Federal Subsidization and Optimal State Provision of Unemployment Insurance in the United States *

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Abstract

This paper studies cross-sectional differences in U.S. state provision of unemployment insurance and the distortionary effects of federal unemployment benefit subsidies in a dynamic labor search model. The paper has two main findings. First, differences in the job-separation rate and the job-finding rate within the model can generate the negative correlation between the average benefit provided by a state and the state's unemployment rate, as observed in the data. Secondly, the model shows how the federal subsidization of unemployment benefit extensions in high-unemployment states causes an over-provision of the benefit, which in turn increases the unemployment rate in those states. Because the extensions are federally subsidized, however, the welfare loss due to the distortion is offset by the benefits of redistribution between states.

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1 Introduction

How much does the federal subsidization of unemployment insurance (UI) in the United States affect the amount of UI provided by each state? How does the subsidy affect job search effort and unemployment rates across states? Why are average UI benefits and unemployment rates negatively correlated across states? This paper answers each of these questions in a dynamic general equilibrium model of UI and labor search.

Insurance allows individuals to pool resources and sustain a quality of life, given the possibility of facing adverse outcomes. When a market for insurance does not exist, often because of some difficulty in verifying outcomes, a potential role for government is created. The government can still improve the expected welfare of individuals by carefully taking their decisions into account and providing the best feasible policy. One of the best known examples of this government-sponsored provision of insurance is UI. The rigidity in this insurance market results mainly for two reasons. First of all, individuals tend to prefer leisure over work. Secondly, once an individual becomes unemployed, searching for a new job can require a significant effort. Therefore, UI reduces the incentives to search for a job intensely at a given time, which in turn reduces the probability of finding a job quickly. Although verifying this search effort is too costly for private insurance providers, the benefits to individuals of sustaining a quality of life during an unemployment spell are sufficiently large for government to provide this benefit.

The decision by a government regarding the optimal provision of UI should be the result of a careful comparison between the benefits of consumption smoothing and the costs of taxation and moral hazard that results from the inability to observe job search effort. In the United States, however, the design of UI financing between the states and the federal government adds another dimension to the state government's decision regarding the optimal provision of UI. Generally, states are allowed to choose the level of UI provided to their own residents. If a state's unemployment rate is high and rising, the federal government requires the state to extend the number of weeks that UI is provided to a recently unemployed individual. The federal government then subsidizes half of these extended benefit payments. This particular subsidy is based on a state's idiosyncratic labor market conditions and creates an incentive for recipient states to offer higher benefit levels. Sometimes, however, if aggregate conditions cause unusually high unemployment throughout the entire country, the federal government mandates and subsidizes UI extensions in all states. The Emergency Unemployment Compensation program of 2008 (EUC08), for example, is a federal program that financed UI extensions in every state.

This paper studies the distortion of state-provided UI caused by the federal subsidization of UI extensions. The benchmark model is designed to simulate the permanent federal UI policy, whereby a state with high unemployment must extend the duration of UI from 26 to 39 weeks. In the model, the federal government partially finances a state's UI through a lump-sum tax on employed individuals in all states. A simple model shows the mechanism driving the over-provision of UI when the federal government subsidizes a portion of the benefit. Once the intuition from the simple model has been gained, the model is extended to replicate the relevant features of the federal-state provision of UI in the United States. In the extended model, unemployed individuals choose job search effort endogenously. Job search is costly to the individual, but it increases the probability of finding a job. States cannot condition UI policy on job search; instead they must take the optimal responses of individuals as given (Phelan and Townsend (1991), Hopenhayn and Nicolini (1997), Wang and Williamson (1996)). States also take federal policy as given. Federal policy has two dimensions: the extended benefit trigger and the partial subsidization of the extended benefits. The state takes this federal policy and the responses of individuals as given and chooses the benefit level that maximizes the *ex-ante* expected utility of its residents.[1] Because states have a positive measure and the UI chosen by a state can affect the federal tax imposed on other states, the equilibrium concept is a stationary, single-stage Nash equilibrium. The model is calibrated by choosing a state's job-separation rate and job-finding parameter such that states' optimal replacement ratio and equilibrium unemployment rate match the respective data.[2] The outcome of the benchmark

[1]Because the focus of this paper is the cross-state differences in the optimal benefit level and not an analysis of overall welfare, some features of the optimal benefits level are omitted for simplicity. For example, this paper assumes that the benefit level is constant throughout the unemployment spell. This assumption is consistent with the way UI is administered in the US. Another example is the lack of individual saving. While the individual saving might be important for an analysis focused on the optimal UI provision, the simple model in this paper suffices for comparisons of state welfare levels.

[2]The replacement ratio is defined as the average weekly benefit payment divided by the average gross weekly earnings.

model (federal subsidy) is compared to the counterfactual experiment, whereby the subsidy is removed, but the extended benefit trigger remains in effect. The results show that states with inherently higher unemployment rates choose a higher benefit provision in the benchmark model, further raising their unemployment rate. Also, the states with inherently lower unemployment rates choose lower benefit levels (relative to the economy with no subsidies), further reducing their unemployment rates. The numerical results, however, suggest that the welfare costs of the distortion are almost entirely offset by the benefits of redistribution between states.

The economics literature on UI can be divided into three categories: empirical, theoretical, and computational. Much of the empirical research focuses on the responsiveness of unemployment exit rates to UI levels and duration. Meyer (1990) estimates that a 10% increase in the benefit level leads to a 9% decrease in the exit rate from unemployment. Moffitt (1985) finds that a 1% increase in the benefit level increases unemployment duration by about .36%. Further, he shows that a one week increase in the duration of UI lengthens unemployment spells by around .15 weeks. Chetty (2008) shows how UI affects an individual's search effort through both moral hazard and liquidity effects. He finds that the liquidity effect is quite large and accounts for as much as 60% of the marginal increase in unemployment duration. Many recent papers also have focused on the economic effects of EUC08. Fujita (2011), for example, estimates that the UI extensions in EUC08 has increased the federal unemployment rate by around 1.2 percentage points.

The theoretical literature on UI is built on the foundations of job search (McCall (1970)). Phelan and Townsend (1991) study the tradeoff between insurance and incentives when actions are not observable. Shavell and Weiss (1979) and Hopenhayn and Nicolini (1997) study the application of this tradeoff in the context of optimal UI and show how the profile of the optimal UI benefit level is decreasing throughout the unemployment spell. Acemoglu and Shimer (2000) show how UI potentially encourages unemployed workers to find higher productivity jobs, thereby improving aggregate output and welfare.

Over the past two decades, much of the macroeconomics UI literature has focused on the numerical outcomes of dynamic models. Hansen and Imrohoroglu (1992) study the importance of liquidity constraints and moral hazard in a heterogeneous-agent dynamic general equilibrium model.

Hopenhayn and Nicolini (1997) show how the optimal replacement ratio is decreasing throughout an unemployment spell, and they compute the welfare gains of transitioning to the optimal UI profile. Wang and Williamson (1996) compute a dynamic general equilibrium model with moral hazard and show how adjustments to the UI profile and worker experience rating can improve expected welfare and decrease the unemployment rate in the US by as much as 3.4%. More recently, Nakajima (2011) computes a dynamic general equilibrium model of Mortensen and Pissarides (1994) and shows how the federal UI extensions mandated by EUC08 have increased the US unemployment rate by 1.2%.

The rest of the paper is organized as follows: Section 2 explains some relevant details of the US state and federal provision of UI. Section 3 presents a simple model to understand the theory and extends the model for computational analysis. Calibration and numerical results are presented in Section 4. Section 5 provides some concluding remarks.

