

# Equilibrium Policy Experiments and the Evaluation of Social Programs

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## Abstract

In this paper we provide new and convincing evidence on the presence and magnitude of feedback effects associated with “make work pay” policies currently under consideration in the US, Canada, the UK and other developed countries. We build a general equilibrium model of the labor market and use the model to study the effects of policies currently implemented in practice only as small-scale social experiments. The evidence from our model experiments is particularly compelling as we first test the partial equilibrium implications of our model using experimental data: in particular, we calibrate the model to the control group in a randomized experiment and find the model predicts the program group outcomes and the experimental impact estimates very well. We then use the model to quantify the effects of the experimental program introduced in general equilibrium. We apply our methodology to the evaluation of the Canadian Self-Sufficiency Project (SSP), a policy providing generous financial incentives for Income Assistance (IA) recipients to obtain stable employment. Our results reveal several important feedback effects associated with the SSP policy; taken together, these feedback effects reverse the cost-benefit conclusions implied by the partial equilibrium experimental evaluation. The substantial general equilibrium effects reported here are illustrative of the feedback effects that are likely to arise in a broad range of other programs that seek to “make work pay” through the subsidization of search and work.

JEL Classification: J2, I38, J6

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# 1 Introduction

Many potential policies have been evaluated using social experiments, where small subsets of the population are randomly assigned to program and control groups, the program group is subjected to the potential policy reform and the difference in outcomes between the groups provides an estimate of the mean impact of the policy. The resulting treatment effects literature provides useful estimates of the effect of treatment on those individuals participating in the program within an experiment, where typically a small number of individuals are affected by the policy. However, such estimates may be of limited usefulness if the policy evaluated in the experiment is implemented in general. A growing body of research indicates that a policy may have very different implications when it is implemented for the general population than when it is implemented on only a small number of participants for evaluation purposes.

As outlined in Calmfors (1994) and elsewhere, such general equilibrium effects of programs represent a critical component of social cost-benefit analysis. Consider two examples of such effects. First, programs may have indirect effects on both participants and non-participants by changing the equilibrium of the labor market. These effects violate the “stable unit treatment value assumption” (SUTVA) invoked to justify partial equilibrium analysis. Heckman, Lochner, and Taber (1998) consider increasing subsidies to college tuition and find that the resulting increase in the number of individuals who attend college has the effect of increasing the supply of college graduates and reducing their wages. In this case, the effect of the tuition policy depends on the number of college graduates in the labor market.

Second, programs may directly affect those who are not treated within the program. As discussed by Heckman and Smith (1998), the standard treatment effects literature assumes

that the outcomes for individuals not treated by the program within an experiment are the same as the outcomes non-participants would experience if the program were implemented more widely. This need not be the case. For example, consider the US Unemployment Insurance Bonus experiments, where individuals starting a spell of unemployment were offered a cash payment if they obtained employment within a limited time period. Davidson and Woodbury (1993) estimate the displacement effects of the bonus program that would result from changes in the search behavior of all workers in the labor market. In particular, the bonus increases the gain to employment for workers eligible to receive it, resulting in increased search effort and employment. Some of the increase in employment will be in jobs that would otherwise have been held by workers not eligible for the bonus. This displacement directly affects a subset of the labor force not treated within the program.

Existing studies, such as those mentioned above, indicate that the equilibrium effects of large-scale policies may be substantial. With regard to the college tuition subsidies, Heckman, Lochner and Taber (1998) estimate that the general equilibrium effects on enrollment rates are 10 times smaller than those obtained from a partial equilibrium analysis. Davidson and Woodbury (1993) estimate that the displacement of UI-ineligible workers offsets 30-60 percent of the gross employment effect of the bonus program. This has a strong effect on the estimated net impact of the program from society's point of view. In recent work, Blundell, Costa Dias, and Meghir (2003) consider the long-run effects of a large-scale wage subsidy policy for low-skill workers. They find that the general equilibrium effects of the policy on unemployment are opposite in sign to the predictions of a partial equilibrium analysis. Van der Linden (2005) finds that the general equilibrium effects of job counselling programs are very different from the partial equilibrium effects. Albrecht, van den Berg, and Vroman (2005) find equilibrium effects that are 1.5 to 2 times the size of partial equilibrium effects in a model of Swedish adult education programs. Overall, the literature shows that gen-

eral equilibrium program evaluations can lead to very different conclusions regarding the cost-benefit performance of labor market policies.

Studying the general equilibrium effects that may result from implementing a small-scale social experiment as a large-scale policy is difficult without the use of an equilibrium model. However, the degree of confidence that can be placed in policy experiments generated within a model depends to a large extent on how well the model captures the behavior of the individuals affected by the policy.

The goal of our paper is to combine the advantages of the literature that attempts to evaluate potential policies through social experiments with the advantages of the literature that evaluates potential policies through model experiments. We construct a dynamic, equilibrium model that is well-suited for conducting labor market policy experiments and we use the model as a tool for evaluating “make work pay” social programs that either subsidize employment or search. Our model is based on the textbook matching model of Pissarides (2000, Ch. 5). Within the model, the amount of time required to find a job can be reduced by increased search effort on the part of the worker. Once workers and firms meet, they bargain over wages in an environment where wages reflect the value of the match and the value of the outside options faced by both parties. This framework is ideally suited for many equilibrium program evaluations, as it explicitly considers the effect of changes in financial incentives introduced by social programs on the intensity with which individuals search for jobs and on the process by which wages are determined in the labor market. In addition to the matching and wage determination process, our model incorporates key features of welfare and unemployment programs, both of which constitute important aspects of the economic context and are likely to have important feedback effects on the labor market.

Before conducting the policy evaluation within the model, we test the partial equilibrium

implications of our model using experimental data: in particular, we calibrate the model to the control group in a randomized social experiment of interest and find the model predicts the program group outcomes and the experimental impact estimates very well.<sup>1</sup> This is one of the main innovations of our approach and provides very compelling evidence on the model's ability to accurately predict the potential response of agents to the introduction of the policy change of interest. In general, calibrated models are tested by examining the extent to which they can replicate features of the economy. Our exercise is more stringent in the sense that the model must also be able to match the behavior observed in the data following a policy change without exploiting the variation introduced by the policy change itself. We are able to replicate the outcomes and impacts produced by a social experiment without using the data from the experimental program group. The ability of the model to do so greatly increases our confidence in the results from our general equilibrium program evaluation.<sup>2</sup> In this respect, our model test serves as an analogue to work by Lalonde (1986) and others, where experiments are used as a benchmark against which to assess the performance of partial equilibrium non-experimental estimators.<sup>3</sup>

We apply our methodology to the equilibrium evaluation of the Canadian Self-Sufficiency Project (SSP), a policy designed to provide incentives for individuals on Income Assistance to leave the system for full-time employment.<sup>4</sup> Similar, but less generous, income supplement programs have been studied in the United States; see Auspos, Miller, and Hunter (2000) on the Minnesota Family Investment Program and Bos, Huston, Granger, Duncan, Brock, and McLoyd (1999) on the Wisconsin New Hope program. Bloom and Michalopou-

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<sup>1</sup>The details of this exercise can be found in our companion paper, Lise, Seitz, and Smith (2005).

<sup>2</sup>In parallel work, Todd and Wolpin (2003) use the data from the experimental evaluation of Mexico's PROGRESA program to test a partial equilibrium, structural, dynamic model of fertility and child schooling using a similar approach. Their model replicates well the experimental impacts from PROGRESA.

<sup>3</sup>See, e.g., Smith and Todd (2004) for a summary of this literature.

<sup>4</sup>A growing literature looks at various aspects of the Self-Sufficiency Project. See, e.g., Card and Hyslop, 2004; Card et al., 2001; Connolly and Gottschalk, 2003; Ferrall, 2000; Foley, 2004; Kamionka and Lacroix, 2002; Zabel et al., 2004).

los (2001) provide an overview of the experimental literature and compare these programs to other approaches. These programs, along with policies such as the Earned Income Tax Credit (EITC) in the US and the Working Families Tax Credit (WFTC) in the UK, aim to “make work pay” by subsidizing low-wage work.

The SSP provides financial incentives by offering a temporary earnings supplement to single parents on IA.<sup>5</sup> Individuals must remain on IA twelve months to become eligible for the earnings supplement; once they do, they receive a supplement if they obtain full-time employment (at least 30 hours per week) and leave IA within the following twelve months. The supplement equals half the difference between the individual’s earnings and a province-specific cutoff level in each month.

Our model incorporates the main features of the SSP. In particular, the model allows for time limits in determining eligibility for receipt of the supplement, consistent with the one-year time limit in the experiment, allows individuals to receive the earnings supplement for up to three years while employed, and allows the earnings supplement to depend on the wages received by eligible recipients. The full-time work requirement is the sole omission, due to the fact that our model does not include the hours choice. In addition, our model incorporates the time limitations on entry and exit in the Canadian unemployment insurance<sup>6</sup> program and captures the interactions between IA, UI and the minimum wage in the labor market.

