Unemployment Insurance Take-up Rates in an Equilibrium Search Model*

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Abstract

In this paper we analyze the issue of unemployment insurance (UI) take-up rates. We develop a theory of take-up rates based on endogenous costs to applying for benefits, and quantitatively explore the implications of our theory. Specifically, we use a search model with matching frictions where firms finance UI with a per-worker tax, but can partially control these costs by varying advertising intensity to attract workers who would not collect benefits upon future separation. The endogenous costs to applying arise as workers who collect benefits face a slower job arrival rate than non-collectors. We estimate take-up rates for the U.S. economy from 1989 − 2011, using state-specific eligibility rules, and calibrate the model using a detailed version of the U.S. unemployment insurance system. Quantitatively, we find that the take-up rate increases when the replacement rate increases, but decreases with increases in the maximum benefit amount and potential benefit duration. We also find that when compared to the standard model that abstracts from take-up decisions, our model has different predictions for how equilibrium outcomes respond to changes in the UI system.

Keywords: unemployment insurance, take-up, matching frictions, search

JEL classification: E61, J32, J64, J65

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1 Introduction

Almost all developed countries offer some level of unemployment (or employment) insurance. Since one can lose his/her job, through no fault of their own, this insurance remains socially desirable. Given this desirability, the providers of benefits should prefer all eligible agents to participate. As with many social insurance programs, the fraction of eligible unemployed who actually collect benefits, referred to as the "take-up rate," remains persistently well below 1. The existing literature contains many studies examining unemployment insurance, its effect on labor market outcomes, and how to optimally design it. There exists little work, however, examining take-up rates, and even less analyzing the relationship between take-up rates and equilibrium outcomes.

In addition to there being little empirical work on the UI take-up rate, the general theory of take-up of social insurance programs has remained relatively static. These theories are based on the existence of a utility cost to applying for benefits, which may take many forms. It could be the specifics of the administrative procedures, uncertainty regarding one's eligibility for the program, or it could stem from lack of anonymity, or a "stigma" attached to collecting benefits. While these theories certainly account for some aspects of the take-up decision, we present data suggesting that, at least for the U.S. unemployment insurance system, these costs are becoming less relevant. We breathe new life into the theory of take-up rates and develop an alternative theory based on the equilibrium interaction between workers and firms.

Since the take-up rate is determined in equilibrium, we can quantitatively explore how it responds to changes in the UI system. In addition, we can also analyze how changes in the UI system affect the unemployment rate and average unemployment duration, in a model where the take-up rate is endogenously determined. This is a departure from the existing literature examining these effects, which either abstracts from take-up rates, or assumes them to be exogenous.

We model the take-up decision in the context of an equilibrium search model with matching frictions, in the class considered by Pissarides (2000). Workers are risk averse, heterogenous in productivity, and can exert variable search effort looking for a job. Firms post vacancies and search/advertise for workers to fill them. The key feature of the model is that we include the costs to firms of financing the unemployment insurance system. In the U.S., unemployment benefits are financed by a tax levied on firms, and this tax rate is "experienced rated," implying firms that more frequently send agents to insured unemployment pay a higher tax rate than those with less "experience." These taxes not only vary based on experience, but they can also vary depending on firm size. For example, in many states, smaller firms pay directly their "bill" from the UI system; i.e. instead of a tax per-worker, they pay taxes only after sending a worker to collect benefits, and pay an amount equal to the benefits collected. Since firms finance the UI system, their costs are reduced when fewer agents collect benefits.[1] We model this tax structure by assuming that when a firm hires a worker who collects benefits, they pay a tax, while they pay no tax if the agent does not collect. In our model, firms can partially control these costs by advertising specifically for workers who would not collect benefits in the event of a future separation. The firm exerts advertising intensity to each "type" of worker (collectors and non-collectors), and the result is workers who collect benefits may face a slower arrival rate of job offers than non-collectors. In equilibrium, this can result in take-up rates below 1. We then calibrate this model to a stylized version of the U.S. system and data, and analyze various policy experiments.

To perform the quantitative analysis, we first need to estimate the UI take-up rate in the U.S. In our estimates, we follow a method similar to Blank and Card (1991), and use CPS data along with detailed, state-level criteria regarding eligibility, for the period from $1989-2011$. We find that the take-up rate is strongly procyclical, and outside of these cyclical variations has remained relatively constant since 1989. On average, from the period from $2003-2006$ (the period we calibrate to), the take-up rate was 64%. To support our focus on an alternative theory, we also analyze data on the method used to file the initial claim for UI. Here we find that in 1988 94% of initial unemployment insurance claims were filed in person, while in 2009, only 11% were filed in person and 85% via phone and internet. This suggests that the typical "red tape" associated with applying has gone done significantly, and anonymity has increased as well. These two trends combined support our search for alternative theories of UI take-up.

We calibrate the model using U.S. data on the UI system, unemployment rate and duration, and wages. Our stylized version of the U.S. unemployment insurance system is relatively detailed

[1]Of course, there are many issues related to such a system. For example, Feldstein (1976) examines the issue of temporary layoffs versus permanent separations as it relates to experience rated UI taxes. Feldstein (1976) finds that given these taxes, a firm may prefer to reduce the number of hours worked as opposed to a layoff and subsequent benefit collection. We abstract from the issue of temporary layoffs, but we contribute to this literature by analyzing how UI benefits affect the interaction between workers and firms.

compared to the existing literature. Specifically, we model two empirical features of the system: there exists a maximum benefit amount, and benefits have a finite potential duration. Since workers in our model are heterogenous with respect to productivity, and benefits are calculated as a fraction of a worker's previous wage, the maximum benefit amount may be binding for some agents. We also allow for a "two-tiered" benefit system, similar to Fredriksson and Holmund (2001), where with a Poisson arrival rate a worker collecting benefits may lose them. To calibrate this stylized version of the U.S. system, we use detailed data from a program called BAM (Benefit Accuracy Measurement) to estimate the replacement rate for those not subject to the maximum benefit amount, those receiving the maximum benefit amount, and to calculate the average potential duration of benefits. Given these parameters of the UI system, we calibrate the model to match the observed unemployment rate and average duration of unemployment from 2003 – 2006, as well as data on the wage distribution.

Our results suggest the model performs well in matching observed take-up rates. Specifically, the model predicts a take-up rate of 60%, compared to 64% observed in the data (average from 2003 – 2006). The model also does well matching other moments in the data. For example, we calibrate to match the observed replacement rate among those in the data for whom the maximum benefit is binding; however, the fraction of agents for whom the maximum benefit binds is a free parameter. With regards to this moment, the model does well, predicting that 19% of agents who collect benefits face a binding maximum, while the data indicates 23% actually do. Since heterogeneity in productivity and wages remains an important driver of the take-up decision, that our model does well in this regard is promising.

Given this parametrization, we then consider several policy experiments and analyze how changes to the UI system affect the take-up rate. We find that the take-up rate is positively correlated with the basic replacement rate (the replacement rate for anyone not at the binding benefit amount), but negatively correlated with the maximum benefit amount. Moreover, the two latter effects tend to be relatively large, while the effect of the basic replacement rate is relatively small. For example, an increase in the basic replacement rate from 0.48 to 0.82 (70% increase) only increases the take-up rate from 60% to 66%. The small effect is the result of two opposing forces: the increase in the basic replacement rate implies more lower productivity workers apply for benefits, but fewer higher productivity workers do, since the maximum benefit amount restricts the impact of the change in replacement rate. In comparison, a 70% increase in the maximum benefit level *decreases* the take-up rate from 60% to 19%. Here, the endogenous interaction between firms and workers is a key driver of the decrease in the take-up rate, since this change increases the gap in job arrival rates between collectors and non-collectors. The change in the maximum benefit level has no effect on the benefits received by low productivity workers, so the result is a decrease in take-up among this group. For higher productivity workers, the increased gap in job arrival rates outweighs the gain in their unemployment benefit, and the net result is a decrease in their take-up rate as well. We find similar effects for an increase in the potential duration of benefits; the take-up rate decreases, and the effect is larger than for the basic replacement rate.