2 UI in the United States

The current system of UI in the United States was originally mandated by the Social Security Act of 1935. States are generally allowed to choose UI eligibility, the amount of the benefit, and the duration of the benefit. Because of the variability in these factors, a complete review of the system would be lengthy and beyond the scope of this paper. Instead, this section focuses on the aspects of UI that are relevant for determining the optimal provision of benefits chosen by states. For an overview of the UI system in the US, see Hamermesh (1977).

With regards to the amount of the benefit, most states provide a weekly payment equal to some linear function of the individual's previous earnings up to some maximum amount. While many states choose similar linear functions, the maximum amount varies significantly across states. Since the limit is binding for a large portion of UI recipients, this variation in the maximum weekly benefit drives much of the state heterogeneity in average weekly payments. Most states choose to provide UI for up to 26 weeks.[3] Every state finances its UI provision through a tax on employers based on the earnings of the employed individuals. This tax on employers is also based on their frequency of

[3]Massachusetts and Washington pay up to 30 weeks.

job-separation. Alaska, New Jersey, and Pennsylvania also finance part of their UI system through a tax on employees.

Under favorable economic conditions, most states provide UI for up to 26 weeks. The federal government, however, can extend benefits based on either aggregate or idiosyncratic instances of high or rising unemployment.[4] The federal government extends benefits in two ways. The first is automatically triggered when a state's unemployment rate rises beyond some threshold. This trigger is purely based on states' idiosyncratic labor market conditions. The second is based on aggregate labor market conditions and is not automatic. This type of extension applies to all states and generally lags the business cycle because of lags in the legislative process. The federal government extended benefits in all states twice in the 1970's, once in the early 1980's, once during the 1990's, and once during the early 2000's. The extensions mandated by EUC08 financed the entire amount of unemployment benefits for up to 73 weeks beyond the state-financed benefit duration.[5]

The permanent federal UI policy partially subsidizes unemployment benefit extensions triggered by a state's unemployment rate. Specifically, the federal government pays for half of the state's extended benefit payments. The federal portion of these payments is financed through the Federal Unemployment Tax Act (FUTA), which is a federal tax on employers in all states based on a small portion of workers' earnings. The second type of benefit extensions, i.e., those determined legislatively based on aggregate conditions, are not necessarily financed through FUTA. They can be financed by general federal tax revenue.

The federal subsidization of UI extensions is designed to insure states against both idiosyncratic and aggregate labor market shocks. The policy, however, reduces the expected marginal cost of providing an extra dollar of UI, which creates an incentive for recipient states to increase the amount of UI provided. Because some states have persistently high unemployment rates, these states have the most to gain from raising the UI benefit amount. Figure 1 shows the relationship between average state unemployment rates from 1976-2011 and the average replacement ratio in the second quarter of 2011.

The correlation coefficient of the series in Figure 1 is $-.38$. This is a surprising result, considering

[4]Nakajima (2011) provides description of federal benefit extension programs.

[5]http://workforcesecurity.doleta.gov/unemploy/pdf/partnership.pdf

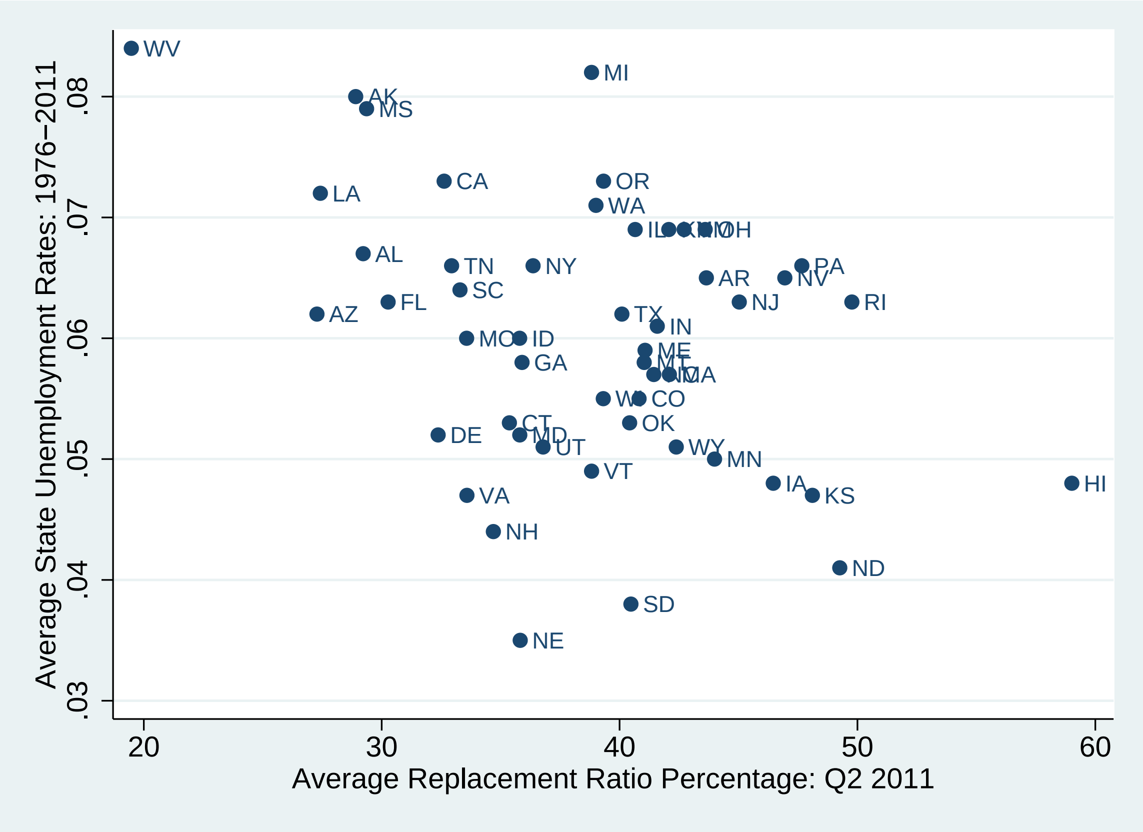

Figure 1: Average state unemployment rates and the average replacement ratio.

higher UI provision reduces the incentives for individuals to search for a job. Therefore, one might expect a state's unemployment rate to be *positively* correlated with the UI benefit provided. After accounting for differences in sources of unemployment across states and the decision faced by a representative social planner, however, the model is able to generate this surprising result. Fujita and Ramey (2009) give empirical evidence that the job-separation rate and the job-finding rate can explain variations in the unemployment rate throughout the business cycle. The model presented in this paper assumes that these two factors can also account for cross-sectional differences in unemployment rates across states.

3 Model

This section introduces a model that explains how the federal subsidization of UI affects the optimal provision of UI across states. The first part of this section presents a simple homogeneous-state model that shows how the subsidy distorts the decisions of the states. Once the theoretical foundations have been established, the model is extended to account for heterogeneity in states and many of the relevant features of the UI system in the US.