The tests reported in Lise, Seitz, and Smith (2005) lend strong support to our parsimonious model, as the simulated program group outcomes match the experimental program

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<sup>5</sup>In Canada, IA provides mean-tested transfers to persons of working age that do not depend on past earnings or employment but do depend on family size and composition. Canada also has an unemployment insurance system (similar to that in the US but more generous) that pays benefits that depend on past earnings and employment (but not on family size or composition) to workers with sufficient past employment. Unemployment insurance is the more generous program, so a worker eligible for both will collect that first until his or her eligibility runs out, and then switch to IA.

<sup>6</sup>The Canadian UI program is presently called Employment Insurance; we use the standard international term here for clarity.

group data quite closely. In particular, the IA-to-work transition rates for the simulated program group during the 54 months following random assignment are virtually the same as those observed in the experimental data. We are also able to match the delayed exit effects of a second randomized experiment that offered SSP to new IA recipients. We subsequently simulate the equilibrium effects that result from introducing the SSP as a general policy for all IA recipients. Our model allows us to quantify the displacement, wage and delayed exit effects of the SSP and provides a more complete picture of the implications of implementing the SSP as policy than does the partial equilibrium experimental evaluation.

Four main results emerge from the equilibrium program evaluation. First, introducing an earnings supplement to the Income Assistance program has implications for unemployed workers, as the increase in employment for IA recipients coincides with a decrease in re-employment rates for those individuals receiving UI benefits. As a result, the overall employment level does not change after the introduction of the policy. Second, although the introduction of an earnings supplement increases the rate of exits to employment from IA, it does so at lower equilibrium wages, as workers are willing to accept lower starting wages so as to benefit from the supplement payments. Surprisingly, the wages of other workers in the economy increase slightly, as the increased value of IA due to the introduction of the earnings supplement increases the fraction of the match surplus transferred from the firm to the worker. This result is primarily due to the fact that the minimum wage limits the ability of firms to extract the surplus generated by the supplement from the worker. Third, the simulation results indicate the presence of entry and delayed exit effects, as the transition rate into the IA program from UI increases and a higher fraction of individuals remain on IA long enough to qualify for the supplement after the policy change. Fourth, taken together, the equilibrium effects reverse the cost-benefit conclusions from the partial equilibrium analysis and further illustrate the importance of equilibrium program

evaluation.

## 2 The Model

In this section, we present the model of the labor market that we use to conduct equilibrium program evaluations. Three segments of the market are incorporated in the model: individuals may be employed ( $E$ ), unemployed and receiving UI benefits ( $U$ ) or on Income Assistance ( $A$ ).<sup>7</sup> This feature of the model allows us to consider how workers, unemployed individuals and Income Assistance recipients interact in the labor market. The model builds on the model of Pissarides (2000), where individuals maximize expected lifetime income by choosing their labor market state and the intensity with which they search for work if not employed.<sup>8</sup> We extend this standard model to incorporate the Income Assistance program, minimum wages, and time limitations for entry to and exit from the unemployment insurance program. Workers bargain with firms over wages that depend on the tenure of the match, the minimum wage, and on the outside options of both parties. Through this channel, the model generates predictions regarding the way starting wages vary depending on the state from which the individual enters employment. It is further assumed that the value of the match surplus increases with job tenure, generating on-the-job wage growth in the model.

Our model incorporates key features of typical unemployment insurance and Income Assistance programs.<sup>9</sup> First, individuals face time limitations regarding entry to and exit from the unemployment insurance system. Individuals who enter employment from Income Assistance or who have exhausted their unemployment benefits become eligible to receive

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<sup>7</sup>Throughout this paper we use the term unemployed to mean collecting UI benefits. In the model, all jobless individuals are actively seeking employment; they are distinguished by whether they are receiving unemployment benefits or Income Assistance benefits.

<sup>8</sup>See also Davidson and Woodbury (1993); Diamond (1982), Mortensen (1982) and Pissarides (1984).

<sup>9</sup>The program details correspond to those in place in Canada at the time of the SSP experiment. Our model could easily be modified to correspond to the institutions present in the US, the UK, or other developed countries.

unemployment benefits after  $I$  months of employment. The number of months of benefit eligibility subsequently increases by one month for each additional month of employment, from a minimum of  $\underline{u}$  months up to a maximum of  $\bar{u}$  months. Workers who enter employment with unused benefits retain their unused benefit months and accumulate additional months with each month worked. Second, individuals who exhaust their UI benefits and do not secure a job are assumed to transit directly to Income Assistance. Finally, it is assumed that individuals can remain on Income Assistance indefinitely or transit to employment if they contact a firm with a vacancy; Income Assistance recipients cannot transit directly from IA to unemployment. In the following sections, we describe the problems faced by individuals and by firms in the model.

## 2.1 Workers

The value of employment for a worker depends on her job tenure  $t$  and unemployment insurance benefit eligibility status  $i$ , where  $i \in \{0, 1, \dots, \underline{u}, \dots, \bar{u}\}$ . The number of months an individual with no benefits must work in order to qualify for the minimum number of UI benefit months ( $\underline{u}$ ) is  $I$ . For every period an individual works beyond  $I$ ,  $i$  increases by 1. The maximum number of benefit months an individual can accumulate is denoted  $\bar{u}$ . If an individual is not working she would therefore be unemployed with  $i$  periods of benefits remaining.<sup>10</sup> With probability  $\delta$ , jobs are exogenously destroyed in the subsequent month, in which case workers transit to Income Assistance if they have not yet qualified for UI benefits ( $i = 0$ ) and transit to unemployment otherwise. With probability  $(1 - \delta)$ , workers remain employed in the next month.

It is assumed that individuals who return to work before their UI benefits expire retain their remaining UI benefit eligibility. Finally, workers experience on-the-job wage growth

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<sup>10</sup>The UI system in our model embodies two simplifications relative to the system in place at the time of the SSP experiment. First, months of employment do not cumulate across job spells in determining benefit eligibility. Second, once obtained, months of eligibility last indefinitely while employed. Both simplifications substantially reduce the state space of the model.

for a maximum of  $T$  months, after which the wage remains constant, where it is assumed that  $T > \bar{u}$ . The value function for a worker with outside option  $i$  and with job tenure  $t$  is:

$$V^E(t, i) = \begin{cases} w(t, 0) + \beta[(1 - \delta)V^E(t + 1, 0) + \delta V^A] & \text{if } t < I \text{ and } i = 0, \\ w(t, 0) + \beta[(1 - \delta)V^E(t + 1, \underline{u}) + \delta V^U(\underline{u})] & \text{if } t = I \text{ and } i = 0, \\ w(t, i) + \beta[(1 - \delta)V^E(t + 1, i + 1) + \delta V^U(i + 1)] & \text{if } 0 < i < \bar{u} \text{ and } I \leq t < T, \\ w(t, \bar{u}) + \beta[(1 - \delta)V^E(t, \bar{u}) + \delta V^U(\bar{u})] & \text{if } i = \bar{u} \text{ and } I \leq t < T, \\ w(T, \bar{u}) + \beta[(1 - \delta)V^E(T, \bar{u}) + \delta V^U(\bar{u})] & \text{if } t \geq T, \end{cases} \quad (1)$$

where  $w(t, i)$  is the wage for a person with tenure  $t$  who has  $i$  months of UI benefit eligibility remaining,  $\beta$  is the discount rate,  $V^A$  is the value of being on Income Assistance, and  $V^U(i)$  is the value of being unemployed with  $i$  periods of UI benefits remaining.