Another contribution of our paper is that is allows us to analyze how the generosity of the UI system affects equilibrium outcomes such as the unemployment rate and average unemployment duration, but we can do so in a model where the take-up rate responds endogenously. To evaluate how much this affects the results, we calibrate an alternative model that assumes a take-up rate of 100%, and perform the same aforementioned policy experiments. We find that including the take-up rate matters for the results. For example, for a 70% increase in the maximum benefit level, our model with an endogenous take-up rate predicts that the average unemployment duration increases by 33%. The standard model with no take-up decision, however, predicts that a 50% increase in the maximum benefit amount only increases the average unemployment duration by 0.7%. Moreover, when the potential duration of benefits increases by 40%, the standard model predicts a 104% increase in the average duration of unemployment benefits, while our model predicts only a 28% increase. These results suggest that those interested in designing UI policies need to include the take-up decision in their analysis.

The literature examining UI is large and has many components; as a result, to understand our contribution to this literature, we only discuss those papers most closely related. While the issue of take-up rates has received little attention, there has been some empirical work in this area. Blank and Card (1991) and Anderson and Meyer (1997) both estimate the take-up rate and perform a reduced-form analysis to determine correlations between the take-up rate and some individual characteristics. We follow Blank and Card (1991) in our estimation of take-up rates, but unlike these papers, our analysis is a general equilibrium one and we show this matters for the results.

Our model is built off of the basic framework for search models with matching frictions discussed in Pissarides (2000). We add several dimensions to this basic model, some of which have been incorporated in other models in various ways. First, we have a similar set-up to that in Fredriksson and Holmund (2001) who allow for both the two-tiered benefit system (finite potential duration of benefits) and variable search effort for workers. The primary departure from this work (as well as the related work on UI in these models) is that Fredriksson and Holmund (2001) abstract from take-up rates, which is instead the focus of our paper. We extend this framework by allowing for worker heterogeneity in productivity, a maximum benefit amount, and for variable advertising intensity by the firm. In the standard model of Pissarides (2000) allowing for variable advertising intensity is redundant, since firms also decide on how many vacancies to open. In our model, however, the redundancy no longer exists since there are two "types" of workers that firms can advertise to. Moreover, we further restrict total advertising intensity to 1, which introduces an additional trade-off for the firm, different from a segmented markets approach where the firm opens as many vacancies as it finds optimal in each sector.

While there exist many papers examining the effects of UI on the unemployment rate and duration, the large majority of these papers either abstract completely from the take-up rate issue, or simply assume it to be exogenous. Davidson and Woodbury (1998) and Wang and Williamson (2002) are two examples where UI policies are considered in models that allow for take-up rates less than 1, but in these papers the take-up rate is exogenous, and thus invariant to changes in policy. In contrast, the take-up rate is endogenously determined in our model, and we find that this matters for how changes in policy affect labor market outcomes. To the best of our knowledge, no other paper has attempted to accomplish this.

The remainder of the paper proceeds as follows. In Section 2 we present the data, our procedure for estimating the take-up rate, and provide a discussion of how the data supports our modeling choices. Next, Section 3 describes the model, while Section 4 presents the calibration, empirical results, and policy experiments. Finally, we conclude in Section 5.

2 Evidence on Take-up Rates

This section has two primary purposes. First, we present data that support our attempt to model alternative costs to applying for UI Second, we detail our estimation of the take-up rate, and explore the key features of our estimates.

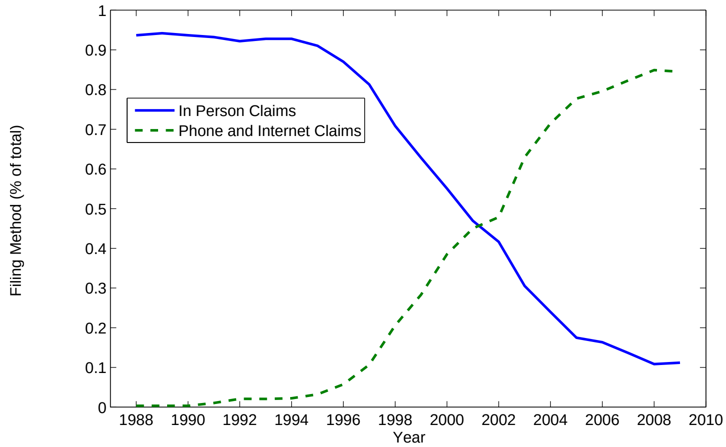

Figure 1: Filing method for initial claim

2.1 Filing Methods for Initial Claim

If there do exist explicit costs to applying for unemployment benefits, these should manifest themselves in the specifics of the application process. Examining data on the initial filing method represents one way to determine how the costs to applying may have changed over time. Such data is available from a program called BAM (Benefit Accuracy Measurement) run by the U.S. Department of Labor. BAM selects a random sample of UI recipients/applicants and audits each case to examine the accuracy of paid claims, as well as the appropriateness of any benefit denials. Among the many variables of interest in the BAM data, the audit determines the method used for filing the initial claim.[2] In Figure 1 we present this data from 1988 − 2009.

There exist five possible initial filing methods listed in the BAM data. These include, in person, mail (including e-mail), telephone, employer filed claim, and internet claim. Figure 1 plots the fraction of agents who file in person, compared to the fraction filing by phone and/or internet (the other filing methods account for a small fraction of the total).[3] The graph indicates that there has been a large shift in how unemployment benefit applications are filed in the U.S., as in person claims and phone and internet claims have switched as the dominant method. This change has almost certainly had an effect on the explicit application costs of applying for UI First, since an in person application is typically no longer required, at a minimum, the time associated with

[2] We use this data set again to calibrate the features of the U.S. unemployment insurance system.

[3] Prior to 2002, there were no internet claims observed, so this represents a recent phenomenon.

filing a claim has been dramatically reduced. Second, applying via phone or internet makes the process more anonymous than an in person application, which works to reduce any negative stigma associated with applying for benefits. Finally, since phone/internet claims imply a low explicit cost of applying, it is less likely an agent uncertain about their eligibility would not apply. Given these changes, if indeed explicit application costs explain the majority of the take-up decision, we should observe an increase in the take-up rate as these costs have clearly decreased. To evaluate whether this has occurred or not, we need to first estimate the take-up rate over time.

2.2 Take-up Rate Estimates

While many statistics and data on the labor market are readily available for public use, there exists little information on take-up rates of unemployment insurance. There is data on the characteristics of the insured unemployed, as well as data on the ratio of insured unemployed to total unemployed (hereafter IUR). The IUR series is simply the ratio of insured unemployed (those collecting benefits) to total unemployment. While this provides some characterization of the take-up rate, the IUR does not control for eligibility. For example, there exist limits on the duration one may collect benefits for (typically 26 weeks); as a result, the IUR includes individuals who are not eligible to collect because they have been unemployed for longer than 26 weeks. Moreover, each state has specific eligibility criteria, which makes the calculation of take-up rates even more difficult, since each state must be considered separately. To calculate the *take-up rate*, we need to first find the fraction of unemployed agents who are currently eligible to collect, and then take the ratio to insured unemployed to total *eligible* unemployed.

To calculate an estimate of the take-up rate in the U.S., we follow a method similar to Blank and Card (1991). Specifically, we use data from the March Supplement of the CPS (Current Population Survey) to estimate the fraction of unemployed agents eligible to collect benefits, and compare this to the fraction actually collecting. To estimate eligibility, we examine the specific eligibility criteria of each state, for each year from $1989-2011$. Eligibility depends primarily on three factors, and Figure 2 displays our estimate of the take-up rate, IUR, and the contribution of each of the three eligibility criteria. The line labeled IUR plots the insured to total unemployment ratio from $1989-2011$, and the line labeled TUR plots our estimate of the take-up rate. We now explain our approach to estimating each of the three primary eligibility categories and how Figure 2 displays

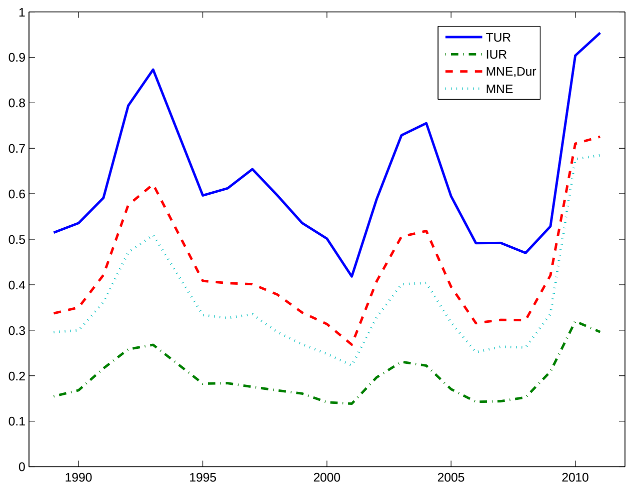

Figure 2: Take-up Rates by Eligibility Criteria

the contribution of each.