3.1 Simple Model

3.1.1 Individuals

The model economy consists of N identical states (as in geographic regions), indexed by $i = 1, \ldots, N$. Each state, i, is populated by a unit measure of infinitely-lived agents who remain in their state of residency for their entire life. Individuals' preferences are:

$$E \sum_{t=0}^{\infty} \beta^t u(z_t), \tag{1}$$

where z_t is the consumption of an individual in period t, β is the discount factor, $u(\cdot)$ is strictly increasing, strictly concave, twice continuously differentiable over $\mathbb{R}_+$, and satisfies $u(0) = 0$, $\lim_{z \to 0^+} u'(z) = \infty$, $\lim_{z \to \infty} u'(z) = 0$, and E is the expectation operator. An employed individual has consumption c, and with probability δ, the employed individual becomes separated from his job. Once separated from the job, the individual is unemployed and consumes the unemployment benefit b for one period (without loss of generality). If the unemployed individual does not become employed, then he transitions into uncovered unemployment, and $z_t = 0$ for the remainder of the unemployment spell. With exogenous probability p, any unemployed individual becomes matched with a job, and accepts it unconditionally. Dropping the time subscripts and using recursive notation, the value functions for these individuals are:

$$V^e(c,b) = u(c) + \beta((1-\delta)V^e(c,b) + \delta V^{uc}(c,b)) \tag{2}$$

$$V^{uc}(c,b) = u(b) + \beta(pV^e(c,b) + (1-p)V^{uu}(c,b)) \tag{3}$$

$$V^{uu}(c,b) = 0 + \beta(pV^e(c,b) + (1-p)V^{uu}(c,b)), \tag{4}$$

where the superscripts e, uc, and uu denote the employed, unemployed and covered, and unemployed uncovered, respectively. Let $\{\lambda^e, \lambda^{uc}, \lambda^{uu}\}$ be the stationary distribution of individuals in any given state. Then it can be shown that the utilitarian welfare function has the form:

$$W(c,b) = \theta_1 u(c) + \theta_2 u(b), \tag{5}$$

where $\theta_1 > 0$ and $\theta_2 > 0$.

3.1.2 Government

Suppose the federal government subsidizes a portion $1-\alpha$ of a state's unemployment benefit, b^i, where $\alpha \in [0,1]$. The federal subsidy is financed by a lump-sum federal tax, τ^f on employed residents of every state, satisfying federal budget constraint:

$$\tau^f = (1-\alpha)\frac{N\lambda^{uc}}{N\lambda^e}\sum_{i=1}^{N} b^i \tag{6}$$

Each state has a social planner whose objective is to maximize the *ex-ante* expected utility of its own residents by choosing the optimal level of the unemployment benefit for a given τ^f. The state finances this benefit by a lump-sum state tax, τ^i on it own employed residents. Then the consumption of the employed residents of state i is:

$$c^i = w - \tau^i - \tau^f, \tag{7}$$

where $w \in \mathbb{R}_{++}$ is the consumption endowed to the employed, and the state budget constraint for state i is:

$$\tau^i = \alpha \frac{\lambda^{uc} b^i}{\lambda^e} \tag{8}$$

Notice how the tax bill of the employed agent depends on the decision of its own state's government and the decision of all other states' governments via τ^f. This interaction between the states caused by the federal subsidy can be studied as the outcome of a static game. Let b^{-i} denote the benefit level chosen by all states except for state i, and let $W(b^i, b^{-i})$ denote the welfare of state i for a given set of strategies, $\{b^1, \ldots, b^N\}$. Then the game can be defined as follows:

Definition 1. *A game is a set of N states choosing strategies $\{b^1, \ldots, b^N\}$, which have payoffs $\{W(b^1, b^{-1}), \ldots, W(b^N, b^{-N})\}$, where*

$$W(b^i, b^{-i}) = \theta_1 u \left(w - \alpha \frac{\lambda^{uc} b^i}{\lambda^e} - (1-\alpha) \frac{N\lambda^{uc}}{N\lambda^e} \sum_{j=1}^{N} b^j \right) + \theta_2 u(b^i), \quad \textit{for all } i = 1, \ldots, N. \tag{9}$$

The decision of the state can be written as a best response to the decision of all other states as follows:

$$BR_i(b^{-i}) = \underset{b^i}{\operatorname{argmax}} \; W(b^i, b^{-i}) \tag{10}$$

where $BR_i(b^{-i})$ is the best response of state i to the actions of all other states. Now the Nash equilibrium can be defined as follows:

Definition 2. *A Nash Equilibrium is a set of strategies $\{b^1, \ldots, b^N\}$ such that $b^i = BR_i(b^{-i})$ for all $i = 1, \ldots, N$.*

Because states are identical in their primitives, it's reasonable to focus on the set of symmetric Nash equilibria, defined as follows:

Definition 3. *A symmetric Nash equilibrium is a strategy $b^* \in \mathbb{R}_+$ such that $b^* = BR_i(b^{-i})$ for all $i = 1, \ldots, N$.*

3.1.3 Distortionary Effect of the Federal Subsidy

In order to understand how the federal subsidy distorts the decision of the state, the solution to the federal social planner's problem is compared to the symmetric Nash equilibrium. This section solves the social planner's problem and shows the optimal solution is unique. Then, the benefit provision chosen by states in the Nash equilibrium is shown to be larger than the optimal benefit provision chosen by the social planner. This result is commonly know as a *free-rider problem* or more specifically, *problem of the commons*.

Let $W_f(b^1, \ldots, b^N) = \frac{1}{N}\sum_{i=1}^{N} W(b^i, b^{-i})$ denote the welfare function of the federal social planner, and let $\lambda_e > \lambda_{uc}$. Then the social planner's problem is written as follows:

$$\max_{c_1,\ldots,c_N,b^1,\ldots,b^N} \frac{1}{N}\sum_{i=1}^{N}\big(\theta_1 u(c^i) + \theta_2 u(b^i)\big) \tag{11}$$

$$\textit{subject to} \quad \lambda_e \sum_{i=1}^{N} c^i + \lambda_{uc}\sum_{i=1}^{N} b^i = \lambda_e N w, \tag{12}$$

where (12) is the resource constraint. Let μ be the multiplier on (12). Then the first-order conditions are

$$c^i\colon \quad u'(c^i) = \frac{\mu\lambda_e}{\theta_1} \quad \forall\ i = 1, \ldots, N \tag{13}$$

$$b^i\colon \quad u'(b^i) = \frac{\mu\lambda_{uc}}{\theta_2} \quad \forall\ i = 1, \ldots, N \tag{14}$$

Let the vector $\hat{S} = (\hat{c^1}, \ldots, \hat{c^N}, \hat{b^1}, \ldots, \hat{b^N})$ be a solution to (13) and (14). Then the following theorem claims that the optimal employed consumption and unemployment compensation are unique and equal across states.

Theorem 1. *There exists a unique* $\bar{c} \in \mathbb{R}_+$ *and* $\bar{b} \in \mathbb{R}_+$ *such that* $\hat{c}^i = \bar{c}$ *and* $\hat{b}^i = \bar{b}$ *for all* $i =$ *1,. . .,N.*

Proof. $u'(\cdot) > 0$, $u''(\cdot) < 0$, $\lim_{z \to 0^+} u'(z) = \infty$, and $\lim_{z \to \infty} u'(z) = 0$ imply that $\hat{S}$ is a unique global maximum. Also, since the RHS of (13) is constant, and (13) holds for all $i = 1, \ldots, N$, then there exists a $\bar{c} \in \mathbb{R}$ such that $\hat{c^i} = \bar{c}$ for all $i = 1, \ldots, N$. An analogous argument holds for $\hat{b^i}$. □

Using the results of the proof of Theorem 1, it can be shown that the optimal solution to the social planner's problem, $\bar{b}$, satisfies the following equation:

$$\frac{u'(w - \frac{\lambda_{uc}}{\lambda_e}\bar{b})}{u'(\bar{b})} = \frac{\lambda_e \theta_2}{\lambda_{uc}\theta_1}. \tag{15}$$

This result will be an important basis of comparison between the federal social planner's solution and the solution to the Nash Equilibrium.

