (2013) find that the interview-finding rate drops from about 7 percent to about 4 percent over the first six months of an unemployment spell, then remains roughly constant. Given a θ_1 and a target search intensity $s_1 = 0.35$, I find the θ_t for $t \in \{2,3,4,5,6,7\}$ (where 7 represents all periods of benefit exhaustion) that generates the same effort cost for $s_t = s_1 - (t-1)s_1/14$.

[40] One referee suggested that if G were instead set suboptimally high, raising UI could "starve the beast"; that is, keeping UI inefficiently generous would limit the government's ability to fund G above the efficient level. While possible, I consider this to be beyond the scope of the current analysis.

TABLE A3—OPTIMAL REPLACEMENT RATES AND WELFARE GAINS WITH FINITE-DURATION BENEFITS

Scenario	Replacement rate r	Welfare gain
Fiscal externality	0.00	0.30 percent
Benchmark	0.34	0.01 percent

TABLE A4—OPTIMAL REPLACEMENT RATES AND WELFARE GAINS WITH ENDOGENOUS G

Scenario	Replacement rate r	Welfare gain
Fiscal externality	0.00	0.23 percent
Benchmark	0.33	0.01 percent

could be an interesting subject for future study. However, it is beyond the scope of the current analysis: I focus on UI as insurance to the unemployed, and rule out the possibility that another program (such as social assistance) would be altered to take its place if UI were removed.

A4. *Results with Transitional Dynamics*

In focusing on a comparison of steady-states, my analysis is consistent with the vast majority of the existing optimal UI literature.[41] This choice was deliberate in order to maximize the comparability of my results to those in the literature. However, Lentz (2009) points out that the optimal policy is generally different when transitional dynamics are accounted for: reducing benefits is more costly than in a steady-state analysis because it requires that individuals reduce consumption along the transition path in order to accumulate more assets for self-insurance.

Therefore, in this Appendix, I investigate the sensitivity of my results to allowing for transitional dynamics. I assume that we start from the steady-state asset distribution at $r = 0.46$, and thus the calibration is identical to the baseline case. When considering a policy change to a new value of r, I solve for the new equilibrium value functions, choosing the tax rate that balances the government's intertemporal budget over the transition path, running for 5,000 periods (nearly 100 years) into the future. Then I calculate welfare by weighting the value functions by the current baseline asset distribution, rather than the steady-state distribution at the new r.

The results are displayed in Table A5. In each case, the optimal replacement rate is larger; raising benefits allows individuals to consume savings along the transition path, raising welfare. However, the effect of fiscal externalities remains strong: the

[41] This majority of the literature includes Baily (1978), Hansen and İmrohoroğlu (1992), Davidson and Woodbury (1997), Hopenhayn and Nicolini (1997), Wang and Williamson (2002), Chetty (2006), Coles and Masters (2006), Coles (2008), and Hopenhayn and Nicolini (2009). In the case of sufficient statistic analyses, determining whether or not the analysis is "steady-state" is less straightforward, but Baily (1978) and Chetty(2006) both consider representative agents who start time with zero savings, and then accumulate and spend down assets at various points in time; they ignore the effects of policy changes on individuals with accumulated assets, which makes them analogous to a steady-state analysis.

Table A5—Optimal Replacement Rates and Welfare Gains with Transitional Dynamics

Scenario	Replacement rate r	Welfare gain
Fiscal externality	0.21	0.07 percent
Benchmark	0.52	0.003 percent

optimal replacement rate drops by 0.31, and so the main conclusion of the paper on the significance of fiscal externalities is robust to transitional dynamics.

Appendix B: Results with Effects of UI on Wages

To this point, I have assumed that UI has no effect on the wages received upon finding a new job, and that therefore the only labor market impact of UI is a lengthening of unemployment durations. This has long been the standard assumption in the literature; only Acemoglu and Shimer (2000) consider effects of UI on wages in a welfare analysis of unemployment insurance, and their analysis features a parametrized structural model with a wage distribution containing only two mass points. However, the idea that more generous unemployment benefits should raise reservation wages is suggested by many job search models,[42] and if UI thus raises the wages received by workers, this should be accounted for in the welfare analysis: higher wages imply a more positive effect on tax revenues, with beneficial welfare implications.[43]

Despite this fact, the existing empirical literature studying the responsiveness of post-unemployment wages to unemployment benefits is fairly sparse and reports a wide range of results; these results, along with those from papers answering questions on the impact of UI on other job characteristics, can be found in online Appendix G. Recent studies have tended to find relatively low estimates of effects of UI on wages, but since the empirical literature covers a wide range of values, in this Appendix, I will extend both of my approaches to allow for effects of UI benefits on reservation wages and therefore on observed post-unemployment wages.[44] I begin with an extension of the structural model, and then I will consider how wage effects can alter the conclusions from the sufficient statistics approach.

B1. *Structural Model with Wage Effects*

Job offers now contain a wage y drawn from a distribution $F(y)$, and an unemployed worker receiving such an offer decides whether to accept or to remain

[42] My analysis will be partial equilibrium, but for an early example of a general equilibrium theory model with an endogenous wage offer distribution, see Albrecht and Axell (1984). van Vuuren, van den Berg, and Ridder (2000) represents one example of a structural estimation of an equilibrium search model with wage dispersion.