First, there exist monetary eligibility requirements. These basically require an agent to have accumulated a sufficient amount of earnings in a specified "base-period," or worked a minimum number of weeks.[4] To estimate monetary eligibility, we use the earnings information contained in the March CPS. The line labeled MNE in Figure 2 displays the increase in the take-up rate from the IUR when only monetary eligibility requirements are imposed.

The nature of the separation leading to the spell of unemployment represents the second element of eligibility criteria. Specifically, in most states, agents who quit their previous job, or were fired for cause, are not eligible to collect benefits.[5] This criteria is intended to limit benefits to only those individuals who have lost their job through no fault of their own. In the CPS data, we can eliminate quits; however, we can not determine whether or not the agent was fired for cause. In addition, the total unemployed in the CPS contain re-entrants (those who had previously left the labor-force, but are now re-entering), and new entrants (those never previously in the labor force). Since these later two groups are clearly not eligible to collect benefits, we exclude them.

[4]The base-period differs across states. Many use a year, while others use two quarters. The base-period is used both to determine monetary eligibility, as well as to calculate the specific benefit an agent is entitled to.

[5]Georgia is an exception, and does allow job leavers (quits) to collect benefits, but they face an increased waiting period of 12 weeks.

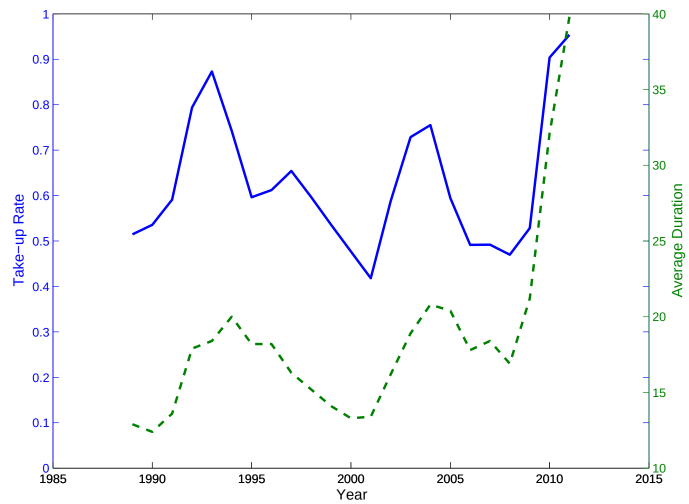

Figure 3: Take-up Rates and Average Duration of Unemployment

Finally, eligibility for benefits depends on the length of the unemployment spell. All states have a maximum potential duration of benefits, which typically limits benefits to 26 weeks. There are some exceptions to this rule, as some states allow for 30 weeks of benefits, and in times of high unemployment, eligibility may be extended through the Federal-State Extended Compensation Program, and we account for these where applicable. In addition the maximum length of benefits, many states also have a minimum waiting period, typically 1 week. Since the CPS contains information on the agent's length of unemployment spells, we are able to control for this criteria. In Figure 2, the line labeled MNE, Dur displays the take-up rate when only the aforementioned duration criteria are removed, and eligibility is determined by the monetary and separation requirements. Overall, Figure 2 displays that the monetary and duration criteria contribute the most to the difference between the take-up rate and IUR, and the separation criteria less so.

Another interesting feature displayed in Figure 2 is the cyclical nature of these data. Figure 3 plots our estimate of the take-up rate from $1989 - 2011$, along with the corresponding average duration of unemployment in March of each year. The left-hand y-axis plots the take-up rate, and the right hand y-axis the average duration of unemployment. There are two interesting features of this graph. First, there is a clear cyclical dimension to the take-up rate, as its movements track very closely the movements in the average duration of unemployment. Second, outside of these cyclical variations, the take-up rate appears to have remained relatively constant, or possibly declined slightly. At least, there does not appear to be any noticeable increase in take-up rates corresponding to the decrease in application costs associated with the information age.

3 Model

The economy consists of a unit-measure of infinitely-lived, risk-averse agents, and a large measure of risk-neutral firms. Time, t, is continuous and goes on forever, and agents and firms both discount the future at rate $r > 0$. Each agent has an endowment of one unit of time with two alternative, mutually exclusive uses: search for a job or work for a firm. Agents have preferences over consumption and leisure, with per-period utility function given by:

$$H(c, s) = h(c, 1 - s)$$

where c represents consumption and s search effort, with $l = 1 - s$ defined as leisure. Agents are heterogenous with respect to productivity, y. An agent's type, denoted by j, remains fixed for life, and is distributed across agents according to $F(y)$. We allow both workers and firms to vary the intensity with which they search for a match. Specifically, a type j worker exerts search effort $s_j \in [0, 1]$ looking for a firm, and firms exert effort $a \in [0, 1]$ "advertising" vacancies.

Unemployed agents can be in one of three possible states. The states are differentiated based on whether or not the agent collects unemployment benefits. First, upon being separated from an employer, the agent decides whether to enter unemployment state $i = 1$ or $i = 3$, where $i = 1$ denotes unemployed collecting benefits, while $i = 3$ denotes unemployed not collecting benefits. Finally, if collecting benefits, we assume that with Poisson arrival rate γ, benefit eligibility ends, and the agent enters state $i = 2$. This feature captures the empirical fact that in the U.S., unemployment benefits are paid for a fixed period of time. Moreover, distinguishing between agents who never collected benefits and those who did collect, but "exhausted" them, is important for firm behavior. If collecting benefits, the agent receives flow income B_j, while if not collecting, they receive d_j. Notice, we allow benefits to depend on the agent's productivity, or equivalently their wage.

We model agent's flow income while unemployed and collecting benefits after the key features of the U.S. system. This system involves payments that are a constant fraction of the previous wage, for a fixed length of time. Denote by b the replacement rate, so an agent's unemployment benefit is given by $b * w^j$, where w^j is the wage paid to agent j. We also model the feature of the U.S. system that there exists a maximum benefit amount, which we denote by $\bar{b}$. Thus, the actual unemployment benefit of the agent is given by $b_j = \min\{bw^j, \bar{b}\}$. Total flow income while unemployed and collecting benefits is the sum of benefits, b_j, and non-market income, d_j.[6] The base level of income is given by $d_j = dw^j$, where $d < b$. Thus, total income while unemployed collecting benefits is $B_j = \left(\min\{b, \frac{\bar{b}}{w^j}\} + d\right) w^j$.

An important feature of our model is that we allow firms to search, or advertise, with different intensity for workers in state $i = 1$ or $i = 2$ versus workers in state $i = 3$. Denote firms' advertising effort for the former by a_1 and for the latter by a_3. We constrain total advertising effort to 1, we have $a_3 = 1 - a_1$. While employed, workers supply labor inelastically, and produce y units of the consumption good. They receive a wage w, which is determined via Nash Bargaining between the worker and firm. Firms are composed of a single job, either filled or vacant, and discount future profits at rate r. Vacant firms are free to enter and pay a flow cost, $\kappa(a) > 0$, to advertise a vacancy. Vacant firms produce no output and filled firms produce the same final good. Unemployment benefits are financed by lump-sum taxes levied on firms. These taxes are experienced rated in the following manner: only firms that hire workers who collect benefits pay taxes, while a firm that hires an agent who does not collect benefits does not pay the tax.

The labor market is subject to matching frictions. The aggregate matching function, $m(sU, aV)$, describes the flow of job offers, where U represents the measure of unemployed workers actively looking for jobs, and V the measure of vacant jobs. Notice, the matching function also depends on s and a, which denote the average search intensities of workers and firms, respectively. The matching function, m, is continuous, strictly increasing, strictly concave (with respect to each of its arguments), and exhibits constant returns to scale. Furthermore, $m(0, \cdot) = m(\cdot, 0) = 0$ and $m(\infty, \cdot) = m(\cdot, \infty) = \infty$. Following Pissarides' terminology, define $\theta \equiv V/U$, referred to as labor market "tightness."