Now consider the benchmark model. Suppose the federal government finances a percentage $1-\alpha$ of each state's unemployment insurance. Then (10) represents the decision of each state, and the following theorem characterizes the Nash equilibrium for each level of the federal subsidy:

Theorem 2. *Let* b^* *denote the symmetric Nash equilibrium of this economy. If* $\alpha = 1$ *(no federal subsidies), then the symmetric Nash equilibrium is equivalent to the solution of federal social planner's problem, and* $W(b^*, b^*) = W(\bar{b}, \bar{b})$*. If* $\alpha \in [0, 1)$ *(positive federal subsidies), then* $b^* > \bar{b}$ *and* $W(b^*, b^*) < W(\bar{b}, \bar{b})$*.*

Proof. See appendix. □

Theorem 2 claims that if the federal government finances a portion of unemployment benefits by levying equal lump-sum taxes on employed agents in all states, then the UI chosen by each state exceeds the quantity chosen when the federal government does not subsidize any portion of UI and reduces social welfare.

3.2 Extended Model

The simple model studied in the previous section was sufficient for understanding how the federal subsidy distorts the decision of the recipient states. This section extends the model in two important ways. First, unemployed individuals will participate in a job search that affects the probability of a job match. Job search effort is costly to the individual and sensitive to the quantity of the UI benefit and the duration of unemployment. Therefore, the distribution of agents in a given state will now depend on the UI provision in that state. The second extension is state heterogeneity in the labor market. Now states will differ in both the job-separation rate, and a parameter affecting the job-finding rate. Differences in these parameters will generate differences in unemployment rates across states. Since the UI extension trigger and federal subsidy eligibility depend on a state's unemployment rate, the state must now account for this outcome in its UI provision decision. All these factors are necessary for understanding the distortionary effects of federal subsidies, and they are modelled explicitly in this section.

3.2.1 States

Each state is now defined by a job-separation rate, $\delta^i \in (0, 1)$ and a job-finding parameter, $r^i \in \mathbb{R}$. States are each endowed with a unit measure of individuals. Individuals in each state are either employed, unemployed and receiving UI, or unemployed and not receiving UI. A state provides benefit level $b^i \in \mathbb{R}_+$ for some finite duration, $T^i \in \mathbb{R}_+$, to the unemployed individuals receiving UI. Depending on a state's extended benefit status, T^i will either be 26 weeks if the state has no extended benefits or 39 weeks if the state has extended benefits. Any state-funded portion of the UI provision is financed by levying lump-sum tax τ^i on employed residents of that state.

3.2.2 Federal Government

Any policy decision of the federal government is taken as exogenous in the benchmark model. Each state must finance the first 26 weeks of an individual's UI payments. However, if a state's unemployment rate passes some threshold level, U_{thresh}, then the state is federally mandated to extend UI coverage duration for an additional 13 weeks. The state must then pay for half of the amount of UI payments provided in the additional 13 weeks. The federal government pays for the remaining half of the extended benefit payments. Federal expenditures are financed by a uniform lump-sum tax, τ^f, on the employed workers in each state.

3.2.3 Individuals

An individual is born into state i, lives infinitely, and remains a resident of state i permanently.[6] Individual preferences are now represented as:

$$E\sum_{t=0}^{\infty}\beta^t[u(z_t)-\phi a_t], \tag{16}$$

where a_t is job search effort and ϕ is a constant. Each state i is populated by T^i+2 types of individuals. Type 1 individuals are employed. As in the simple model, employed individuals receive wage $w \in \mathbb{R}_{++}$ in units of the consumption good, pay state tax τ^i, and federal tax τ^f, and their after-tax consumption is

$$c^i = w - \tau^i - \tau^f. \tag{17}$$

Maintaining a job requires no effort, but with exogenous probability δ^i, the individual becomes unemployed. Type $j = 2, \ldots, T^i+1$ individuals are unemployed for the $(j-1)^{th}$ consecutive week and receive unemployment benefit b^i. Type T^i+2 individuals have been unemployed beyond the duration of UI coverage and receive zero consumption.[7] For job search effort a_j, any unemployed individual finds a job with probability $p(a_j;r^i)$, where $p(\cdot;r^i)$ is increasing and concave in the variable a and increasing in the parameter r. To simplify notation, denote $p^i(a_j) \equiv p(a_j;r^i)$.

[6]This assumption of no mobility is plausible in the sense that US residents can not make ad hoc decisions to move to a different state shortly after job-separation in an effort to receive higher benefit payments.

[7]One objectionable assumption in this model is the lack of a welfare system. Such a system would allow an unemployed, uncovered individual to have positive consumption once UI has been exhausted. This might be a greater concern if utility of consumption represented a longer duration, as in Wang and Williamson (1996). However, since a period represents only one week, marginal utility of consumption is relatively low near the origin.

Value functions of the individuals (subscripted by their type) are:

$$V_1^i(c,b) = u(w-\tau^i-\tau^f) + \beta((1-\delta^i)V_1^i(c,b) + \delta^i V_2^i(c,b)) \tag{18}$$

$$V_j^i(c,b) = \max_{a_j} u(b^i) - \phi a_j + \beta(p^i(a_j)V_1^i(c,b) + (1-p^i(a_j))V_{j+1}^i(c,b)),\ \ j = 2,\dots,T^i+1 \tag{19}$$

$$V_{T^i+2}^i(c,b) = \max_{a_{T^i+2}} u(0) - \phi a_{T^i+2} + \beta(p^i(a_{T+2})V_1^i(c,b) + (1-p^i(a_{T+2}))V_{T^i+2}^i(c,b)). \tag{20}$$

3.2.4 Optimal Search Effort and the Stationary Distribution

As mentioned, search effort does not affect the probability of remaining employed. Therefore, an employed individual makes no decision. An unemployed individual, however, will choose the optimal search effort based on three (non-parametric) variables. First, a higher benefit level reduces an individual's search effort by reducing the opportunity cost of unemployment. Secondly, a higher employed consumption level raises search effort by increasing the opportunity cost of unemployment. Finally, search effort depends on the duration of the unemployment spell. The following equations represent the optimal search effort for a given employed consumption, benefit level, and unemployment duration:

$$a_j^i(c,b) = \underset{a_j\in[0,\infty)}{\operatorname{argmax}}\ \ u(b^i) - \phi a_j + \beta(p^i(a_j)V_1^i(c,b) + (1-p^i(a_j))V_{j+1}^i(c,b)),\ \ j = 2,\dots T^i+1 \tag{21}$$

$$a_{T^i+2}^i(c,b) = \underset{a_{T^i+2}\in[0,\infty)}{\operatorname{argmax}}\ \ u(0) - \phi a_{T^i+2} + \beta(p^i(a_{T^i+2})V_1^i(c,b) + (1-p^i(a_{T^i+2}))V_{T^i+2}^i(c,b)) \tag{22}$$

Substituting the optimal search effort into the function $p^i(\cdot)$ gives a set of hazard rates: $\{p^i(a_2^i(c,b)),\dots,p^i(a_{T^i+2}^i(c,b))\}$. Let $\left\{\lambda_{1,t}^i,\dots,\lambda_{T^i+2,t}^i\right\}$ denote the distribution of individuals in state i at time t. Then the job-separation rate δ^i combined with the hazard rates imply a law of motion described by the set of equations:

$$\lambda^i_{1,t+1} = (1-\delta^i)\lambda^i_{1,t} + \sum_{j=2}^{T^i+2} p^i(a^i_j(c,b))\lambda^i_{j,t} \tag{23}$$

$$\lambda^i_{2,t+1} = \delta^i \lambda^i_{1,t} \tag{24}$$

$$\lambda^i_{j+1,t+1} = (1-p^i(a^i_j(c,b)))\lambda^i_{j,t} \quad \text{for } j = 2,\ldots,T^i \tag{25}$$

$$\lambda^i_{T^i+2,1} = (1-p^i(a^i_{T^i+1}(c,b)))\lambda^i_{T^i+1,t} + (1-p^i(a^i_{T^i+2}(c,b)))\lambda^i_{T^i+2,t}. \tag{26}$$

The first equation shows that the measure of employed agents equals those remaining employed plus those transitioning out of unemployment. The second equation shows the measure of agents that transition from employment to unemployment. The third equation represents the measure of individuals that transition from one week of covered unemployment to the next week of covered unemployment. Finally, the last equation represents the measure of individuals who are unemployed and uncovered. This last measure is equal to those who enter uncovered unemployment plus those who remain in uncovered unemployment.