[43] If I assume a zero-profit condition for entry, I can safely ignore any impact on firms, since their net return is always zero on average. If UI impacts other dimensions of job quality, such as duration, then the analysis could of course be further extended to those margins as well.

[44] Ultimately, what we want is an elasticity of discounted future wages over the individual's career with respect to UI benefits; however, long-run evidence on effects of UI on wages is hard to come by, so I will consider a range of possible values.

unemployed. Denoting the reservation wage by $\bar{y}$, the individual's recursive decision problem is

$$V_e(k,y) = \max_{k' \in \Gamma_{y(1-\tau)}(k)} \big[U((1+i)k + y(1-\tau) + L - k') + \beta[(1-\delta) V_e(k',y) + \delta V_u(k')] \big],$$

$$V_u(k) = \max_{k' \in \Gamma_b(k), \bar{y}, s \geq 0} \big[U((1+i)k + b + L - k') - e(s) + \beta[s \tilde{V}_e(k',\bar{y}) + (1 - s(1 - F(\bar{y}))) V_u(k')] \big],$$

where $\tilde{V}_e(k',\bar{y}) = \int_{y \geq \bar{y}} V_e(k',y)\, dF(y)$.

To calibrate the model, I now allow for a constant in the search disutility function: $e(s) = d + \frac{(\theta s)^{1+\kappa}}{1+\kappa}$, where d can be thought of as direct disutility from being unemployed; this is necessary in order to obtain the desired order of magnitude for the effect of UI on wages. Meanwhile, the wage is defined as $y = \underline{y} + y_{LN}$, where $\underline{y}$ is a constant and $y_{LN} \sim \ln N(\mu, \sigma^2)$; for the purpose of simulations, a discretized approximation is used with intervals of 0.002 over a central portion of the distribution and mass points at each end containing the remainder of the mass, at the mean value for said mass.

The parameters are set to match the previous moments, as well as a mean wage of 1 (or 0.7293) at baseline and a wage elasticity $\frac{d \ln(E(y))}{d \ln(b)}$. For the latter value, I use estimates derived from Nekoei and Weber (2017), who perform a regression-discontinuity estimation of the effect of UI duration on unemployment duration and wages in Austria.[45] They find that a 9-week increase in potential UI duration raises wages by 0.45 percent and unemployment durations by 1.67 percent (a 1.9 day increase from an average base of 114 days); further discussion in online Appendix G explains that, given central estimates used elsewhere in the paper on the fraction of overall jobs affected by UI, this corresponds to a value of $\frac{d \ln(E(y))}{d \ln(b)} = \frac{0.432}{1.892} \frac{0.45}{1.67} 0.2544 = 0.0157$. The parameters and moments can be found in Tables D.9 and D.10 in online Appendix D.3, and the numerical results are in Table B1.

Allowing for this positive effect on wages leads to dramatically different results from those observed in Table 4; while the optimal replacement rates are higher in both cases, this is especially true in the fiscal externality scenario, sufficiently so that fiscal externalities actually lead to an increase in the optimal benefit level. Online Appendix E demonstrates that similarly dramatic results can be found for the case in which $R = 5$. Therefore, if UI benefits increase reservation wages and thus subsequent wages by an amount that is conceivable given the existing empirical estimates,

[45] While Nekoei and Weber (2017) consider the effect of changes in UI *durations* rather than the benefit level, this is outweighed for my purposes by the careful empirical design and the fact that their estimates seem to represent a plausible upper bound among recent estimates of effects of UI on the tax base.

TABLE B1—OPTIMAL REPLACEMENT RATES AND WELFARE GAINS WITH WAGE EFFECTS

Scenario	Replacement rate r	Welfare gain
Fiscal externality	0.51	0.003 percent
Benchmark	0.45	0.001 percent

the resulting positive effect on income tax revenues can overturn the earlier conclusion of lower optimal UI.

B2. *Sufficient Statistics with Wage Effects*

I now extend the sufficient statistics approach to account for effects of UI on wages. I begin by returning to (9), and while I maintain Assumption 2, I replace Assumption 1 with 1.A.

ASSUMPTION 1.A: *In the analysis in this subsection, I assume that y_n comes from a nondegenerate distribution, but that in equilibrium, y_n will be approximately equal to y.*