Each vacancy is filled according to a Poisson process, which depends on the relative search effort of worker j and the firm. Define $q(s, a, \theta) \equiv \frac{m(sU, aV)}{V} = m(\frac{s}{\theta}, a)$. Further, denote the

[6]Depending on the specific utility function, it may be necessary to set $d > 0$. There are several possible ways to interpret this value. A natural interpretation of non-market income is home production. Another possibility is that d serves as a proxy for other assets or savings. The main idea is that for positive d, an agents total consumption while not employed is not equal to only UI benefits if collecting.

job advertising intensity of firm p, searching for a worker in state $k \in \{1,3\}$, by a_k^p. The average advertising intensity for all firms searching for type k workers is denoted by a_k. Given this, a vacancy is filled with Poisson arrival rate $\frac{a_k^p}{a_k}\frac{m(sU, a_k V)}{V} = \frac{a_k^p}{a_k} q(s, a_k, \theta)$. Similarly, each unemployed worker in state k finds a job according to a Poisson process with arrival rate $\frac{s_j m(sU, a_k V)}{sU} = \frac{s_j}{s}\theta q(s, a_k, \theta)$. Filled jobs receive negative idiosyncratic productivity shocks rendering the match unprofitable with a Poisson arrival rate λ. Denote by n_0, n_1, n_2, and n_3 the measure of workers employed, unemployed collecting benefits, unemployed exhausted benefits, and unemployed never collected benefits, respectively.

3.1 Bellman Equations

This section details the Bellman equations describing the behavior of workers and firms.

3.1.1 Workers

The Bellman equations for a worker of type j, in state $i = 0, 1, 2, 3$ are denoted by, V_i^j, and are given by, respectively:

$$
\begin{aligned}
rV_1^j &= \max_{s_1^j} h(B_j, 1 - s_1^j) + \frac{s_1^j}{s}\theta q(s, a_1, \theta)\left(V_0^j(w_1^j) - V_1^j\right) + \gamma\left(V_2^j - V_1^j\right) && (1)\\
rV_2^j &= \max_{s_2^j} h(d_j, 1 - s_2^j) + \frac{s_2^j}{s}\theta q(s, a_1, \theta)\left(V_0^j(w_1^j) - V_2^j\right) && (2)\\
rV_3^j &= \max_{s_3^j} h(d_j, 1 - s_3^j) + \frac{s_3^j}{s}\theta q(s, a_3, \theta)\left(V_0^j(w_3^j) - V_3^j\right) && (3)\\
rV_0^j(w) &= h(w) + \lambda\left(\max\{V_1^j, V_3^j\} - V_0^j(w)\right) && (4)
\end{aligned}
$$

Equation (1) says that an unemployed agent collecting benefits receives instantaneous flow utility $h(B_j, 1 - s_1^j)$ from unemployment compensation and the utility cost of search effort s_1^j. With arrival rate $\frac{s_1^j}{s}\theta q(s, a_1, \theta)$ the worker matches with a firm and transitions to employment, while at rate γ unemployment benefits expire, and the agent transitions to state $k = 2$. Equation (2) and (3) have similar interpretations for an agent who has exhausted benefits and one who never collected, respectively. Finally, equation (4) states that an employed agent receives instantaneous flow utility $h(w)$ from the wage, w.[7] With Poisson arrival rate λ, the job dissolves and the agent then decides whether or not to collect unemployment benefits.

[7] We have assumed that employed workers enjoy leisure equal to the time endowment. Alternatively, we could

The optimal choice of search effort for an unemployed agent, in state $k \in \{1, 2, 3\}$, is given by:

$$\frac{\theta q(s, a_k, \theta)}{s} \left(V_0^j(w_k^j) - V_k^j \right) = h_l(1 - s_k^j) \tag{5}$$

which is obtained by taking the F.O.C. in the agent's problem with respect to s_k^j.

3.1.2 Firms

Denote by V_v the value of an open vacancy and by $V_{fk}, k \in \{1, 3\}$ the value of a filled vacancy for a worker who collects ($k = 1$) or does not collect ($k = 3$) unemployment benefits. Further, denote the subset of workers across types j, with collection status k, by $\mathbf{Y}_k$. When hiring a worker who collects benefits, the firm pays lump sum taxes τ. These Bellman equation describing firm p's vacancy and advertising decisions

$$rV_v = \max_{a_1^p, a_3^p} -\kappa(a_1^p + a_1^p) + \frac{a_1^p}{a_1} q(s, a_1, \theta) \int_{\mathbf{Y}_1} \left(V_{f1}^j - V_v \right) dF(y_j) + \frac{a_3^p}{a_3} q(s, a_3, \theta) \int_{\mathbf{Y}_3} \left(V_{f3}^j - V_v \right) dF(y_j) \tag{6}$$

$$\text{s.t.} \qquad 1 = a_1^p + a_{3b}^p \tag{7}$$

The Bellman equations describing the value of a filled vacancy are given by:

$$rV_{f1}^j = y_j - w_1^j - \tau + \lambda \left(V_v - V_{f1}^j \right) \tag{8}$$

$$rV_{f3}^j = y_j - w_3^j + \lambda \left(V_v - V_{f3}^j \right) \tag{9}$$

Denoting the multiplier on the constraint in (7) by ψ, the F.O.C. for firm p's choice of advertising intensity are given by:

$$-\kappa'(a_1^p + a_3^p) + \frac{\partial}{\partial a_1^p} \left(\frac{a_1^p}{a_1} q(s, a_1, \theta) \right) \int_{\mathbf{Y}_1} \left(V_{f1}^j - V_v \right) dF(y_j) - \psi = 0 \tag{10}$$

$$-\kappa'(a_1^p + a_3^p) + \frac{\partial}{\partial a_3^p} \left(\frac{a_3^p}{a_3} q(s, a_3, \theta) \right) \int_{\mathbf{Y}_3} \left(V_{f3}^j - V_v \right) dF(y_j) - \psi = 0 \tag{11}$$

Using the fact that $\frac{\partial q(s, a_k, \theta)}{\partial a_k^p} = \frac{q(s, a_k, \theta)}{a_k}$, and that with free-entry of firms $rV_v = 0$, (10) and (11) imply

$$\frac{q(s, a_1, \theta)}{a_1} \int V_{f1}^j d\Pi_1 = \frac{q(s, a_3, \theta)}{a_3} \int V_{f3}^j d\Pi_3 \tag{12}$$

assume agents spend some fixed amount of time working; however, our assumption simply represents a normalization, which we explain in more detail in Section 4.1 when discussing the calibration.

3.2 Wage Determination

Upon meeting and deciding to form a match, wages are determined by the generalized Nash Bargaining solution between workers and firms. Letting $\beta \in (0,1)$ denote the worker's bargaining power, the wage for an agent of type j and collection status $k \in \{1,3\}$ is determined by:

$$\max_{w_k^j} \left(V_0^j(w_k^j) - V_k^j \right)^{\beta} \left(V_{fk}^j(w_k^j) - V_v \right)^{1-\beta} \tag{13}$$

We also assume that wages can be re-negotiated at any time, so that the threat value of an agent who collects benefits is V_1^j, regardless of whether or not benefits have expired. The F.O.C. for this Nash Bargaining problem are given by,

$$\left(V_0^j(w_k^j) - V_k^j \right) = \frac{\beta}{1-\beta} \left(V_{fk}^j - V_v \right) h_c(w_k^j) \tag{14}$$

where $h_c(c, 1-s) \equiv \frac{\partial}{\partial c} h(c, 1-s)$ is the partial derivative of $h(c, 1-s)$ with respect to its first argument.