## 2.2 IA Recipients

IA recipients receive benefits ( $b_a$ ) and pay search costs  $c_a[p(0)^z]$  every month they remain on IA, where  $z$  is the elasticity of search costs with respect to search effort,  $c_a$  is a parameter capturing the disutility of search effort, and  $p(i)$  is the optimal search effort for individuals with  $i$  months of UI benefits remaining (and also the probability that such a worker contacts a firm). The cost of search depends directly on the intensity with which individuals search. In particular, for values of  $z > 1$ , the marginal cost of search increases as search effort increases. If IA recipients match with a firm, they transit to employment. Otherwise, they remain on IA in the next period. The value function for an IA recipient is

$$V^A = \max_{p(0)} \left\{ b_a - c_a[p(0)^z] + \beta \left[ m(0)V^E(1, 0) + (1 - m(0))V^A \right] \right\}, \quad (2)$$

where  $m(0)$  is the match rate for IA recipients, which depends in part on the search effort  $p(0)$ . The only reason IA recipients are not employed is because an employment opportunity is not available and the only way an IA recipient can increase the likelihood of finding a job is through increased search effort.<sup>11</sup>

<sup>11</sup>It is worth noting that we assume all income assistance recipients enter employment with zero tenure. This assumption could be relaxed by assuming workers retain their experience when they enter Income

### 2.3 Unemployed Individuals

Unemployed agents receive exogenous UI benefits ( $b_u$ ) and pay search costs  $c_u[p(i)^z]$ . We make the simplifying assumption that unemployment benefits are independent of the individual's pre-separation earnings. With probability  $m(i)$ , individuals contact a firm with a vacancy and transit to employment in the next month. If individuals remain unemployed in the next month, it is assumed they continue to collect UI benefits. Following the last month of UI benefit eligibility, individuals can either transit to employment, if a job opportunity is available, or transit to IA. The value function for unemployed individuals with  $i$  months of benefits remaining is

$$V^U(i) = \begin{cases} \max_{p(i)} \left\{ b_u - c_u[p(i)^z] + \beta \left[ m(i)V^E(1, i-1) + (1-m(i))V^U(i-1) \right] \right\} & 1 < i \leq \bar{u}, \\ \max_{p(i)} \left\{ b_u - c_u[p(i)^z] + \beta \left[ m(1)V^E(1, 0) + (1-m(1))V^A \right] \right\} & i = 1. \end{cases} \quad (3)$$

### 2.4 Firms

Production takes place when there is a match between one firm and one worker; the number of firms can alternatively be interpreted as the number of jobs in the economy. In every period, each firm has the option of filling a vacancy, if one exists, by hiring a worker or keeping the vacancy open. If matched with a worker, firms earn profits that depend on the surplus generated by the match and pay wages, determined in equilibrium, that depend on the worker's outside options and the minimum wage. Profits depend on the worker's tenure in order to allow match-specific capital to increase the productivity of the match over time.

Denote the surplus generated by a worker-firm pair of tenure  $t$  by  $S(t)$ . With probability  $\delta$  the match separates and the firm is left with a vacancy in the following month. Denote the profits of a firm matched with a worker with outside option  $i$ ,  $i \in \{0, 1, \dots, \underline{u}, \dots, \bar{u}\}$  and

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Assistance and then allowing their experience to depreciate over time. One implication of this extension would be that the hazard of leaving IA would decline as the length of the IA spell increased. The drawback of this extension is that it involves a large increase in the size of the state space. We thank Jim Walker for this valuable suggestion.

match tenure  $t$  as  $\Pi(t, i)$ .

The expected discounted present value of profits for matches of job tenure  $t$  and workers with outside option  $i$  are

$$\Pi^E(t, i) = S(t) - w(t, i) + \begin{cases} \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, 0)] & \text{if } i = 0 \text{ and } t < I, \\ \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \underline{u})] & \text{if } i = 0 \text{ and } t = I, \\ \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, i + 1)] & \text{if } 0 < i < \bar{u} \text{ and } t < T, \\ \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \bar{u})] & \text{if } i = \bar{u} \text{ and } t < T, \\ \beta[\delta\Pi^V + (1 - \delta)\Pi^E(T, \bar{u})] & \text{if } t \geq T, \end{cases} \quad (4)$$

where match tenure beyond  $T$  no longer increases profits.

If a firm has a vacancy, the value of the vacancy is determined by the probability of meeting an unmatched worker, by the profits the firm expects to make from the match, and by the costs of posting a vacancy ( $\xi$ )

$$\Pi^V = -\xi + \beta \left[ \sum_{i=0}^{\bar{u}} q(i) \Pi^E(1, i) + \left( 1 - \sum_{i=0}^{\bar{u}} q(i) \right) \Pi^V \right], \quad (5)$$

where  $q(i)$  is the probability a firm matches with a worker with outside option  $i$ . Firms will post vacancies unless the expected profit from doing so is negative. We assume free entry, so that in the steady state equilibrium the number of firms in the economy will be determined by the condition that the expected profits from posting a vacancy equal zero.

## 2.5 Search Technology

Assume, for simplicity, that there is no on-the-job search in the economy. The probability that a jobless individual receives a job offer depends on the probability the worker contacts a firm and the probability a firm has a vacancy.

### 2.5.1 Workers

The probability a firm has a vacancy is simply the total number of vacancies divided by the total number of firms

$$\frac{V}{F}.$$

If a firm has a vacancy, it will hire a worker and pay a wage which is the outcome of Nash bargaining between the worker and the firm, discussed in detail below. Applications for jobs arrive according to a Poisson process, where  $\lambda$  is the average number of applications filed by workers at each firm. Firms with more than one applicant randomly draw a worker from the applicant pool.<sup>12</sup> The probability a worker is offered a job is:

$$\frac{1 - e^{-\lambda}}{\lambda}.$$

The conditional re-employment probabilities for unemployed workers and workers on Income Assistance can then be expressed as the product of the above components, multiplied by the worker's search effort

$$m(i) = \frac{p(i)V}{\lambda F} (1 - e^{-\lambda}), \quad (6)$$

where

$$\lambda = \frac{1}{F} \left( \sum_{i=1}^{\bar{u}} p(i)U(i) + p(0)A \right). \quad (7)$$

Workers determine the optimal level of search effort by equating the marginal benefit from an increase in search effort with its marginal cost.<sup>13</sup> The optimal level of search effort, for each labor market state and program eligibility combination, is described by:

$$\begin{aligned} p(0) &= \left( \frac{\beta m(0)}{c_a z} [V^E(1,0) - V^A] \right)^{\frac{1}{z}}, \\ p(1) &= \left( \frac{\beta m(1)}{c_u z} [V^E(1,0) - V^A] \right)^{\frac{1}{z}}, \quad i = 1, \\ p(i) &= \left( \frac{\beta m(i)}{c_u z} [V^E(1, i-1) - V^U(i-1)] \right)^{\frac{1}{z}}, \quad 1 < i \leq \bar{u}. \end{aligned} \quad (8)$$

### 2.5.2 Firms

From the firm's perspective, the probabilities of matching with potential workers from unemployment and IA equal the numbers of workers from unemployment and IA who

<sup>12</sup>Alternatively, we could let the length of a period tend to zero and work in continuous time, where there is zero probability of more than one application arriving at a given time.

<sup>13</sup>In determining the marginal cost and benefit of search effort  $\lambda$  is held constant under the assumption that each worker believes her impact is small relative to the labor market as a whole.

transit to employment, divided by the total number of vacancies, so that

$$q(i) = \frac{m(i)U(i)}{V} \quad \text{and} \quad q(0) = \frac{m(0)A}{V}, \quad (9)$$

respectively.

## 2.6 Equilibrium Wage Determination

After meeting in the labor market, a firm and a worker bargain over wages by making alternating wage offers until both sides find the offer acceptable. It is assumed that the parties have equal bargaining power, but may have different threat points. The equilibrium of this game is the Nash cooperative bargaining solution and results in workers and firms splitting the surplus of a match evenly. The surplus of the match from the worker's perspective is the difference between employment at the equilibrium wage and the worker's outside option, which depends on their current labor market state and program eligibility. The surplus from the perspective of the firm is the difference between the profits the firm receives at the equilibrium wage and the value of leaving the vacancy open. It is further assumed that the bargaining process is constrained such that the wage can not fall below the minimum wage  $\underline{w}$ . The equilibrium wage,  $w(t, i)$ , equals the solution to

$$[w(t, i) - \underline{w}][(V^E(t, i) - V^i) - (\Pi^E(t, i) - \Pi^V)] = 0, \quad (10)$$

subject to  $[w(t, i) - \underline{w}] \geq 0$ , where  $V^i \in \{V^A, V^U(i)\}$  is the value of outside option  $i$ .

## 2.7 Steady State Conditions

Let  $E$  denote the steady state number of jobs occupied by workers and  $V$  the number of vacancies. By definition, the total number of jobs in the labor market is equal to the total number of occupied jobs and the total number of vacancies

$$F = E + V. \quad (11)$$

Denote the total number of individuals in the labor market  $L$ . The total number of individuals can be decomposed into three groups. The first group consists of the employed, who are distinguished both by their current job tenure and their current outside option

$$E = \sum_{t=1}^T \sum_{i=0}^{\bar{u}} E(t, i) + \bar{E},$$

where  $\bar{E}$  is the group of workers no longer experiencing on-the-job wage growth. The second group, denoted  $A$ , consists of those on Income Assistance. The final group, denoted  $U$ , consists of unemployed individuals, who can receive UI benefits for a maximum of  $\bar{u}$  periods

$$U = \sum_{i=1}^{\bar{u}} U(i),$$

where  $U(i)$  indicates the number of unemployed persons with  $i$  periods of benefits remaining.

The total number of individuals in the labor market is the sum of the three components

$$L = E + A + U. \tag{12}$$

Using these definitions, we can describe the conditions governing the steady state, where the flows in and out of every labor market state must be equal over time. We now discuss the steady state conditions for each state and eligibility combination in turn.