This assumption states that, although y_n is chosen by the worker from a nondegenerate distribution, the value that is chosen in equilibrium is not very different from y. In general, the optimal level of UI depends both on the level of y_n (as that determines the weight placed on income lost from unemployment) and the elasticity of y_n with respect to UI benefits; Assumption 1.A allows the elasticity to impact the results, but fixes the level effect of y_n by assuming it to be close to y. As in the case of Assumption 2, this can only be an approximation, since the worker is now allowed to choose y_n. Assumption 1.A then allows me to simplify the equation for optimal UI to as before, and I find a new expression for the derivative of the government budget constraint:

$$\frac{d\tau}{db} = \frac{\delta(1-s) - \delta b\frac{ds}{db} - \delta\tau y\frac{ds}{db} - \delta s\tau\frac{dy_n}{db}}{(2-\delta+\delta s)y},$$

where the fourth term in the numerator is a second "revenue effect" capturing the gain in tax revenues if higher UI increases y_n, reducing the tax increase needed to finance higher benefits. Equation (13) is now

$$E_b^{\tau} = \psi + \left(\psi + \frac{u}{1-u}\right)E_b^D - \frac{\delta s}{2(1-u)}E_b^y, \tag{B1}$$

where $E_b^y = \frac{b}{y_n}\frac{dy_n}{db}$ is the elasticity of post-unemployment wages y_n with respect to b, and so the equation for the optimum is

$$\frac{\Delta c}{c_1}R = (1-u)\frac{\left(\psi + \frac{u}{1-u}\right)E_b^D - \frac{\delta s}{2(1-u)}E_b^y}{\psi + \left(\psi + \frac{u}{1-u}\right)E_b^D - \frac{\delta s}{2(1-u)}E_b^y}. \tag{B2}$$

This equation can be utilized to provide numerical results as before, but there are three new statistics to take into account: E_b^y, s, and δ. Table G.1 in online Appendix G presents the wide range of estimated values of the effect of UI on wages from the empirical literature, and I attempt to capture that wide range of values by using $E_b^y = 0.48 \times \{-0.17, 0, 0.1, 0.2, 0.4, 0.64\}$.[46] Meanwhile, the starting value s_0 depends on the way the structure of the model is interpreted. If the two periods are taken literally to represent two years, then the finding of Chetty (2008) that the mean unemployment duration in his sample is 18.3 weeks implies an estimate of $s_0 = \frac{52 - 18.3}{52} = 0.648$. If, however, the model represents a larger portion of an individual's working life, perhaps its entirety, then the fact that Farber (1999) finds that 20.9 percent of workers aged 45–64 had at least 20 years of tenure in 1996 can be interpreted to mean that $\delta = 0.791$, so $s_0 = 1 - \frac{2u_0}{\delta} = 0.863$. To cover this range of possibilities, I use the set of values given by $s_0 = \{0.648, 0.725, 0.8, 0.863\}$. Then, in each case, the definition $u_0 = \frac{\delta(1 - s_0)}{2}$ implies a fixed value of δ. Table B2 presents the optimal r for my parameter values, as well as the results when I set $P = 0$, and I report a numerical check on the second-order conditions in online Appendix J.

The difference between the two scenarios is substantial; as already seen earlier, for low values of E_b^y, fiscal externalities from the income tax cause the optimal replacement rate to drop to zero, but now we see that for higher values of E_b^y, the replacement rate increases significantly, perhaps even above one.[47] For comparison to the case studied with the structural model in the previous subsection, the corresponding value of E_b^y is $\frac{1.892}{0.432}\,0.0157 = 0.0688$, and the optimal replacement rates with $s_0 = 0.8$ and $E_b^y = 0.0688$ are 0.4771 in the benchmark case and 0.4974 in the fiscal externality scenario, quite similar to the estimates of 0.45 and 0.51, respectively, from the structural model. In online Appendix K, I report results for $R = 5$ as well, and show that although the effect of fiscal externalities is less dramatic, the optimal replacement rates spread out as seen here.

An important lesson from these results is that if P is assumed to be zero, effects of UI on wages have a relatively small impact on optimal UI, but the effect is multiplied significantly once a positive P is used in the calculations. It is therefore not surprising that previous work has ignored any effects of UI on wages, as in their analysis it would not have a large impact. However, although the optimal replacement rate is zero under standard assumptions, it is highly sensitive to the effect of UI on wages over the empirically plausible range, and better estimates of the wage effects of UI are therefore critical to the determination of the optimal generosity of UI.

[46] Since estimates of E_b^y are based on samples of UI recipients, I again multiply by 0.48.

[47] Since the replacement rate corresponds to that from a real-world six-month UI benefit, this does not correspond to infinite-duration benefits of greater value than wages, as that would shut down all job search in the economy.

TABLE B2—OPTIMAL REPLACEMENT RATES CALCULATED FROM (B2)

		s_0			
		0.648	0.725	0.8	0.863
Optimal r for benchmark scenario					
E_b^y	−0.0816	0.4500	0.4459	0.4390	0.4275
	0	0.4595	0.4595	0.4595	0.4595
	0.048	0.4651	0.4675	0.4717	0.4789
	0.096	0.4707	0.4756	0.4842	0.4987
	0.192	0.4821	0.4921	0.5095	0.5399
	0.3072	0.4959	0.5122	0.5410	0.5922
Optimal r for fiscal externality scenario					
E_b^y	−0.0816	0	0	0	0
	0	0	0	0	0
	0.048	0.0278	0.2228	0.3831	0.5287
	0.096	0.3614	0.4706	0.6076	0.7851
	0.192	0.5734	0.7024	0.8842	1.1356
	0.3072	0.7361	0.8969	1.1290	1.4514

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