3.3 Equilibrium

This section describes the determination of equilibrium. In this case, there are seven equilibrium variables to be determined from the optimal choices of household's and firms: $\{w_1^j, w_3^j, s_1^j, s_2^j, s_3^j, a_1, \theta\}$; as a result, we need seven equations in these seven unknowns. Towards this end, using $V_v = 0$, (8) and (9) to solve for V_{f1} and V_{f3}, respectively, and plugging into (6) and using (12) gives

$$\frac{a_1 \kappa}{q(a_1, \theta)} = \int_{\mathbf{Y}_1} \left[\frac{y_j - w_1^j - \tau}{r + \lambda} \right] dF(y_j) \tag{15}$$

Next, letting $s_k^j, k = 1,2,3$ be the optimal choice of effort in each unemployment state, using the decision rules for effort in (5) we can write the agents' Bellman equations for unemployment as:

$$rV_1^j = h(B_j, 1 - s_1^j) + s_1^j h_l(B_j, 1 - s_1^j) + \gamma \left(V_2^j - V_1^j \right) \tag{16}$$

$$rV_2^j = h(d_j, 1 - s_2^j) + s_2^j h_l(d_j, 1 - s_2^j) \tag{17}$$

$$rV_3^j = h(d_j, 1 - s_3^j) + s_3^j h_l(d_j, 1 - s_3^j) \tag{18}$$

Then, (16) and (17) imply

$$(r+\gamma)\left(V_2^j - V_1^j\right) = h(d_j, 1-s_2^j) + s_2^j h_l(d_j, 1-s_2^j) - h(B_j, 1-s_1^j) - s_1^j h_l(B_j, 1-s_1^j) \tag{19}$$

Combining (4), (16), and (19) we have

$$\begin{aligned} V_0^j(w_1^j) - V_1^j &= \left(\frac{1}{r+\lambda}\right)\left\{h(w_1^j) - \left(\frac{r}{r+\gamma}\right)[h(B_j, 1-s_1^j) + s_1^j h_l(B_j, 1-s_1^j)]\right. \\ &- \left.\left(\frac{\gamma}{r+\gamma}\right)[h(d_j, 1-s_2^j) + s_2^j h_l(d_j, 1-s_2^j)]\right\} \end{aligned} \tag{20}$$

Then, for an agent who has exhausted benefits, combining (4), (17), and (20) we have

$$\begin{aligned} V_0^j(w_1^j) - V_2^j &= \frac{1}{r+\lambda}\left\{h(w_1^j) + \frac{\lambda}{r+\gamma}\left[h(B_j, 1-s_1^j) + s_1^j h_l(B_j, 1-s_1^j)\right]\right\} \\ &+ \frac{1}{r}\left(\frac{\lambda\gamma}{(r+\lambda)(r+\gamma)} - 1\right)\left[h(d_j, 1-s_2^j) + s_2^j h_l(d_j, 1-s_2^j)\right] \end{aligned} \tag{21}$$

Similarly for a non-collector, using (4) and (18) we have

$$V_0^j(w_3^j) - V_3^j = \left(\frac{1}{r+\lambda}\right)\left[h(w_3^j) - h(d_j, 1-s_3^j) - s_3^j h_l(d_j, 1-s_3^j)\right] \tag{22}$$

Combining (20) and (22) with the Nash F.O.C. in (14) determines the values of $w_k^j, k = 1, 3$, and combining (20)-(22) with (5) determines the optimal values of $s_k^j, k = 1, 2, 3$. Since agents (workers and firms) need to form beliefs about the value of average search effort, S, to make their decisions, we denote these beliefs by S^B. A condition of equilibrium is that these beliefs are *consistent*, i.e. $S^B = S$.

To determine equilibrium, we also need to determine the set $\mathbf{Y}_1$. This can be characterized by V_1^j and V_3^j crossing either once or twice (of course they need not cross for every parametrization). Figure 4 plots the difference $V_3^j - V_1^j$ across y for our baseline calibration. In all parameterizations that we tried, however, the difference $V_3^j - V_1^j$ had the non-monotonic shape displayed in this Figure; s a result, the computation of equilibrium involves finding two values, y_0 and y_1. The $V_3^j - V_1^j$ difference starts increasing at the value of y where the maximum benefit level begins to bind. Once the maximum benefit binds, as y (and thus w^j) increases, the replacement rate is decreasing, and eventually becomes low enough that the benefits of not collecting (higher job arrival rate) outweigh the benefits of collecting. Thus, for productivity values below y_0 and above y_1, agents do not collect benefits (i.e $V_1^j < V_3^j$), while for intermediate productivity values, agents do collect. Given this, the take-up rate is calculated as $F(y_1) - F(y_0$. Moreover, notice that as in the case of average search

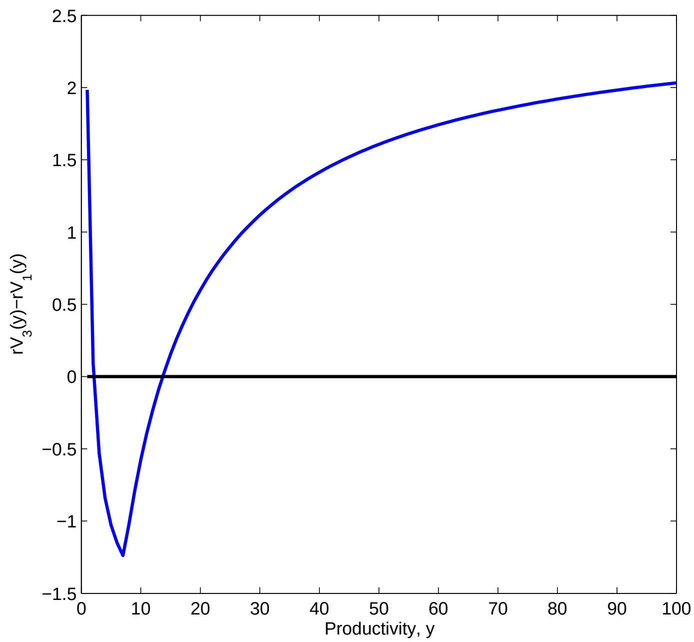

Figure 4: Determination of $\mathbf{Y}_1$

effort, agents must form beliefs about the set $\mathbf{Y}_1$ in order to make decisions. Denote these beliefs by $\mathbf{Y}_1^B$.

Our description of equilibrium also requires the flow equations determining, n_0, n_1, n_2, and n_3. These are given by,

$$\lambda^1 n_0 = \alpha^1 n_1 + \alpha^2 n_2 \tag{23}$$

$$\lambda^3 n_0 = \alpha^3 n_3 \tag{24}$$

$$\gamma n_1 = \alpha^2 n_2 \tag{25}$$

$$1 - n_0 = n_1 + n_2 + n_3 \tag{26}$$

$$\tag{27}$$

Here, $\alpha^k \equiv \left(\frac{1}{S}\right)\left(\int s_k^j d\Pi_k\right)\theta q(s, a_k, \theta)$, where $a_2 = a_1$. Similarly, s_k denotes the average search effort for unemployed agents in state k, and is defined by $\int_{\mathbf{Y}_k} s_k^j dF(y_j)$. Finally, $\lambda^k = \lambda \int_{\mathbf{Y}_k} dF(y_j), k = 1, 3$. Equation (23) states that the flows into and out of insured employment remain equal, while equation (24) equates the flow into and out of un-insured unemployment. The flows of agents who have exhausted benefits is governed by equation (25), and equation (26) completes the description of equilibrium, ensuring measure 1 of agents.

Finally, we have the government's budget constraint:

$$n_1 \int_{\mathbf{Y}_1} \min\{b_j w_1^j, \bar{b}\} dF(y_j) = n_0 \tau \int_{\mathbf{Y}_1} dF(y_j) \tag{28}$$

the L.H.S. gives total benefits paid, the R.H.S. total revenue collected from firms. We now define an equilibrium as follows.

Definition 1 *An equilibrium is a list* $\{\theta, w_1^j, w_3^j, s_1^j, s_2^j, s_3^j, a_1, n_0, n_1, n_2, n_3\}$*, such that*

1. *Given equations (20)-(22),* θ *satisfies (15),* w_1^j *and* w_3^j *satisfy (14), and* $s_k^j, k = 1, 2, 3$ *satisfy (5)*
2. *Beliefs are consistent:* $S^B = S$ *and* $\mathbf{Y}_1^B = \mathbf{Y}_1$*.*
3. τ *satisfies (28)*
4. $n_0, n_1, n_2,$ *and* n_3 *satisfy (23)-(26).*

4 Quantitative Analysis

In this section, we present a quantitative analysis of the aforementioned model and equilibrium. The goal in this section is to evaluate how well the endogenous mechanism explains observed take-up rates. Our calibration focuses on the time period from $2003 - 2006$, and all moments are taken as the average over this time period.

4.1 Calibration

The model described in Section 3 leaves the following parameters to be determined: β, r, b, d, $\bar{b}$, λ, γ, κ, $h(c,l)$, $F(y)$, and functional forms for the matching function and utility function. We first describe those parameters whose values can be found using the existing literature. Specifically, we use the following functional forms for the baseline analysis. The utility function is given by

$$h(c,l) = \frac{\left(cl^{\delta}\right)^{1-\sigma} - 1}{1-\sigma} \tag{29}$$

For the coefficient of relative risk aversion, we use a standard value of 1.0, which falls within the range considered in Hansen and Imrohoroglu (1992) and the existing RBC literature.