### **Employment**

As above, let  $m(0)$  and  $m(i)$  denote the probabilities that IA recipients and unemployment recipients with  $i$  periods of benefits remaining, respectively, match with a firm. The flow into the first period of employment includes those workers from IA and unemployment who receive job offers. They are indexed by their respective outside options as this will determine their progression of benefit entitlements. In subsequent periods, the inflow consists of workers who were employed in the previous period and who were not exogenously separated

from their jobs. Formally,

$$\begin{aligned}
E(1, 0) &= m(0)A + m(1)U(1); \\
E(1, i) &= m(i + 1)U(i + 1), \quad 0 < i < \bar{u}; \\
E(t, 0) &= (1 - \delta)E(t - 1, 0), \quad 1 < t < I \text{ and } i = 0; \\
E(t, i) &= (1 - \delta)E(t - 1, i - 1), \quad 1 < t < T \text{ and } 0 < i \leq \bar{u}; \\
E(t, \bar{u}) &= (1 - \delta)E(t - 1, \bar{u}), \quad 1 < t < T \text{ and } i > \bar{u}; \\
\delta \bar{E} &= (1 - \delta)E(T, \bar{u}), \quad t \geq T.
\end{aligned}$$

### Income Assistance

The flow into IA includes those employed workers who were exogenously separated from their jobs and ineligible for UI benefits and unemployed workers no longer eligible for UI benefits. The flow out of IA includes IA recipients who find employment. The steady state condition for IA is the following:

$$\delta \sum_{t=1}^I E(t, 0) + (1 - m(1))U(1) = m(0)A. \quad (13)$$

### Unemployment

Employed workers who are separated from their jobs and who are eligible for the maximum months of UI benefits flow into the first period of unemployment,  $U(\bar{u})$ . For  $U(i)$  where  $0 < i < \bar{u}$ , the inflow consists of unemployed workers from the previous period who did not find jobs, and workers separated from their jobs who qualify for less than the maximum number of benefit months. All workers flow out of the unemployment state when benefits run out due to the time limitations in the UI program

$$\begin{aligned}
\delta \sum_t E(t, \bar{u}) &= U(\bar{u}) \\
\delta \sum_t E(t, i - 1) + (1 - m(i + 1))U(i + 1) &= U(i) \quad \text{if } 0 < i < \bar{u}. \quad (14)
\end{aligned}$$

### 3 Combining Social Experiments and Structural Models for Policy Evaluation

In this section, we describe a way to use social experiments in combination with structural models to conduct equilibrium policy evaluations. The social experiment we consider is the Canadian Self-Sufficiency Project (SSP). We start by providing some details on the SSP experiment and then outline our approach for conducting a general equilibrium evaluation of the policy it embodied.<sup>14</sup>

The SSP experiment focused on long-term IA recipients.<sup>15</sup> The universe for the experiment was long-term single parent IA recipients ages 19 and older in the lower mainland of British Columbia and the lower third of New Brunswick from November 1992 to March 1995. This universe was sampled at random. Of those selected, 6,028 recipients volunteered to participate in the experiment and were subsequently placed in program and control groups by random assignment.<sup>16</sup> Individuals assigned to the program group were informed that they were to receive an earnings supplement if they found a full-time (30 hours per week) job within one year and left Income Assistance. The supplement received by members of the program group equaled one-half of the distance between the earnings of the recipient and a benchmark earnings level, set at \$37,000 in British Columbia and at \$30,000 in New Brunswick.<sup>17</sup> Once eligible, individuals could receive the supplement for up to three years. Individuals in the program group who were not able to secure full-time employment within the twelve months following random assignment become ineligible to receive the supplement. Individuals in the control group were never eligible for the supplement.

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<sup>14</sup>For comprehensive details on the Self-Sufficiency Project, see Michalopoulos, et al. (2002).

<sup>15</sup>In particular, individuals had to receive IA in at least 11 months during the last year including the current month in order to be included in the experiment.

<sup>16</sup>Kamionka and Lacroix (2002) examine the potential for randomization bias in the (partial equilibrium) experimental impact estimates due to refusals to participate in the experiment. They find evidence that the published estimates understate the true impact of the SSP treatment.

<sup>17</sup>No other sources of income affected the calculation of the earnings supplement.

The data contain information on 5,685 individuals from the main study: 2,827 control group members and 2,858 program group members. We imposed the following additional sample restrictions. First, 280 males were dropped from the sample so that our analysis can focus on a homogeneous group (single mothers) within the study.<sup>18</sup> Second, observations with inconsistent information in the baseline survey were removed from the sample and cases with missing information on hours, earnings and other relevant variables in the 18, 36, and 54-month follow-up data were eliminated. The remaining sample contains 3,346 single mothers, of whom 1,671 are members of the control group and 1,675 are members of the program group. This final sample is the one we use to test our model.

The policy evaluation we undertake involves the following four stages:

1. Calibrate the model to be consistent with the population targeted in the SSP social experiment using data on the experimental control group and external data sources. This represents the *model control group*.
2. Introduce the Self-Sufficiency Project in the model as an experiment in much the same way it was implemented in reality. Simulate the behavioral effects of the program in partial equilibrium. This represents the *model program group*.
3. Compare the impact predicted by the model to the mean impact observed in the data. This exercise provides evidence on how well the simulated experiment based on our model replicates the impacts observed in the actual experiment. It is important to emphasize that the partial equilibrium version of the model is the appropriate comparison to the experiment because the experiment only affected a small subset of the economy and as such is not expected to have general equilibrium impacts.
4. If the model is able to capture the response of individuals to the experiment, then

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<sup>18</sup>This is a relatively innocuous restriction, as 95% of the individuals in the SSP experiment are female.

proceed to simulate the equilibrium effects of the policy in the model economy for the target population of all low-skill workers.

The first three stages were implemented, and full details are available, in Lise, Seitz, and Smith (2005). We summarize their results in Section 3.1. The fourth stage is the focus of this paper and is presented in detail in Section 4.

### **3.1 Testing the Model in Partial Equilibrium**

In this section, we summarize the main results of Lise, Seitz, and Smith (2005), where we compare the predicted impacts of SSP generated by the model to those found in the experiment. This comparison represents an empirical test of our model, in the same spirit as the comparisons of experimental and non-experimental partial equilibrium estimates in LaLonde (1986) and other, similar papers in the treatment effects literature. It is important to emphasize that we do not use any information on the SSP program group in the calibration of our model; we are interested in whether the model can predict the behavior of the program group as an informal out-of-sample test. The model is calibrated for British Columbia, one of the two provinces in which the SSP experiment was implemented. We focus on British Columbia in the current paper, rather than New Brunswick, for two reasons. First, a second component of the SSP, the Entry Effects experiment, was only carried out in British Columbia. Second, Lise, Seitz, and Smith (2005) show that the model is able to closely replicate the SSP experiment in British Columbia, but not New Brunswick. Since this paper is primarily concerned with estimating the potential equilibrium effects of introducing the SSP as policy, we focus on the province in which we are confident in the predictive power of the model. As the SSP experiment affected only a small fraction of the population, we use a partial equilibrium version of the model when generating simulated impacts from the model to compare to the measured impacts from the actual experiment.

Figure 1 compares the Income Assistance survival rates for the control and program groups in the SSP experiment and in the model simulation.<sup>19</sup> The basic pattern matches the experimental data very well.<sup>20</sup> Both the simulation and the experiment indicate that the SSP increases the exit rate from Income Assistance to work substantially, with the impact ending once eligibility expires. During the 12 months of program eligibility individuals increase their search effort and as a result transit to employment at a faster rate. Once the 12-month eligibility period is over, behavior reverts back to what it was in the absence of the program, and the transition rate to employment returns to exactly what it was in the absence of the treatment. It is very encouraging that the model correctly predicts not only the basic pattern, but also matches the proportion of the program group remaining on Income Assistance 54 months after random assignment.

As an additional test of how well the model predicts behavior we reproduce a second experiment designed to estimate the extent of any delayed exit from Income Assistance that results from the 12-month SSP qualification period. The delayed exit experiment was a separate experiment conducted on a sample of 3,315 single parents in their first month of IA receipt in the metropolitan area of Vancouver, British Columbia. This sample was randomly assigned to program and control groups, where the program group was told that

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<sup>19</sup>To maintain comparability between our model and the experimental data we condition on not being employed full-time in the month of random assignment and consider exits to employment as the end of an Income Assistance spell. In the model, receiving Income Assistance and employment are mutually exclusive states, while in the data they are not. This is due to lags in the receipt of Income Assistance payments, as well as the definition of full-time employment in the SSP data: “being employed full-time during any portion of the month.” Conditioning on not being employed at random assignment gives us an appropriate group for comparison with the model at the expense of dropping the 25 percent who were employed.