Define Λ^i_t as the entire distribution of agents in state i at time t as follows:

$$\Lambda^i_t = \left\{\lambda^i_{1,t},\ldots,\lambda^i_{T^i+2}\right\}, \tag{27}$$

and let Γ^i be the state's transition function defined as follows:

$$\Lambda^i_{t+1} = \Gamma^i(\Lambda^i_t), \tag{28}$$

where $\Gamma^i(\cdot)$ satisfies the set of equations (23)-(26). Taking the infinite limit of this function for a given employed consumption level, c, and benefit level, b, gives the stationary distribution of agents:

$$\Lambda^i(c,b) = \lim_{t\to\infty} \Gamma^i(\Lambda^i_t). \tag{29}$$

3.2.5 Decision of the State

The policy decisions of each state are made by the state's social planner who chooses the quantity of the UI benefit, b^i that maximizes the *ex-ante* expected utility of the state's residents. The state takes federal policy and the moral hazard of unemployed individuals as given and chooses optimal UI benefit and state tax, τ^i. As implied by (29), both the benefit and the state tax will affect the distribution of individuals. Therefore, the marginal cost of an additional unit of benefit provision is not only the additional tax on employed agents, but also the increase in individuals that remain unemployed because of decreased search efforts. The marginal cost will also depend on whether the state provides 26 or 39 weeks of unemployment benefits. If the state offers 26 weeks, then the marginal cost of additional benefit is the marginal increase in the state tax required to fund 26 weeks of UI for unemployed individuals plus the increase in unemployed individuals. If the state offers 39 weeks of UI, then the federal subsidy reduces the marginal cost of financing the additional 13 weeks of UI coverage.

The possibility of triggering extended benefits adds another dimension to the state's decision. As mentioned above, federal policy requires the state to extend UI for an additional 13 weeks if the unemployment rate in a state exceeds some threshold level, U_{thresh}. To understand how the unemployment rate responds to both the benefit level and the unemployment benefit duration, consider the unemployment rate function $U^i : R^2_+ \rightarrow [0, 1]$, which assumes both the benefit level and benefit duration take a value in the positive real numbers. The function $U^i(b, T)$ maps the domain into the unit interval, representing the measure of unemployed residents in state i. As mentioned in the previous section, search effort is a *decreasing* function of both the benefit level and UI duration. Therefore, the unemployment rate is an *increasing* function of both the benefit level and UI duration. Figure 2 shows the functions $U^i(b, 26)$ and $U^i(b, 39)$. If there exists a $\hat{b} > 0$ such that $U^i(\hat{b}, 26) = U_{thresh}$, denote this value as $\hat{b} = b_{26}$. Then for a UI duration of 26 weeks, $b < b_{26}$ implies that $U^i(\hat{b}, 26) < U_{thresh}$. In other words, if the benefit provision remains within the interval $[0, b_{26})$, then unemployment benefit extensions will not be triggered, and $T^i = 26$. Now consider jump in the unemployment rate that results from extending the duration from 26 weeks to 39 weeks near b_{26}.

Since U^i is increasing in each of it's arguments, we know that $U_{thresh} = U^i(b_{26}, 26) < U^i(b_{26}, 39)$. Now, if there exists a $\hat{b}$ such that $U^i(\hat{b}, 39) = U_{thresh}$, denote this value as $\hat{b} = b_{39}$. Then we know that $b_{39} < b_{26}$. This means that a state could intentionally trigger unemployment benefit extensions by increasing b from $b_{26} - \epsilon$ to b_{26} for some small but positive ϵ. Then, once the benefit extension has been triggered, the state can reduce b below b_{26}, as far down as b_{39}, while allowing the federal government to finance half of the extended benefits. Therefore, it is assumed that the state can simply achieve whichever duration within the interval $[b_{39}, b_{26}]$ yields the higher welfare. The welfare function (given the decisions of other states) is defined as follows:

$$W^i(c,b) = \begin{cases} W^i_{26}(c,b) & \text{if } b < b_{39} \\ \max\left\{W^i_{26}(c,b), W^i_{39}(c,b)\right\} & b_{39} \leq b_{26} \\ W^i_{39}(c,b) & \text{if } b \geq b_{26} \end{cases} \tag{30}$$

where

$$W^i_{26}(c,b) = \sum_{j=1}^{28} \lambda^i_j(c,b) V^i_{j,26}(c,b) \tag{31}$$

$$W^i_{39}(c,b) = \sum_{j=1}^{41} \lambda^i_j(c,b) V^i_{j,39}(c,b). \tag{32}$$

$V^i_{j,26}$ and $V^i_{j,39}$ denote the value functions for type-j individuals if UI duration is 26 weeks and 39 weeks, respectively. Also, notice the individuals' measures are elements of the stationary distribution.

To understand the cost of UI in this environment, consider the budget constraint of the state and federal governments. The budget constraint of a state government is:

$$\lambda^i_1(c,b)\tau^i = \sum_{j=2}^{m+1} \lambda^i_j(c,b) b^i + \gamma^i \tag{33}$$

where $m = 26$ and $\gamma^i = \frac{1}{2} \sum_{j=m+2}^{T^i+1} \lambda^i_j(c,b) b^i$ if UI is extended, and $\gamma^i = 0$ otherwise. The left-hand-side of the state budget constraint is simply the total revenue from taxes, while the right-hand-side equals the amount of UI financed by the state. The term γ^i is simply equal to one-half of the

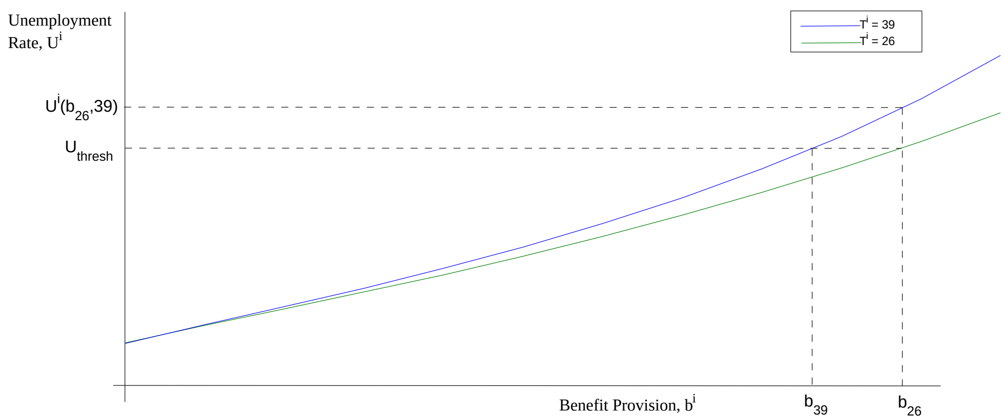

Figure 2: The unemployment rate operator $U^i(b,T)$ shown for $T = 26$ and $T = 39$.