For the matching function, $m(sU, aV)$, we use the standard constant returns to scale form given by $m(sU, aV) = (sU)^{\eta}(aV)^{1-\eta}$.[8] As in Fredriksson and Holmund (2001), we use a value of 0.5 for β; furthermore, to set η, we impose the Hosios (1990) condition. The time period is set to one quarter, so a per-annum risk-free interest rate of 0.04 implies $r = 0.01$.

The remaining parameters are determined by targeting different moments in the data. First, we choose δ so that average search effort in the model is consistent with the data. Since we have normalized leisure while employed to equal the time endowment, average search effort in the model needs to be compared to the ratio of time spent searching to time spent working in the data. From the ATUS (American Time Use Survey), we calculate that on average, unemployed individuals who are actively searching for a job spend 194 minutes a day engaged in this activity.[9] From the same survey, we also calculate that employed individuals spend 399 minutes a week-day working. If we use this as the time spent working, the model must produce average search effort equal to $\frac{194}{399} = 0.486$. If we include all 7 days, we find that employed individuals spend 39.9 hours per week working, implying 479 minutes per day working. Using this as time spent working, we find the aforementioned ratio as $\frac{194}{479} = 0.405$. We calibrate to the average of these two estimates, 0.445. In our model, this implies $\delta = 7.4$.

The job separation rate λ is set to the observed transition between employment and unemployment, $\lambda = 0.017$. For this, we use data constructed by Robert Shimer, who uses CPS (Current Population Survey) data to calculate the flows in and out of the different labor market states.[10] Given this transition rate, we then choose non-market income, d, to match an unemployment rate of 5.34% during the period from $2003 - 2006$. Finally, κ is set so that the equilibrium value of θ implies an average unemployment duration of 19.48 weeks, or 1.4981 quarters, which matches the average duration observed from $2003 - 2006$. Finally, for the productivity distribution, in the

[8]An alternative, used by others including Shimer (2005), is to use $m(sU, aV) = A(sU)^{\eta}(aV)^{1-\eta}$. Then, θ is normalized to 1, and A is chosen appropriately.

[9]Note, our estimate is much higher than that calculated in Krueger and Mueller (2010). The discrepancy arises because we restrict attention only to those unemployed individuals, while Krueger and Mueller (2010) include those who do not spend any time on job search.

[10]For additional details, please see Shimer (2007) and his web page http://robert.shimer.googlepages.com/flows.

baseline analysis we assume an exponential distribution, so that $F(y) = 1 - \exp(-\frac{1}{\mu_y} y)$. We set the rate parameter of this distribution, μ_y, so that the standard deviation of log wages predicted by the model matches that observed in the CPS (average from $2003 - 2006$), which is 0.801; this implies $\mu_y = \frac{1}{6.8} = 0.1471$.

4.1.1 U.S. Unemployment Insurance System

Our model in Section 3 specifies a stylized, but relatively detailed version of the U.S. unemployment insurance system. The next step in our calibration is to determine the relevant parameters describing this system. To do so, we need to find three values: b, the basic replacement rate; $\bar{b}$ the maximum benefit level; and γ, which determines the potential duration of benefits. While the CPS does contain some information about the actual amount of benefits collected, given the incomplete nature of the earnings information, any calculations of replacement rates is likely to be relatively inaccurate. Moreover, there exist many idiosyncracies among states regarding unemployment insurance laws, regulations, and benefit calculations; as a result, difficulties arise determining the actual replacement rate for a given state, let alone for the overall U.S. economy. In addition to the variability across states, a particular state often has complicated rules for calculating benefits, with many possible deductions and limits. To circumvent this difficulty, we use data from BAM (Benefit Accuracy Measurement) from $2003 - 2006$ to directly calculate the replacement rate, maximum benefit amount, and potential duration of benefits. Since the data are from careful audits of unemployment claims, the earnings and benefit information is more complete and accurate for this task than the CPS data.

For the U.S. overall, we calculate the average benefit duration is 24 weeks and the average replacement rate is 0.45. These are similar to the commonly used 26 week duration and 0.50 replacement rate. When we take into account the maximum benefit amount, we find that on average 23% of those collecting are receiving the maximum benefit level in their respective state. We find that for those agents receiving below the maximum benefit, the replacement rate is $b = 0.48$, and we thus set b accordingly. To set the maximum benefit, we target the average replacement rate among those receiving the maximum benefit, which is 0.36. Accordingly, we set the maximum benefit to $\bar{b} = 3$. We also set the value of γ to match the expected potential duration of benefits of 24 weeks, or 2 quarters, implying $\gamma = 0.5$. Given the aforementioned parameters, we compute the

Table 1: Parameters

β	0.5	Bargaining parameter
η	0.5	Elasticity of matching function
r	0.1	Discount rate
b	0.48	Replacement rate, UI, non-binding
d	0.037	Minimum consumption rate
$\bar{b}$	2.20	Maximum UI benefit
λ	0.017	Job separation rate
γ	0.5	Length of unemployment benefits
κ	15.4	Vacancy creation cost
σ	1.0	Coefficient of relative risk aversion
δ	7.4	Utility parameter
μ_y	$\frac{1}{6.8}$	Rate parameter of $F(y)$

equilibrium and compare its moments to those observed in the U.S. economy from $2003 - 2006$.

4.2 Results

Table 2 presents the results from our calibration.

There are several interesting features of the results that we now explore in more detail. First, notice that relative to the case of fixed search effort, the difference in job finding rates between collectors and non-collectors remains much smaller. These job arrival rates imply an average duration of unemployment of 1.6720 (21.7360 weeks) for agents who are collecting benefits, 1.4331 (18.6303 weeks) for agents who have exhausted benefits, and 1.3617 (17.7021 weeks) for agents who never collect. Notice, this implies a duration elasticity (with respect to the benefit level) of 0.39, as a 58% decrease in the benefit (from 0.48 to 0.2) decreases the average unemployment duration by 23%.

Second, it is interesting to look at the differences in search effort across unemployment states. Figures 5-7 plot search effort over productivity for different unemployment states. First, in Figure 5, the main feature is the kink in s_1, which occurs at the level of y where the maximum benefit begins to bind. While the benefit does not bind, the since the benefit remains a constant fraction

Table 2: Calibration Results

Moment	Model	Data
Unemployment rate	5.34%	5.34%
Unemployment duration	1.4962 (19.45) weeks	1.4981 (19.48)
Take-up rate	0.6462	0.6424
Market Tightness, θ	2.3116	0.6
Average search intensity	0.444	0.445
Average unemployment duration, collect	1.5856	1.5063
Average unemployment duration, non-collect	1.2251	0.597
Replacement rate, binding benefit	0.35	0.36
Fraction with binding benefit	0.21	0.23
Standard deviation of log wages	0.809	0.801

of the previous wage, the difference in value functions $V_0^j(w_1^j) - V_1^j$ remains constant. After the maximum benefit binds, however, the replacement rate decreases with y causing $V_0^j(w_1^j) - V_1^j$ to increase, and thus search intensity to increase.

The change in search effort upon benefit expiry represents another interesting dimension to analyze, and we plot this in Figure 6. While a binding benefit increases search intensity with y, it has the opposite effect on s_2^j, search intensity of agent's for whom the benefit has expired. Once benefits have expired, search intensity increases, which is evident in Figure 6, as s_2^j lies everywhere above s_1^j. This difference, however, decreases with y, implying that unemployment benefits have a smaller effect on the unemployment duration for higher wage earners relative to low earners. Finally, in Figure 7 we plot the difference in search intensity for agents in unemployment state $k = 2$ and $k = 3$. First notice that search effort remains constant over y for $k = 3$, the non-collectors. Since they do not collect benefits, the difference between employment and unemployment remains constant over y (i.e. the binding benefit issue does not arise). This figure also illuminates the effect of a binding benefit on s_2^j, collectors who have exhausted benefits.

Finally, notice in Table 2 the model does well matching the fraction of individuals collecting benefits who are receiving the maximum benefit. Further, recall we have not made any parametric restrictions targeting this moment, so the model's success along this dimension is encouraging.

4.2.1 Policy Experiments

This section analyzes several policy experiments and their effect on labor market outcomes. We begin by changing the relevant parameters of the stylized unemployment insurance system. Here, there exist three parameters defining the system: the basic replacement rate, b, the maximum benefit level, $\bar{b}$, and the potential duration of benefits, γ. Below we explore the implications of changes in each of these three parameters.