<sup>20</sup>Consistent with the usual practice in the calibration literature, we do not present any standard errors for the predictions from the calibrated model. Instead, we treat the predictions as constants. In fact, the predictions from the calibrated model embody four sources of error: (1) simulation error, (2) variation due to the use of estimates rather than population parameters to do the calibration, (3) conceptual mismatch between the parameter estimates used to calibrate the model and the parameters in the model as discussed in Hansen and Heckman (1996) and (4) model specification error. Standard procedures in the literature for calculating standard errors for calibrated models, such as those Christiano and Eichenbaum (1992), address at most the first two sources of error, and thus likely substantially understate the actual uncertainty. As such, they may do more to mislead than to inform. In our view, the last two sources of error likely dominate empirically; we address source (3) in our sensitivity analysis in Section 6 and we plan to address source (4) in future work that examines alternative model specifications.

they would become eligible for the SSP program if they remained on IA for 12 months. The difference between the fraction remaining on IA in the program and control groups 12 months after random assignment is estimated by Ford, Gyarmati, Foley, Tattrie and Jimenez (2003) to be 3.9 percentage points with a standard error of 1.4. We conduct the same experiment in our model in partial equilibrium. The model predicts a delayed exit effect of 4.3 percentage points in British Columbia, which is within one-third of the standard error of the effect estimated by Ford et al. (2003). The model is thus able to predict the magnitude of the experimental delayed exit effect quite well.

Comparing the model predictions with the experimental impacts we can see that the model correctly predicts both the degree of delayed exit associated with the expectation of receiving the SSP supplement in the future as well as the increased transition rate into employment that becoming eligible for the SSP program induces. This comparison indicates that the model captures the fundamental dynamics introduced by the SSP policy, which increases our confidence in the policy simulations that follow.

## **4 The Equilibrium Impacts of the SSP Policy**

### **4.1 Introducing the SSP in the Model**

The following additions are made to the model to incorporate the Self-Sufficiency Project.<sup>21</sup> First, individuals on IA face several time constraints. IA recipients become eligible for SSP after they have been on Income Assistance a minimum of 12 months. Once eligible for SSP, individuals have 12 months to find full-time employment in order to receive supplement payments. If an individual secures a job before the eligibility period ends, she can receive the supplement while employed for a maximum of 36 months. We assume that individuals become enter the eligibility period for the treatment once they have spent 12 months on

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<sup>21</sup>Extending the model to include the SSP requires only minor changes. As such, we omit the details from the paper, but describe them in an appendix available from the authors upon request.

IA.<sup>22</sup> individuals in the general equilibrium model who collect the supplement for at least one month and then lose their job do not transit back to supplement eligibility, but instead transit to the first month of IA or the first month of UI, depending on the length of their employment spell. Once the eligibility period for the supplement payments expires, individuals return to the regular IA system. Second, eligible individuals who find work receive supplement payments that are a function of their wage upon obtaining employment.

## 4.2 Calibrating the equilibrium model

In the equilibrium analysis, we focus on all IA recipients rather than just single parents. We do so for two reasons. First, it simplifies our analysis substantially. If the SSP were limited to single mothers (or single parents), the model would have to be extended to allow for two types of IA recipients: those potentially eligible for the SSP supplement and all the rest. This extension would require a large increase in the size of the state space. Second, if the SSP policy were adopted, it would likely apply to all IA recipients rather than just to single parents, both for political reasons related to equal treatment and to avoid incentive effects of SSP on marital dissolution and on out-of-wedlock childbearing. Regarding the relevant population of unemployed and employed individuals, we approximate the low-skill population most likely to be affected by the policy by individuals with less than a completed post-secondary level of education.

The parameters to be calibrated include monthly Income Assistance and unemployment benefits ( $b_a$  and  $b_u$ , respectively), the wage profile, the size of the labor force ( $L$ ), the vacancy rate ( $V/F$ ), the job separation rate ( $\delta$ ), the discount factor ( $\beta$ ), and the search friction parameters ( $c_a$ ,  $c_u$ ,  $z$ ). Table 2 reports the values used for these parameters.

Monthly Income Assistance benefits ( $b_a$ ) are based on the average IA benefits for IA

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<sup>22</sup>Individuals in the general equilibrium model who collect the supplement for at least one month and then lose their job do not transit back to supplement eligibility, but instead transit to the first month of IA or the first month of UI, depending on the length of their employment spell.

recipients in the 1990s, as reported in the National Council of Welfare Reports (2002), and are set equal to \$695.<sup>23</sup> UI benefits ( $b_u$ ) are set at 55 per cent of average earnings. The earnings data are based on the usual hourly wage for the latter sub-population in British Columbia, as reported in the monthly Labour Force Survey (1997-2000), assuming a 37.5 hour work week.<sup>24</sup> Earnings, IA benefits and unemployment benefits are all converted to 1992 dollars using the all-goods CPI.<sup>25</sup> The resulting monthly unemployment benefit level is \$1,174.

The model is homogeneous of degree zero in  $L$  and  $F$ ; we can therefore normalize the size of the labor force to 100 without loss of generality. The number of firms in the economy will be estimated in the baseline model, and is identified using the observed vacancy rate in the economy. Equation (11) determines  $V$  endogenously as a function of  $F$  and  $E$ . In order to estimate  $F$  we use the additional relationship between  $F$  and  $V$  given by the vacancy rate ( $v$ )

$$\frac{V}{F} = v.$$

The vacancy rate of 3.20 is taken from Galarneau et al. (2001) and is based on the average for the retail trade and consumer services and labor-intensive tertiary manufacturing sectors, both of which have average incomes similar to our sample. Therefore, using equation (11), and for a given value of  $E$ ,

$$F = \frac{E}{(1 - 0.032)}.$$

The job separation rate in the model ( $\delta$ ) is constant and can be directly estimated by the average job tenure for low-skill workers in British Columbia in the monthly Labour Force Survey (1990-2000). Job tenure is only reported for individuals currently employed in the

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<sup>23</sup>IA benefits by province are provided for the sub-groups of single employable persons, persons with disabilities, single parents with one child, and couples with two children. We take a weighted average for these groups, with the weights reflecting their size in the IA population. The population shares are based on those reported for British Columbia in Barrett and Cragg (1998).

<sup>24</sup>The Canadian Labour Force Survey is the analogue of the U.S. Current Population Survey.

<sup>25</sup>All figures are reported in 1992 Canadian dollars, where \$1Cdn is presently equal to about \$0.75US.

data; we do not have direct information on separations. However, average job tenure is observed and in the model is equal to

$$\frac{\sum_{t=1}^{\infty} tE(t)}{E} = \frac{E(1) \sum_{t=1}^{\infty} t(1-\delta)^{t-1}}{E(1) \sum_{t=1}^{\infty} (1-\delta)^{t-1}} = \frac{1}{\delta}.$$

Average job tenure in the Labour Force Survey (LFS 1990–2000) for this group is 72.91 months; therefore the monthly separation rate equals 0.0137.<sup>26</sup>

As in Lise, Seitz, and Smith (2005), we use parameter estimates for our search cost function from Christensen, Lentz, Mortensen, Neumann and Wervatz (2005), whose estimates of the elasticity of search costs imply  $z = 1.8457$ , and we set the monthly discount factor  $\beta$  equal to 0.9835, corresponding to an annual discount factor of 0.82 as in Davidson and Woodbury (1993). We assess the sensitivity of our results to the values of these parameters in Section 6 below. The costs of search are allowed to differ depending on whether individuals are receiving UI benefits or IA in order to capture the notion that searching may be less costly while unemployed. For example, unemployed individuals may have access to better search technologies through unemployment offices than do IA recipients, which would be consistent with  $c_a > c_u$ .

Next we must specify the length of time a worker is eligible for unemployment insurance benefits. The length of the UI benefit eligibility period in Canada depends on the unemployment rate in the region of residence (British Columbia in this case) and on the worker's previous job tenure. We set the eligibility periods in the model according to the eligibility rules in place during the 1990s. In British Columbia, this implies that a worker is entitled to 5 months of benefits after working 4 months, and to 10 months of benefits after working 9 months or more (Lin 1998).