extended benefit payments if they are offered in state i. The budget constraint of the federal government is:

$$\sum_{i=1}^{N} \lambda_1^i(c,b)\tau^f = \sum_{i=1}^{N} \gamma^i \tag{34}$$

The federal budget constraint, (34), shows how the federal subsidies on unemployment benefit extensions is financed by a tax on all employed individuals. (34) also shows how the federal tax depends on the decisions of all the states. This identifies the free-rider problem that creates an externality between states. Since the decisions of any state affects the consumption of employed individuals in all other states, it is appropriate to consider this interaction in the context of a game. The game is then defined by a set of N states choosing strategies $b^1, \ldots, b^N$ and receiving payoffs $W(b^i, b^{-i})$ for $i = 1, \ldots, N$, where W is the modified welfare function of the state, and b^{-i} represents the decisions of all other states. Now the decision of the state can be considered as the best response to the decision of all other states. Let $BR_i(b^{-i})$ denote the best response of state i to the decisions of all other states. Then the decision of the state can be written as follows:

$$BR_i(b^{-i}) = \underset{b^i}{\text{argmax}} \;\; W^i(b^i, b^{-i}) \tag{35}$$

s.t. (21), (22), (33), and (34)

The constraints (21) and (22) are the optimal search effort chosen by individuals for a given policy. This reflects the inability of government to condition policy on search effort. Instead, the government takes the optimal response of individuals as given and chooses policy. The constraints (33), and (34) are just the state and federal budget constraints, respectively. Finally, we can define a stationary Nash equilibrium as follows:

Definition 4. *A stationary Nash equilibrium is a set of strategies* $\left\{b^1, \ldots, b^N\right\}$ *such that* $b^i = BR_i(b^{-i})$ *for all* $i = 1, \ldots, N$.

Notice that the concept of a stationary distribution is implied through the statement of each state's best-response function.

4 Quantitative Analysis

This section provides the functional forms, parameter choices, and quantitative results from the numerical exercises. The first part of this section shows how some parameters were chosen and how remaining parameters were calibrated. The second part of this section provides the numerical results of the computational exercise. A sensitivity analysis is presented in the third part of this section.

4.1 Calibration

This subsection describes the functional forms and parameter choices as well as calibration techniques used to derive some parameters. The utility function takes the form of constant relative risk aversion, $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, where $\sigma = .5$. As in Hopenhayn and Nicolini (1997), the low coefficient of relative risk aversion is chosen because of the relatively short length of each period. The remaining preference parameters are the weekly discount factor, $\beta = .999$, and the marginal disutility from job search intensity, $\phi = .75$. The wage w is normalized to 100 so that the values b^i are inherently gross replacement ratios. The number of states, N is 50, and the threshold unemployment rate that triggers unemployment benefit extensions, U_{thresh} is .065. The hazard function is a cumulative distribution function for an exponential distribution parametrized by the coefficient r^i, $p(a; r^i) = 1 - exp(-r^i a)$. The job-finding parameter r^i and the job-separation rate δ^i are calibrated to match the state's unemployment rate (U^i) and replacement ratio (B^i) shown in Figure 1 by minimizing the sum of squares:

$$(r^i, \delta^i) = \underset{r,\delta}{\operatorname{argmin}} \left\{ \left(\frac{\hat{U}(r,\delta) - U^i}{U^i} \right)^2 + \left(\frac{\hat{b}(r,\delta) - B^i}{B^i} \right)^2 \right\}, \tag{36}$$

where $\hat{U}(r,\delta)$ and $\hat{b}(r,\delta)$ are the state unemployment rate and optimal benefit level chosen when all other states choose reasonable benefit levels.[8] The estimates for the job-finding parameter, r^i, and the job-retention rate, $1 - \delta$, fall in the intervals [4.1395e-4,8.4990e-4] and [0.9930,0.9985], respectively.

4.2 Numerical Results

This subsection presents the results of the numerical exercise. The model predicts that 7 states have unemployment rates that exceed the threshold level of 6.5%, triggering unemployment benefit extensions. According to data from the U.S. Department of Labor, the average annual number of states that have federally subsidized unemployment benefit extensions under the permanent program is 11.9, although the median is 5. Table 1 shows how the subsidy affects the average optimal benefit provision and corresponding unemployment rate for states that extend benefits ($T^i = 39$) and those that do not ($T^i = 26$).

Variable (averages over subset)	Subsidy	No Subsidy
b, $T^i = 26$ (N=43)	42.67	43.18
U, $T^i = 26$ (N=43)	.0345	.0347
b, $T^i = 39$ (N=7)	28.29	26.44
U, $T^i = 39$ (N=7)	10.09%	9.70%
W (N=50)	15509	15509

Table 1: Comparing State UI Provision with and without the Federal Subsidy.

[8] As shown in Figure 4, the optimal benefit level and unemployment rate for a state i is relatively insensitive to the decisions of other states, making this a reasonable assumption.

The first row of Table 1 shows how the subsidy reduces the optimal benefit provision of those states that do not extend benefits. This happens because the federal tax raises the marginal cost of providing an extra dollar of UI. The reduction in the benefit caused by the subsidy leads to a small decrease in the average unemployment rate, shown in the second row. The third row shows how the federal subsidy *increases* the optimal benefit provided by states that have triggered the benefit extensions. The subsidy has the opposite effect as the other states because the effect of the subsidy for these states is a net reduction in the marginal cost of UI. Because the subsidy causes an increase in UI provision in these states, search effort falls slightly, and the average unemployment rate rises. In one case, the unemployment rate rises over one half percentage point. The bottom row of Table 1 shows that the average welfare is nearly unaffected by the subsidy. This result shows how the costs of higher unemployment are offset by the benefits of redistribution.[9]

Figure 3 shows the relationship between the simulated optimal replacement ratio in the benchmark case and the corresponding unemployment rate. The relationship between the two series is clearly negative. The intuition behind that result is that the *marginal moral hazard cost* of an extra dollar of UI increasingly exceeds the marginal benefit of insurance for states with inherently higher unemployment rates. Since the only parameters differentiating states are the job-separation rate and the job-finding parameter, variation in these two parameters are sufficient to explain the negative correlation between the optimal benefit ratio and the corresponding unemployment rate.

Figure 4 gives an example of a best response function for a state that has extended benefits. The computation of the series in that plot assumes that 8 states offer extended benefits, the states act symmetrically, and the distribution of agents is fixed in all other states. The graph shows how the optimal benefit level provided is a decreasing function of the extended benefits offered by the other states. This makes sense because a higher benefit level provided by those states raises the federal tax rate, which in turn raises the marginal cost of providing a higher benefit in all other states.

[9]The numerical results show an improvement in welfare for states that receive the UI subsidy and a reduction in welfare for the states that don't receive the UI subsidy.