First, consider changes to the basic replacement rate, b, which assumes a baseline value of 0.48. Table 4 displays the results from increases in the basic replacement rate. The results imply the unemployment rate and average duration of unemployment respond slowly to changes in b, which represents a surprising result, as micro estimates (for example in Meyer (1990)) appear to imply a higher duration elasticity with respect to the benefit level. There are several interesting points to note about this result. First, as the other policy experiments highlight below, the key factor in determining the effect of changes to the benefit system on labor market outcomes is their effect on the taxes imposed on firms. Our analysis indicates changes to the benefit system have relatively small effects on the incentives of job searchers (i.e. search effort), but much larger effects on the incentives of firms to (i)create vacancies and (ii) to search with more intensity (a_1) for individuals not collecting benefits. These forces can be noted by examining how θ, a_1, $\theta q(a_1, \theta)$, and $\theta q(a_3, \theta)$ change with b in Table 4. Notice, there is very little change in any of these variables, which again occurs because the total cost of financing the UI system is changing slowing as b increases. With little additional taxes, firm behavior does not change drastically. Finally, also note that the take-up rate is increasing in b. The increase in the basic replacement rate implies that more higher productivity workers are subject to the maximum benefit amount, and as a result, fewer of such workers collect benefits. On the other end, however, the increase in the basic replacement rate does increase the benefit to applying for lower productivity workers, and among this group the take-up rate increases. For our baseline parametrization the latter effect dominates, but the opposing forces helps explain the overall small response of the take-up rate to changes in the basic replacement rate.

Another experiment to consider changes in the benefit levels is to change the maximum benefit amount, $\bar{b}$. When $\bar{b}$ increases, this effectively increases the overall replacement rate, as fewer agents are constrained by the maximum amount. In Table 5, we present the results from changes in $\bar{b}$. In this case, changes to $\bar{b}$ have a much larger effect on labor market outcomes than the changes to b. In this case, changes to $\bar{b}$ have a larger effect on the total cost to the UI system, and as a result, firm responses are larger. This is most evident when the maximum benefit increases from 3 to 5. Under this change, almost all agents collect the standard benefit, while only 1% are constrained by $\bar{b}$. Given the relatively large increase in the cost of the UI system, firms respond by decreasing advertising intensity for agents who do collect benefits (a_1 decreases), and market tightness increases. In response to the firms' decisions, the take-up rate decreases from 60% to 19%.

Finally, we also analyze changes to the potential duration of benefits, γ, and we present these results in Table 6. Again, relative to the case of changing b, changes in γ have a relatively large effect on labor market outcomes. Moreover, when the potential duration of benefits increases (an increase in benefit generosity), the take-up rate actually declines.

4.2.2 Comparison to Standard Search Model

In this section we briefly describe a version of our model that abstracts from the take-up decision; i.e. all workers collect benefits when moving from employment to unemployment. This model represents the standard used in the existing literature (although we have heterogeneous workers and variable search effort, which are not commonly used), and we compare the results of our policy experiments to the predictions of the standard model. This comparison allows us to understand what role an endogenous take-up rate plays in how changes to UI benefits affect labor market outcomes.

This alternative model follows closely the one presented in Section 3, with the following exceptions. First, since all workers collect benefits, the firm no longer varies advertising intensity along this dimension. Thus, there only exists one job arrival rate for workers, $\theta q(S, \theta)$ and for firms, $q(S, \theta)$. Moreover, the workers' problem is now described by only three Bellman equations, described in (1), (2), and (4); furthermore, in (4) there is no longer a decision to collect benefits or not upon separation. With these changes, the optimal decision and equilibrium are determined as in Section 3. Given this alternative model, we first re-calibrate the appropriate parameters, and

Table 3: Calibration Results, No Take-up Model

Moment	Model	Data
Unemployment rate	5.35%	5.34%
Unemployment duration	1.4922 (19.40) weeks	1.4981 (19.48)
Take-up rate	1	0.6424
Market Tightness, θ	1.5268	0.6
Average search intensity	-	0.486
Replacement rate, binding benefit	0.3558	0.36
Fraction with binding benefit	0.0930	0.23

then perform the aforementioned policy experiments. The only changes from Table 1 are to the maximum benefit amount, $\bar{b} = 6.5$, the job separation rate, $\lambda = 0.065$, and the vacancy creation cost, $\kappa = 13$. These parameters produce the calibration results summarized in

That the model with take-up rates better matches the fraction of workers with a binding benefit level is worth noting. First, in the model with a take-up decision, since higher productivity workers choose not to collect, the maximum benefit level must be higher relative to the standard no take-up model in order to match the observed average replacement rate for this group. Moreover, since the fraction of workers at the binding benefit applies to only those collecting benefits, the model with no take-up decision predicts a much lower fraction relative to the model with the take-up decisions. We also consider differences in the two models with respect to how the labor market responds to changes in UI benefits.

Tables 7-9 present the results from these policy experiments. First, in Table 7 we consider changes to the basic replacement rate, b. Similarly to our model with the take-up decision, the effects of changes in b are relatively small. There do exists interesting differences, however. In our baseline take-up model, the unemployment rate responds slightly more, and the average duration of unemployment less, relative to the no take-up model.

In Table 8 we consider changes to the maximum benefit level. Here, there exist noticeable differences with the model including a take-up decision. Specifically, in the latter, changes in $\bar{b}$ produced large changes in both the unemployment rate and average unemployment duration; in contrast, there are only small effects on these moments in the model with no take-up decision.

Finally, in Table 9 we present the results for the no take-up model when the potential duration of benefits, γ, changes. Again, there exist differences with the model including a take-up decision. In the no take-up model, the unemployment rate changes little, while there are large changes to the average duration of unemployment. The magnitude of these effects are reversed for the model with take-up decisions; the unemployment rate has a large response, while the average unemployment duration less so. The results in Tables 7-9 show that including an endogenous take-up rate has important implications for the effects of changes in the UI system on labor market variables.

5 Conclusion

We developed a model to explain unemployment insurance take-up rates with endogenous application costs. The model was calibrated to U.S. data, and performed well matching observed take-up rates, which we estimate from CPS data. Specifically, we find the endogenous mechanism, driven by variable firm vacancy advertising, represents a plausible explanation for take-up rates below 100%. While the model did well explaining observed take-up rates, there exist several interesting directions for future research. One in particular is to examine more carefully the state-level variation in take-up rates, unemployment durations, and eligibility criterion. Such an analysis could also explore the relationship between these factors, i.e. how they may be jointly determined. Finally, our model of variable firm advertising intensity may have interesting applications to other problems. For example, differences between the labor market experiences of males and females could perhaps be better, or more completely analyzed in this context, as opposed to the traditional segmented markets approach.