We set the minimum wage to 5.50 to match the legislated minimum wage in BC at the

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<sup>26</sup>This measure of job tenure does not take quits into account. As a result, we may overestimate the job separation rate as individuals moving between jobs because of quits report holding jobs of shorter durations.

beginning of the SSP experiment (Michalopoulos, Tattrie, Miller, Robins, Morris, Gyarmati, Redcross, Foley, and Ford, 2002) and abstract from increases in the minimum wage during the remainder of the experiment.<sup>27</sup>

We calibrate the parameters for firm behavior and equilibrium wage determination and impose the steady state conditions. The fractions of the relevant population in each labor force state ( $A$ ,  $U$ , and  $E$ ) in British Columbia are estimated from the 1993-94 longitudinal wave of the Survey of Labour Income Dynamics (SLID).<sup>28</sup> Unlike the LFS, the SLID has separate data on IA and UI benefit receipt. We adopt the following definitions in the data in order to maintain consistency with the model. We define employed workers as individuals who are employed in the first week of the month and report no UI or IA benefits during the month. Unemployed workers are defined as individuals who are either unemployed or not in the labor force and report receiving UI benefits. Finally, IA recipients are individuals who are either unemployed or not in the labor force and report receiving IA. We exclude all individuals who do not fit these criteria, such as those who report working full time and receiving either UI or IA benefits. Similarly, we exclude those reporting that they are unemployed or not in the labor force, but not receiving any UI or IA benefits.<sup>29</sup>

We calibrate the match surplus for each of the first 48 months of job tenure ( $S(1)$ – $S(48)$ ), with one additional match surplus for all jobs of a longer duration ( $S(49)$ ). We do not directly observe the match surplus; however, we do observe the average wage for workers with different tenure levels in the data. We can therefore use the wage and tenure information from the LFS for the sample of individuals in British Columbia without completed

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<sup>27</sup>As discussed in Michalopoulos et al. (2002), the minimum wage in British Columbia increased several times following random assignment, from \$5.50 per hour in November 1992 to \$7.15 in April 1998. We repeated our analysis using the minimum wage in place at the end of the experiment and found the qualitative results were the same. These results are available from the authors upon request.

<sup>28</sup>The SLID is the Canadian analogue of the U.S. Survey of Income and Program Participation.

<sup>29</sup>71 per cent of the individuals in the data fit into one of these three mutually exclusive categories. Of those who do not, 80 per cent report being either unemployed or not in the labor force, but do not report receiving either UI or IA benefits.

post-secondary education to infer the match values in the baseline economy. In particular, we estimate a wage profile that is cubic in job tenure and then determine the match values in the model that generate the equilibrium wage profile observed in the data. It is important to emphasize that we assume the match values  $S(t)$ , but not wages, are invariant to policy changes. In particular, the policy changes we consider change the value of the outside options of workers and firms, and thus the way the match value is divided, but not the total value of the match itself.<sup>30</sup>

The first period of employment in the model differs from later periods of employment, as the model allows starting wages to differ depending on whether the worker's outside option is IA or unemployment. However, it is not possible to separate out the starting wages in the data for individuals with different outside options. In the model, all matches are assumed to have the same match surplus value, but workers may receive different wages, as they face different outside options when bargaining with firms. Therefore, when estimating the wages for workers in each of the first  $\bar{u}$  periods of employment, we restrict the average of the wage for each month in the model to equal the average wage for a worker with the corresponding tenure in the data. The cost of posting a vacancy ( $\xi$ ) is calibrated so that the value of a vacancy equals zero.

Given  $b_a, b_u, L, E, U, A, F, z, \delta, \beta$ , and data on wages, the baseline model is a system of 377 equations and unknowns. Solving the baseline model yields estimates for  $c_a, c_u, \xi, S(1) - S(49)$ , and starting wages  $w(t, i)$  for each unemployment insurance eligibility status.<sup>31</sup>

### 4.3 The equilibrium model with SSP

In this section we incorporate the SSP program as policy in the model. There are two key differences between the partial equilibrium analysis and the following simulations. First,

<sup>30</sup>This assumption would be invalid if the policy experiments considered involved changing the productivity of worker-firm matches.

<sup>31</sup>Estimates of the match surplus values and wages are available from the authors upon request.

all workers and firms are now aware of the SSP program and will include this information in their decision making processes; as a result, the SSP program will now have feedback effects, just as the unemployment insurance and Income Assistance program have feedback effects. Second, the Self-Sufficiency policy now applies to all IA recipients, rather than just to single parent IA recipients as in the experiment and in our partial equilibrium test of the model in Section 3.

Our discussion of the effects of implementing the SSP as policy focuses on three questions. First, does an increase in the employment rate for IA recipients come at the expense of reduced employment for others in the labor market? Second, what impact does offering an earnings supplement have on the distribution of wages in the economy? Finally, does the existence of the SSP program delay exit from IA during the pre-qualifying period? We now discuss the answer to each question in turn.

#### **4.4 The Displacement Effect**

The top half of Table 3 presents the expected durations of joblessness. As expected, the average duration of Income Assistance spells is substantially reduced under the SSP program, as SSP-eligible individuals face greater incentives to exit the IA program. The model predicts a decrease in expected IA duration of approximately 32 days (1.1 months). In contrast, the expected duration of unemployment spells for those eligible for the maximum number of months increases by approximately 3 days (0.09 months). In essence, the policy change increases the likelihood that unemployed workers exhaust their UI benefits and transit to IA, as unemployed workers are displaced in the labor market by IA recipients. The total jobless duration increases for those who begin a spell in unemployment, while the total jobless duration decreases for those exiting employment to IA.

The last two rows of Table 3 indicate that employment rates and vacancies decline in

British Columbia following the introduction of SSP. Employment falls within the model due to the relationship between wage bargaining and the minimum wage (discussed below). In particular, because firms are constrained to pay at least the minimum wage and the value of IA increases for workers because of the presence of SSP, workers have a higher threat point. As a result, firms are not able to extract the surplus introduced by the SSP when bargaining with workers.

#### **4.5 The Wage Effect**

As discussed in Section 2, starting wages differ depending on whether the worker transits from IA or UI and depending on the length of the unemployment spell. Once the SSP is in place, starting wages also differ depending on whether the worker is transiting from an SSP-eligible state. Table 4 displays the average earnings, over the first six months of employment, for workers transiting to employment from selected states. Several patterns are worth discussion.

First, individuals eligible to receive supplement payments in British Columbia experience only a 5% ( $894 - 938/938$ ) reduction in wages. The reason supplement-eligible workers do not experience large reductions in wages is that firms are constrained to pay them at least the minimum wage. The income of workers receiving supplement payments, as a result, rises substantially: for example, before the policy change an individual in British Columbia that transited to employment from the first period of IA would earn, on average, \$938 per month over the first six months of employment. In contrast, the same worker would expect to receive \$1,989 per month in earnings and supplement payments if he or she transits to employment during the first month of eligibility for the SSP supplement.

Surprisingly, other workers experience an increase in wages following the introduction of the SSP. For example, UI recipients who are one month from exhausting benefits receive

starting wages that are 13% higher after the introduction of the SSP program. One's initial intuition may be that they should receive a lower wage; the reason they do not is because supplement-eligible workers do not experience a large decline in wages because of the minimum wage. As a result, the introduction of the supplement does not result in firms receiving a larger share of the match surplus. At the same time, the value of entering IA has increased due to the introduction of the supplement, and the optimal level of search effort has decreased, so that the outside options of UI recipients and IA recipients who are not eligible to receive the supplement improve.

#### **4.6 Delayed Exit Effects**

As discussed earlier, the equilibrium unemployment rate increases slightly with the introduction of the SSP program, the result of a lower re-employment probability for unemployed workers. The fall in re-employment probabilities for unemployed workers is due in large part to the fact that unemployed workers exert less search effort after the policy change. The difference in search effort for unemployed workers in the baseline and in the model following the introduction of the Self-Sufficiency policy is presented in Figure 2. In general, search effort for unemployed workers increases in the months leading up to unemployment benefit exhaustion. However, because the value of transiting to IA has increased following the policy change, search effort for unemployed workers in the SSP world does not rise to the same extent as it did in the baseline economy. As a result, a larger fraction of unemployed workers transit from unemployment to IA after the policy change. Figure 2 reveals that after the end of the SSP eligibility period, the search intensity of IA recipients closely resembles that in the baseline world without SSP. Though it is too slight to see in the figure, in fact search intensity is slightly lower in the SSP world because of the reduced job-finding probability resulting from the intensive search efforts of IA recipients during the SSP eligibility window.

The search behavior of IA recipients also changes following the policy change. Figure 3

compares the survival rates for individuals entering IA in the baseline world and the SSP world. In the presence of the SSP, the survival rate is higher in the first 15 months than in the base case. This finding is indicative of the presence of delayed exit effects, due to the fact that individuals have incentives to remain on IA long enough to become eligible to receive the supplement. Although survival rates are higher in the first 15 months of an IA spell with the SSP, the subsequent decrease in survival rates that results from the increased search effort of supplement-eligible IA recipients outweighs the delayed exit effects, as the average duration of IA spells declines following the imposition of the SSP.