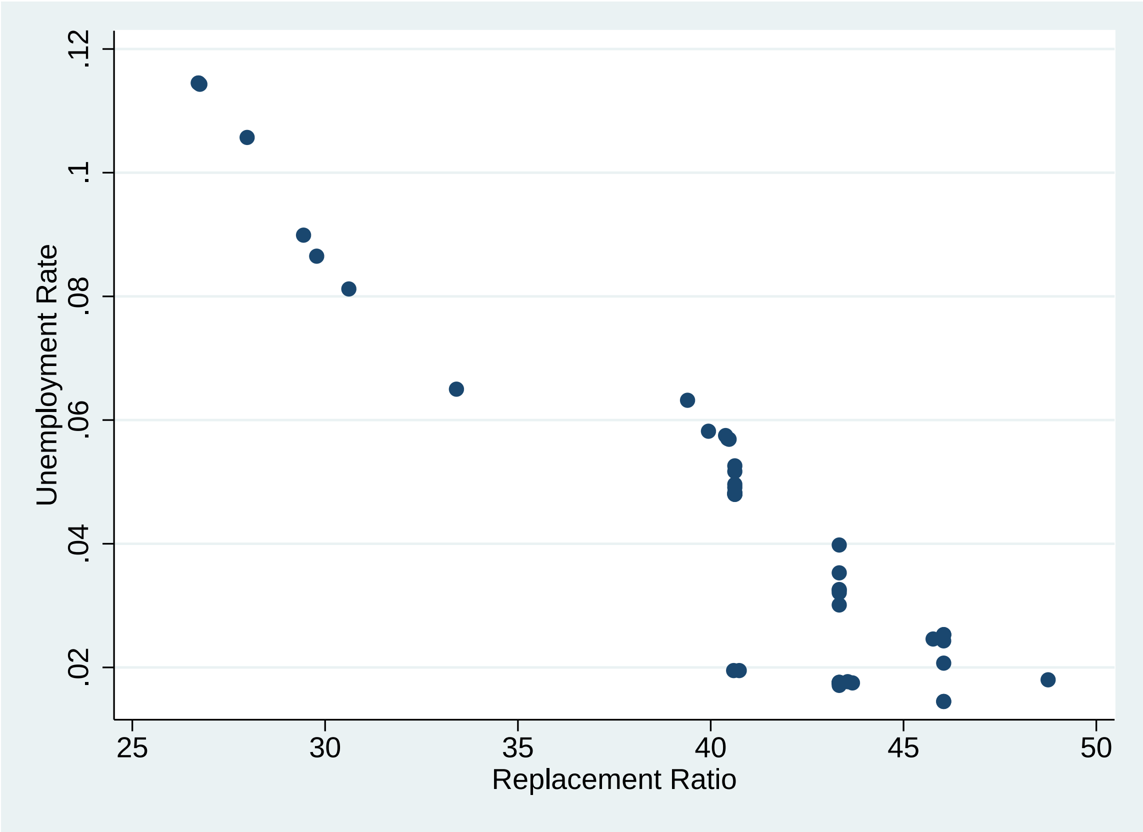

Figure 3: Simulated state unemployment rates and replacement ratios.

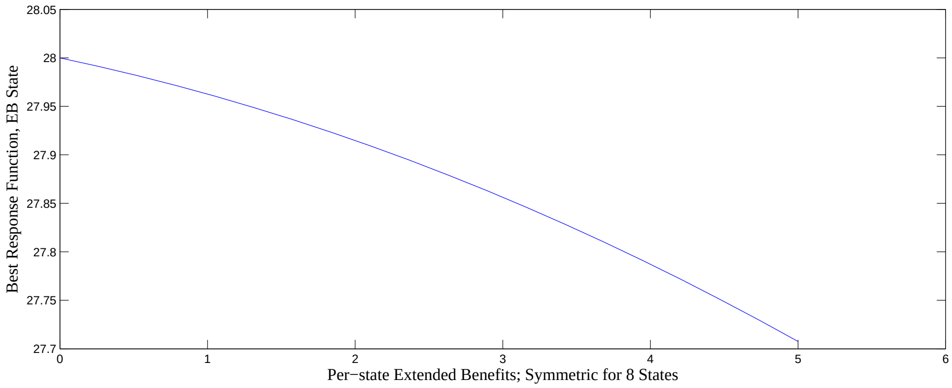

Figure 4: Optimal benefit provided in state i, b^i, as a function of extended benefits paid in all other states $-i$, γ^{-i}.

4.3 Sensitivity Analysis

This section presents the results of the sensitivity analysis. Since the coefficient of relative risk aversion (σ) measures the value of insurance, the model is solved at three different values: .45, .5 (benchmark), and .55. The results presented in Table 2 show how changes in σ not only affect the optimal benefit provided, but also the decision to become an extended benefit state. Therefore, the averages over the subsets (extended benefit states) should be interpreted loosely since the subset is changing at each value of σ.

	EB States	b (subsidy)	b (no subsidy)	U (subsidy)	U (no subsidy)
$\sigma = .45$	16	27.23	25.81	9.55%	9.15%
$\sigma = .5$	7	28.29	26.44	10.09%	9.70%
$\sigma = .55$	1	33.63	34.73	7.83%	6.50%

Table 2: Understanding how the results change with changes in σ.

As expected, the amount of the benefit increases with σ, and increases in the benefit lead to increases in the unemployment rate. Perhaps the most interesting case is the behavior of the single state that has extended benefits when $\sigma = .55$. Whereas the subsidy led to increases in the benefit in the first two cases, the opposite happens in the third case. This behavior can be explained by understanding the decision of the state near the threshold unemployment rate. As shown in Figure 2, the state chooses to trigger the partially subsidized benefit extension (within the region $[b_{39}, b_{26}]$), then reduce the amount of the benefit.

5 Conclusion

This paper studied the decision of states with respect to the provision of UI. The model gave a framework for understanding how the federal subsidization of UI extensions affects the optimal UI provision by states. Although the context of the model was the more permanent policy of UI extensions whereby UI extensions are triggered by the state-specific unemployment rate, the framework could certainly be used to understand the incentives created by the less frequent aggregate UI extensions. EUC08, for example, significantly extends UI duration in each state, creating an incentive for all states to provide a higher benefit level. The model also provided a plausible explanation for the negative correlation between a state's unemployment rate and the benefit level provided in that state. Under the set of parameter values used in the numerical exercise, the results suggested that the costs of higher unemployment and moral hazard were greater than the insurance value of UI as a state's unemployment rate increases.

The framework applied in this model could be used to understand a variety of policy issues regarding optimal state and federal UI policy. For example, how might the federal government choose to address inequality between states along the dimension of unemployment? If the model was extended to include production, one possible solution would be federal income tax credits for firms that relocate to states with high unemployment. This policy potentially improves the welfare of high unemployment states without creating job search distortions. Another possible solution is a federal tax credit for states with high unemployment. This tax credit would raise the opportunity cost of unemployment and encourage individuals to search more intensely for a job. Future research could also focus on the determinants of cross-state differences in unemployment. If empirical studies show that the job-separation rate and the job-finding rate vary significantly across states, then the framework provided in this paper can be applied to show how federal government could condition policy based on these two parameters.

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Appendix 1: Computational Algorithm

This appendix provides the computational algorithm used arrive at the equilibrium in the benchmark version of the model. The computation involves three parts: solving the individual agents' problem, solving the state's problem, and solving the equilibrium. The computation from the individual agent's problem is exactly derived from Hopenhayn and Nicolini (1997), so this appendix will focus on computing the equilibrium and the decision of the state.

A.1 Computing the Equilibrium in the Benchmark Model

1. Given the job-separation rate and job-finding parameter, solve for the individuals' value functions and policy functions for each state, $V^i(c^i, b^i)$, $a^i(c^i, b^i)$.

2. For each state, guess an initial distribution of individuals, $\Lambda_0^i(c^i, b^i)$, benefit level, b_0^i, and extended benefit payments, γ_0^i. This information provides the external components of the federal tax for a given state.

3. For each state, solve for the best response to b_0^{-i} and store the values mentioned in Step 2 in a separate vector.

4. Update the values in Step 2 with those solved in Step 3, and iterate until the distribution of benefit levels converges.[10]

A.2 Decision of the State

Given $\{b^{-i}, \Lambda^{-i}, \gamma^{-i}\}$:

1. Solve for the state's welfare and distribution of individuals over a grid of b^i for $T^i = 26$ and $T^i = 39$. To do this:

   (a) Guess an initial state tax rate. This gives enough information to solve for c^i. Then solve for the optimal job search effort and corresponding hazard rates.

[10] As implied in Figure 4, the best response function is relatively insensitive to the decisions of other states. Therefore, we can be confident that we've arrived at a unique optimal solution. Also, starting the algorithm at different initial points returns the same equilibrium values.

(b) Guess a distribution of individuals. Use the hazard rates solved in Step 1 to update the distribution and iterate to convergence.

(c) If the state budget constraint clears, then done. Otherwise, update the state tax rate and iterate to convergence.