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A Tables and Graphs

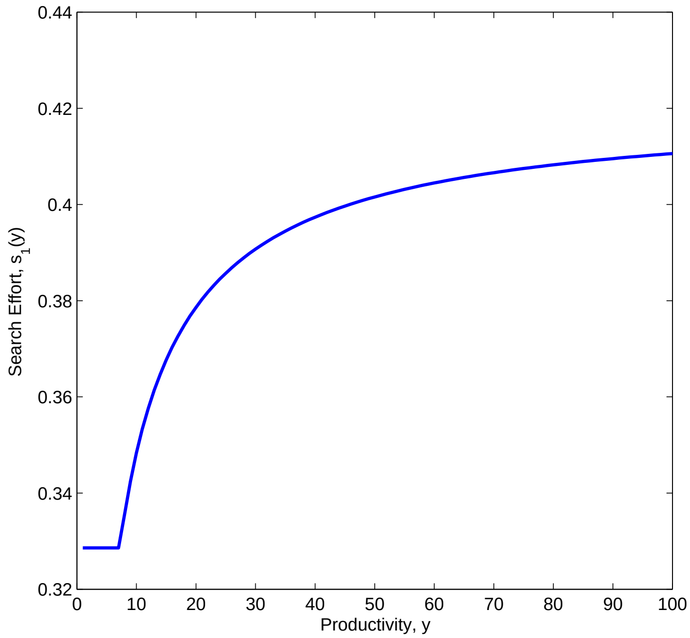

Figure 5: Search effort, collectors

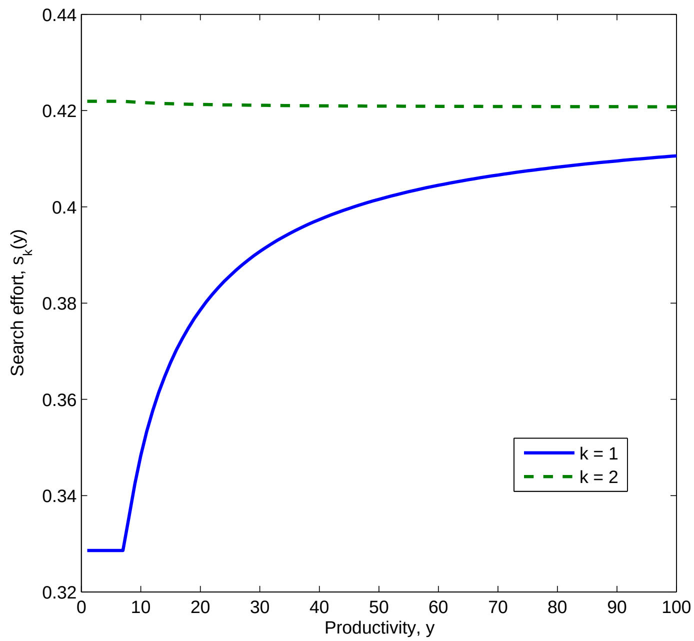

Figure 6: Search effort upon benefit expiry

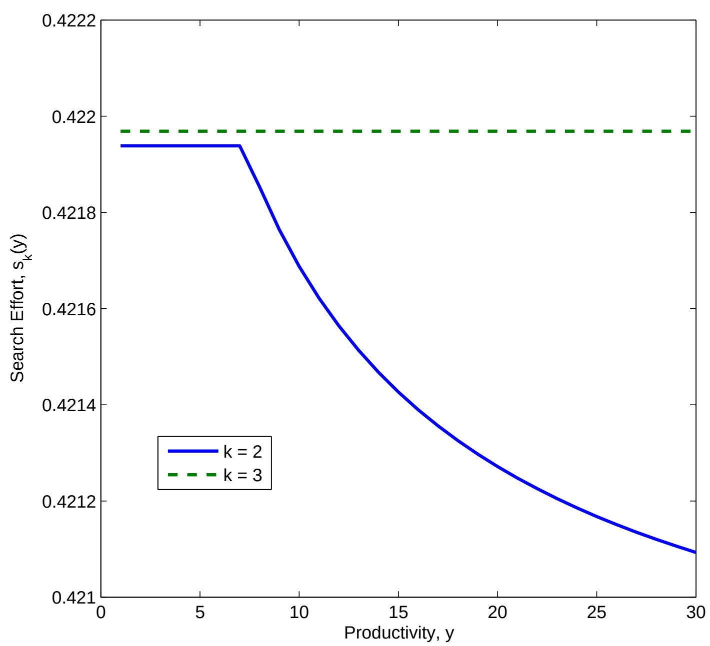

Figure 7: Search effort, $k = 2$ and $k = 3$

Table 4: Changes in replacement rate, b

Moment	$b = 0.48$	0.528	0.576	0.624	0.672	0.720	0.820
Unemployment rate	5.33%	5.36%	5.38%	5.40%	5.42%	5.44%	5.47%
Unemployment duration	1.4328	1.4385	1.4438	1.4482	1.4525	1.4563	1.4632
Take-up rate	0.5930	0.6185	0.6215	0.6315	0.6397	0.6473	0.6610
Advertising intensity, a_1	0.4571	0.4567	0.4569	0.4570	0.4568	0.4572	0.4571
Market Tightness, θ	3.0031	2.9906	2.9793	2.9703	2.9616	2.9543	2.9412
Job finding rate, collect	0.6954	0.6930	0.6912	0.6896	0.6880	0.6867	0.6843
Job finding rate, non-collect	0.7580	0.7559	0.7535	0.7517	0.7499	0.7484	0.7457
Replacement rate, binding benefit	0.3361	0.3631	0.3959	0.3965	0.3969	0.4389	0.4396
Fraction with binding benefit	0.1897	0.2361	0.2908	0.2898	0.2891	0.3514	0.3504

Table 5: Changes in maximum benefit, $\bar{b}$

	γ				
Moment	1	2	**3**	4	5
Unemployment rate	4.99%	5.20%	5.33%	5.64%	7.08%
Unemployment duration	1.3523	1.4013	**1.4328**	1.5314	2.0355
Take-up rate	0.6977	0.6825	**0.5930**	0.4566	0.1916
Advertising intensity, a_1	0.4817	0.4677	**0.4571**	0.3862	0.2021
Market Tightness, θ	3.1416	3.0483	**3.0031**	3.0172	3.1259
Job finding rate, collect	0.7375	0.7111	**0.6954**	0.6401	0.4713
Job finding rate, non-collect	0.7650	0.7589	**0.7580**	0.8072	0.9365
Replacement rate, binding benefit	0.1920	0.2934	**0.3361**	0.4073	0.4695
Fraction with binding benefit	0.5025	0.3489	0.1897	**0.0956**	0.0010

Table 6: Changes in potential benefit duration, γ

	γ						
Moment	2	1.0	0.8	**0.5**	0.3	0.1	0.05
Unemployment rate	4.73%	4.93%	5.04%	5.33%	5.79%	7.32%	8.50%
Unemployment duration	1.3099	1.3539	1.3748	**1.4328**	1.52	1.7721	1.9299
Take-up rate	0.6368	0.6184	0.6112	**0.5930**	0.5689	0.5063	0.4685
Advertising intensity, a_1	0.4794	0.4684	0.4648	**0.4571**	0.4504	0.4462	0.4501
Market Tightness, θ	3.2515	3.1552	3.1127	**3.0031**	2.8541	2.4819	2.2708
Job finding rate, collect	0.7586	0.7332	0.7224	**0.6954**	0.6604	0.5781	0.5338
Job finding rate, non-collect	0.7906	0.7811	0.7755	**0.7580**	0.7295	0.6441	0.59
Replacement rate, binding benefit	0.338	0.3374	0.3371	**0.3361**	0.334	0.3261	0.32
Fraction with binding benefit	0.1859	0.1867	0.1874	**0.1897**	0.1946	0.2148	0.2316

Table 7: Changes in replacement rate, b, no take-up model

Moment	$b = 0.48$	0.528	0.576	0.624	0.672	0.720	0.820
Unemployment rate	5.35%	5.37%	5.38%	5.40%	5.41%	5.42%	5.45%
Unemployment duration	1.4922	1.5155	1.5381	1.5602	1.5819	1.6033	1.647
Take-up rate	1	1	1	1	1	1	1
Market tightness, θ	1.5268	1.5051	1.4855	1.4678	1.4516	1.4369	1.41
Job finding rate	0.6893	0.6819	0.6753	0.6692	0.6635	0.6583	0.6487
Replacement rate, binding benefit	0.3558	0.3875	0.4059	0.4261	0.4485	0.4734	0.5332
Fraction with binding benefit	0.093	0.1194	0.1353	0.1534	0.1738	0.1969	0.2528

Table 8: Changes in maximum benefit, $\bar{b}$, no take-up model

	$\bar{b}$				
Moment	1.5	3.5	7.5	8.5	9.5
Unemployment rate	5.26%	5.32	5.36	5.36	5.36
Unemployment duration	1.3754	1.4545	1.4973	1.5006	1.5028
Take-up rate	1	1	1	1	1
Market tightness, θ	1.691	1.5795	1.5197	1.5148	1.5115
Job finding rate	0.7367	0.7039	0.6873	0.686	0.6851
Replacement rate, binding benefit	0.2102	0.3098	0.3652	0.3729	0.3794
Fraction with binding benefit	0.5353	0.2865	0.0639	0.0439	0.0302

Table 9: Changes in potential benefit duration, γ, no take-up model

	γ						
Moment	2	1	0.8	0.5	0.3	0.1	0.08
Unemployment rate	5.12%	5.2	5.24	5.35	5.51	5.91	6.00
Unemployment duration	1.2696	1.3415	1.3788	1.4922	1.6932	2.6657	3.049
Take-up rate	1	1	1	1	1	1	1
Market tightness, θ	1.8242	1.7046	1.654	1.5268	1.3608	0.9475	0.8602
Job finding rate	0.7891	0.7516	0.7345	0.6893	0.6261	0.4542	0.4158
Replacement rate, binding benefit	0.3597	0.3579	0.3572	0.3558	0.3543	0.352	0.3517
Fraction with binding benefit	0.093	0.093	0.093	0.093	0.093	0.093	0.093