#### **4.7 A Comparison of the Simulated Impacts in Partial Equilibrium and General Equilibrium**

To gauge the importance of general equilibrium effects in the simulated economy, we compare the simulated impacts of the Self-Sufficiency program in partial equilibrium to the general equilibrium effects highlighted above. The difference in survival rates for IA recipients in the partial equilibrium model as compared to the general equilibrium model are presented in Figure 4. The impact of the policy change is slightly greater in the partial equilibrium version of the model. This result is not surprising for two reasons. First, wages do not fall in the partial equilibrium model after the workers become eligible for the supplement.<sup>32</sup> Second, re-employment probabilities do not decline in response to the increased flow of IA recipients into employment. Both factors are consistent with greater incentives to exit IA for employment when equilibrium effects are not taken into account. Our results are consistent with the findings from the literature discussed in the introduction of smaller impacts of policy changes when equilibrium effects are taken into account (Davidson and Woodbury, 1993; Heckman, Lochner and Taber, 1998). It should be noted that, because of the assumption of free entry for firms and constant returns to scale in production, our

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<sup>32</sup>Lise, Seitz, and Smith (2005) provide evidence from the SSP experiment that there are no significant differences in earnings between the program and control groups after random assignment, despite large differences in wages and hours, which are higher and lower for the program group, respectively.

simulation likely captures a lower bound on the general equilibrium effects.

## 5 Reconsidering the Costs and Benefits of the Self-Sufficiency Project

In this section, we look at the benefits of implementing the SSP policy relative to the costs. To highlight the importance of equilibrium effects, we conduct our cost-benefit analysis using both the partial equilibrium and the general equilibrium results. Our analysis has two limitations worth noting. First, SSP was found to have both positive and negative effects on other variables of interest such as marriage and child outcomes (Michalopoulos et al., 2002). We ignore outcome variables other than earnings, as they are beyond the scope of this paper. Second, we do not consider any additional costs or benefits associated with the process of moving from the baseline steady state to the SSP steady state.

We start with the partial equilibrium cost-benefit analysis. In this case, the following assumptions are imposed. First, the only individuals who change their behavior in response to the policy change are those who have been on Income Assistance for 12 months. Second, any jobs obtained as a result of the SSP program are ‘new jobs’, leading to an increase in aggregate output. Finally, wages do not change from the baseline economy. In other words, we assume that there are no displacement effects, no delayed exit effects, and no wage effects.

Our cost-benefit analysis, presented in Table 5, draws on SSP program cost information presented in Michalopoulos et al. (2002). First, we calculate the direct costs of administering the Self-Sufficiency policy. Michalopoulos et al. (2002, Table 7.7) estimate that the net average cost per individual eligible for the SSP program is \$1,367. In addition, SSP increases the costs of administering other transfer programs and generates management information systems costs totaling \$251 per eligible person in British Columbia. In the first two columns

of Table 5, the total program costs for each province are multiplied by 1.5, an estimate of the marginal social cost of a tax dollar.<sup>33</sup> The estimated cost of SSP program services weighted by the number of individuals eligible for SSP in the partial equilibrium version of our model is \$128,276 per 1000 individuals in the low-skill population of British Columbia (hereafter “per 1000”).

Second, we calculate the total value of transfer payments in the baseline economy and in the economy with the SSP. We multiply the difference in the value of the transfer payments by the deadweight loss associated with the taxes necessary to finance the difference in transfers, estimated at 0.5. The deadweight loss of the change in transfer payments is therefore estimated as \$493,144 per 1000.

Third, we calculate total output in the baseline economy and in the economy with the SSP. In the partial equilibrium version of the model, the value of monthly output increases after the Self-Sufficiency policy is introduced. In particular, we predict output to increase, per 1000, by \$2,383,891 in British Columbia after the imposition of the policy change. Finally, we add the direct costs of the program to the social cost of the net increase in taxes resulting from the increase in transfers and then subtract the total from the increase in the value of output. Under these assumptions the SSP program more than pays for itself; there is a net gain from the program of \$1,762,470 per 1000.

The equilibrium effects of the policy change the cost-benefit conclusion drawn from the partial equilibrium analysis substantially. Performing the same calculations using the general equilibrium values for output, UI benefit receipt, and IA receipt yields dramatically different cost-benefit estimates. After taking the equilibrium effects into account, the SSP policy yields a net cost of \$1,982,444 per 1000. The key to the change in the sign of the cost-benefit analysis is the change in output. In the partial equilibrium analysis, the jobs

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<sup>33</sup>See, e.g., Diewert (1988) and Dalhby (1994) for Canada and Browning (1987) for the U.S.

taken by SSP recipients are new jobs, which the cost-benefit analysis treats as increasing total output. In contrast, in the general equilibrium analysis, the number of jobs, and thus total output, falls. In the presence of both SSP and a minimum wage, firms capture less of the surplus created by a match, with the result that some firms exit the market and total output declines. The changes in search behavior induced by SSP also affect the cost-benefit calculation, but the effect on the number of firms predominates. These findings highlight the importance of conducting general equilibrium evaluations of programs, rather than relying solely on the findings from partial equilibrium social experiments, to guide policy.

The third and fourth columns of Table 5 present the cost-benefit analysis in the case where the marginal social cost of a tax dollar equals zero. This comparison provides a lower bound on the indirect costs of implementing the Self-Sufficiency Project as a wide-scale program. Even neglecting the marginal social cost of taxes, our model indicates that in general equilibrium the benefits of the SSP do not cover its costs.

## 6 Sensitivity Analysis

Table 6 presents evidence on the extent to which our results are sensitive to the choice of the discount factor ( $\beta$ ) and the elasticity of search costs with respect to search effort ( $z$ ). It is worth emphasizing that the search friction parameters  $c_a$  and  $c_u$  are re-calibrated in the baseline model for each combination of  $\beta$  and  $z$ . Lower values for  $\beta$  reduce the incentives of individuals on UI or IA to search as the value of employment falls. Lower values of  $c_a$  and  $c_u$  are required to match the observed transitions into employment from unemployment and Income Assistance. A similar argument holds for  $z$ . If search costs become more elastic (a higher value for  $z$ ), then lower search costs are necessary to match the transition into employment. The re-calibrated values for  $c_a$  and  $c_u$  are presented in the top four rows of Table 6.

First, we consider the sensitivity of our partial equilibrium measure of the estimated impact of SSP on Income Assistance survival rates. For comparison purposes, we also present the experimental impact constructed from the data. Lowering the discount factor increases the simulated impact of the policy in partial equilibrium. This occurs because lower values of  $c_a$  and  $c_u$  associated with the decrease in the discount factor result in a higher exit rate from IA. As search costs become less elastic with respect to search effort, the shape of the cost function changes such that the simulated IA survival rate is greater than its experimental counterpart during the 12 months of supplement eligibility. The consistency of Davidson and Woodbury's (1993) estimate of the discount factor and of the search elasticity parameter estimated by Christensen et al. (2005) with the behavior of participants in the Canadian SSP is quite striking.

Next, we consider the sensitivity of the general equilibrium program evaluation to changes in the parameters outlined above. In general, the predicted labor force composition is relatively insensitive to the changes in parameter estimates, as are the number of firms and vacancies. It is also important to note that the cost-benefit conclusions do not change in any of the specifications: the partial equilibrium analysis consistently results in a net gain from the SSP program and the general equilibrium analysis consistently reports a net loss.

## **7 Alternative Versions of the Self-Sufficiency Policy**

One of the main advantages to the approach taken in this paper is that we are able to explore the implications of changing the parameters of the SSP policy within our framework. To this end, we consider three alternative versions of the policy and simulate the predicted outcomes of each version in general equilibrium. First, we consider changes in the generosity of the earnings supplement for eligible Income Assistance recipients. In particular, we reduce

the earnings ceiling by 75%. Second, we reduce the supplement payment period from 36 months to 12 months. Finally, we require new IA recipients to remain on IA for 24 months, as opposed to 12, in order to qualify for SSP. Results of each policy experiment are presented in Table 7.

We find that all of the changes we examine improve the cost-benefit performance of the SSP in general equilibrium without reductions in employment. This finding results from reductions in the delayed exit effect: individuals are less willing to exhaust their unemployment benefits or to remain on IA for longer periods as SSP becomes less generous.

## 8 Conclusion

This paper makes three main contributions to the literature. First, we add to the small but growing literature that uses structural equilibrium models to study the general equilibrium effects of labor market interventions. Except in unusual cases, as when a policy is implemented differently in separate jurisdictions of sufficient number to allow econometric analysis (and the effects of the policy do not spill over jurisdictional boundaries), estimating general equilibrium effects requires a structural model.<sup>34</sup>

Second, we show how evidence from social experiments can be used in combination with structural models to perform convincing policy analysis. In so doing, we extend the literature starting with LaLonde (1986) that uses experimental data to benchmark non-experimental evaluation estimators. Our companion paper, Lise, Seitz, and Smith (2005) considers the ability of a model, fit to an experimental *control group*, to match the experimental *program group* as a test of the model. Our model passes both versions of this test for the SSP in British Columbia. The caveat is that the SSP experiment considered here only allows for direct testing of the partial equilibrium aspects of the model. Because the Self-

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<sup>34</sup>See Bobonis and Finan (2002) for an example of this type of analysis using the data from the PROGRESA experiment in Mexico.