2. Using the unemployment rates from Step 1, interpolate to find b_{39} and b_{26}.

3. Choose the b^* that maximizes the state welfare function over the feasible regions defined in (30).

Appendix 2: Proof of Theorem 2

Proof. For any strategy $(b^1, \ldots, b^N)$, payoffs for each state i are simply the state's welfare function,

$$W(b^i, b^{-i}) = \theta_1 u(w - T^i - T^f) + \theta_2 u(b^i), \tag{37}$$

where T^f and T^i are defined by (6) (8). Substituting these two values into (37), the best response function can be written as follows:

$$BR_i(-i) = \underset{b^i}{\text{argmax}} \;\; \theta_1 u(w - \alpha \frac{\lambda_{uc}}{\lambda_e} b^i - \frac{(1-\alpha)\lambda_{uc} \sum_{j=1}^{N} b^j}{N\lambda_e}) + \theta_2 u(b^i) \tag{38}$$

Taking the first-order condition of the best-response function gives the following equation:

$$\frac{\theta_1}{\theta_2} \frac{\lambda_{uc}(1 + \alpha(N-1))}{N\lambda_e} u'(w - \alpha \frac{\lambda_{uc}}{\lambda_e} b^i - \frac{(1-\alpha)}{N} \frac{\lambda_{uc}}{\lambda_e} \sum_{j=1}^{N} b^j) = u'(b^i). \tag{39}$$

Then applying the concept of a symmetric Nash equilibrium, set $b^i = b^*$ for all $i = 1, \ldots, N$ to get the following equation:

$$\frac{\theta_1}{\theta_2} \frac{\lambda_{uc}(1 + \alpha(N-1))}{N\lambda_e} u'(w - \frac{\lambda_{uc}(1 + \alpha(N-1))}{N\lambda_e} b^*) = u'(b^*) \tag{40}$$

Setting $\alpha = 1$, we get:

$$\frac{u'(w - \frac{\lambda_{uc}}{\lambda_e} b^*)}{u'(b^*)} = \frac{\lambda_e \theta_2}{\lambda_{uc} \theta_1}, \tag{41}$$

which is exactly the same equation that must be satisfied to arrive at the optimal solution of the social planner's problem. Then the uniqueness of the social planner's solution implies that $b^* = \bar{b}$ and $W(b^*, b^*) = W(\bar{b}, \bar{b})$.

Now, suppose $\alpha \in [0, 1)$. I want to show that $\frac{db^*}{d\alpha} < 0$. Taking the total derivative of both sides of (41) with respect to b^* and α gives:

$$\frac{db^*}{d\alpha} = \frac{k_1}{k_3 - k_2}, \quad \text{where} \tag{42}$$

$$k_1 = \frac{\theta_1 \lambda_{uc}(N-1)}{\theta_2 N \lambda_e} \frac{\theta_1(1 + \alpha(N-1))}{N\lambda_e} u'(z) - \frac{\lambda_{uc}(N-1)}{N\lambda_e} \frac{\theta_1 \lambda_{uc}(1 + \alpha(N-1)}{\theta_2 N \lambda_e} u''(z) \tag{43}$$

$$k_2 = -\frac{\theta_1}{\theta_2} (\frac{\lambda_c(1 + \alpha(N-1)}{N\lambda_e})^2 u''(z) \tag{44}$$

$$k_3 = u''(b^*) \tag{45}$$

$$z = w - \frac{\lambda_{uc}(1 + \alpha(N-1))}{N\lambda_e} b^* \tag{46}$$

Keeping in mind that $u'(\cdot) > 0$ and $u''(\cdot) < 0$, it can be seen that $k_1 > 0$, $k_2 > 0$, and $k_3 < 0$. Therefore, $\frac{db^*}{\alpha} < 0$. Then, $\alpha < 1$ implies that $b^* > \bar{b}$. Further, since $\bar{b}$ is a unique optimal solution, $b^* > \bar{b}$ implies that $W(b^*, b^*) < W(\bar{b}, \bar{b})$. □

Appendix 3: Optimal Search Effort and Hazard Rates

This appendix shows the optimal search effort and corresponding hazard rates for a chosen state that has extended UI and a state that has no extended UI.

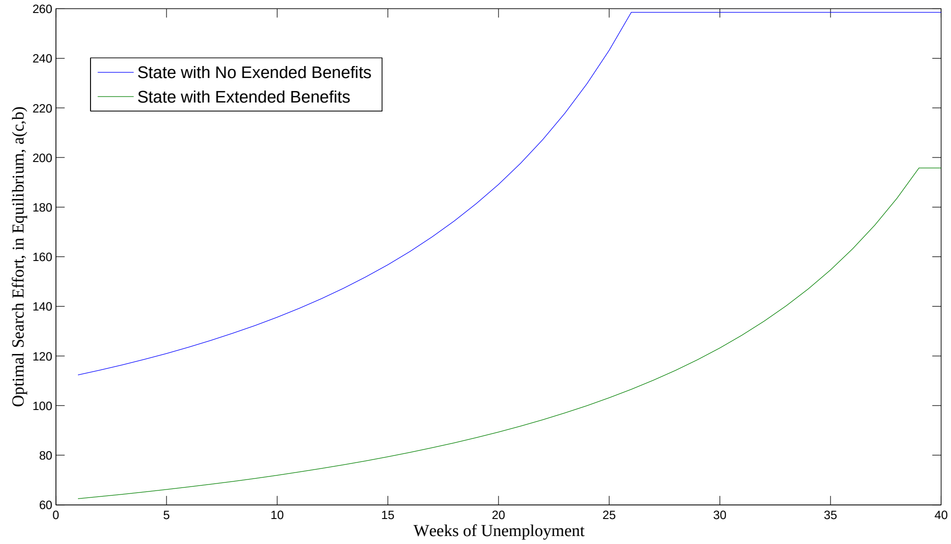

Figure 5: Optimal job search effort for a state with extended benefits and a state with no extended benefits.

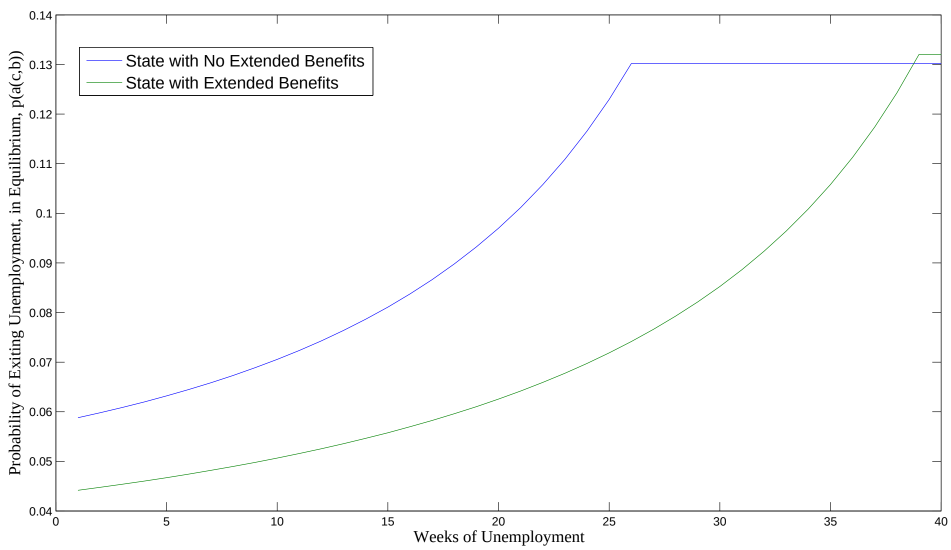

Figure 6: Hazard rates for a state with extended benefits and a state with no extended benefits.