Sufficiency Project has not been implemented on a wide scale, it is not possible to conduct out-of-sample tests regarding the general equilibrium effects of the program. Nonetheless, our research, together with the recent paper by Todd and Wolpin (2003), indicates that the combination of social experiments and structural models of labor market interventions represents a powerful tool for program evaluation.

Third, we present empirical estimates of the general equilibrium effects of the SSP. This program represents a special case of a broad class of interventions designed to “make work pay” for individuals collecting government benefits. Such interventions have received a great deal of academic and policy attention in recent years. We find that equilibrium wages fall for those treated by the program after the introduction of the earnings supplement, as workers are willing to accept lower starting wages so as to benefit from the supplement payments. However, wages of other workers in the economy increase slightly as the existence of the SSP, along with the minimum wage, increases the threat point of workers. Furthermore, the simulation results indicate the presence of delayed exit effects, as a higher fraction of individuals remain on IA in order to become eligible for the supplement after the policy change. All these effects have important implications for the cost-benefit performance of the SSP policy; we find that taking account of the general equilibrium effects reverses the cost-benefit calculation from the partial equilibrium experiment.

Table 1: Summary of Notation Used

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$A$	Steady state number of workers on social assistance
$b_a$	Income Assistance benefits
$b_u$	Unemployment insurance benefits
$c_a$	Parameter capturing the disutility of search effort in the cost of search function for social assistance
$c_u$	Parameter capturing the disutility of search effort in the cost of search function for unemployment
$E$	Steady state number of employed workers
$E(t, i)$	Steady state number of employed workers eligible for $i$ unemployment insurance benefit months in jobs of tenure $t$
$\bar{E}$	Steady state number of workers no longer experiencing wage growth
$F$	Number of firms (jobs)
$L$	Total labor force
$m(0)$	Conditional probability a social assistance recipient finds a job and transits to employment next period
$m(i)$	Conditional probability of re-employment with $i$ months of unemployment benefits remaining
$p(0)$	Search effort for those on social assistance
$p(i)$	Search effort for the unemployed with $i$ benefit months remaining
$S(t)$	Match surplus for a worker firm match of tenure $t$
$q(i)$	Firm's probability of meeting a potential worker with $i$ months of unemployment benefits remaining
$T$	Match tenure beyond which match surplus no longer increase
$I$	Number of months required to qualify for minimum unemployment insurance benefits
$\underline{u}$	Minimum number of unemployment benefit months
$\bar{u}$	Maximum number of unemployment benefit months
$U$	Steady state number of workers receiving unemployment insurance benefits
$V$	Steady state number of vacancies
$V^A$	The value function for a worker on social assistance
$V^E(t, i)$	The value function for an employed worker in the $t^{\text{th}}$ period of employment with unemployment benefit eligibility $i$
$V^U(i)$	The value function for an unemployed worker with $i$ months unemployment insurance benefits remaining
$w(t, i)$	The wage for a worker in the $t^{\text{th}}$ month of employment with unemployment eligibility $i$
$\underline{w}$	Minimum wage
$z$	The elasticity of search cost with respect to search effort
$\beta$	Discount factor
$\delta$	Exogenous job separation rate
$\lambda$	The average number of applications filed by workers at each firm
$\xi$	The per period cost to a firm of posting a vacancy
$\Pi^E(t, i)$	Firms' expected future profit from a match of tenure $t$ , with a worker with unemployment eligibility $i$
$\Pi^V$	Firms' value of a current vacancy

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Table 2: Moments and Parameters for the Baseline General Equilibrium Model

Income Assistance benefits, monthly ( $b_a$ ) <sup>1</sup>	695
Unemployment benefits, monthly ( $b_u$ ) <sup>2</sup>	1174
Search costs, income assistance ( $c_a$ )	0.3281
Search costs, unemployment ( $c_u$ )	0.0526
Average job tenure, months ( $1/\delta$ )	72.91
Employment rate ( $E$ ) <sup>3</sup>	90.15
Unemployment rate ( $U$ )	5.80
Income Assistance rate ( $A$ )	4.05
Average hourly wage	13.14
Average wage, tenure > 48 months	16.14
Exogenous job separation rate ( $\delta$ ) <sup>5</sup>	0.0137
Monthly discount rate ( $\beta$ ) <sup>6</sup>	0.9835
Elasticity of search costs w.r.t effort ( $z$ ) <sup>7</sup>	1.8457
Cost of posting a vacancy ( $\xi$ )	9,445
Number of firms ( $F$ )	92.99
Vacancy rate ( $V/F$ ) <sup>4</sup>	3.20

Notes: All values are in 1992 Canadian dollars. 1. National Council of Welfare (2002). 2. Unemployment benefits are based on 55 per cent of average monthly earnings from Labour Force Survey (1997–2000). 3. Labour Force Survey (1997–2000). 4. Galarneau et al. (2001), based on the average for retail trade and consumer services and labor-intensive tertiary manufacturing sectors. 5. Inverse of average job tenure in the Labour Force Survey (1997–2000). 6. This corresponds to an annual discount rate of 0.82, the rate used for all figures and tables in Davidson and Woodbury (1993). 7. From Christensen, Lentz, Mortensen, Neumann, and Wervatz (2005).

Table 3: Labor Force Composition — Baseline and SSP Models

	Baseline	SSP
Expected UI duration, months	5.07	5.16
Expected IA duration, months	31.03	29.96
Expected jobless duration, months	8.33	8.73
Employment rate	90.15	89.72
Unemployment rate	5.80	5.92
Income Assistance rate	4.05	4.36
Number of firms	93.13	92.67
Number of vacancies	2.98	2.95

Notes: The sources for the the baseline vales of the labor force, number of firms and vacancy rate are given in Table 2. All other values are generated by the model.

Table 4: Average Monthly Earnings — First Six Months

Entering employment from:	Baseline	SSP
Maximum months of UI remaining ( $U(\bar{u})$ )	2,070	2,085
Last month of UI ( $U(1)$ )	972	1,097
First month on IA ( $A(1)$ )		967
12 <sup>th</sup> month on IA ( $A(12)$ )		987
First month eligible for SSP ( $SSP(1)$ )		894
with SSP top-up		1,989
Last month eligible for SSP ( $SSP(12)$ )		894
with SSP top-up		1,989
IA, no longer eligible for SSP ( $A(0)$ )	938	967
Mean earnings	1,563	1,593
SD earnings	407	672
Mean income	1,563	1,634
SD income	407	390

Notes: Authors' calculations based on model simulations.

Table 5: Cost-Benefit Analysis—SSP Applied to All Income Assistance Recipients

	Partial Equilibrium	General Equilibrium	Partial Equilibrium	General Equilibrium
	Marginal Social Cost of 0.5		Marginal Social Cost of 0	
<i>Direct Costs</i>				
SSP program service costs <sup>1</sup>	1,367	1,367	1,367	1,367
Net SSP admin. costs	251	251	251	251
Number eligible for SSP	53	63	53	63
Total Direct Costs	85,517	102,698	85,517	102,698
Adjusted for MSC <sup>2</sup>	128,276	154,047	85,517	102,698
<i>Indirect Costs</i>				
Change in UI payments	0	95,414	0	95,414
Change in IA payments	-212,553	144,375	-212,553	144,375
Change in SSP payments	1,198,843	1,648,983	1,198,843	1,648,983
Total Change in transfers	986,289	1,888,772	986,289	1,888,772
Adjusted for MSC <sup>3</sup>	493,144	944,386	0	0
Change in output	2,383,891	-884,011	2,383,891	-884,011
Net gain from program	1,762,470	-1,982,444	2,298,374	-986,709

Notes: Costs are calculated over five years for a labor force normalized to 1000. 1. The direct costs are taken from Michalopoulos et al. (2002, Table 7.7). 2. The marginal social cost (MSC) of a tax dollar is estimated to be 1.5 (Diewert 1988; Dalhby 1994; Browning 1987). 3. The marginal social cost of the increase in transfers is just the dead weight loss associated with a tax and transfer system: 0.5.

Table 6: Sensitivity to the choice of  $\beta$  and  $z$ 

Parameters	Base		SSP Simulations			
Annual discount rate ( $\beta$ )		0.82	0.77	0.87	0.82	0.82
Elasticity of search costs ( $z$ )		1.85	1.85	1.85	1.75	2.00
Search costs, Income Assistance ( $c_a$ )		0.33	0.26	0.40	0.37	0.28
Search costs, Unemployment ( $c_u$ )		0.05	0.04	0.06	0.07	0.03
12 month impact <sup>1</sup> in partial equilibrium	-0.178	-0.173	-0.186	-0.159	-0.201	-0.140
35 month impact in partial equilibrium	-0.123	-0.118	-0.127	-0.108	-0.137	-0.096
Labor force composition in general equilibrium						
Employment	90.15	89.72	89.63	89.75	89.76	89.76
Unemployment	5.80	5.92	5.96	5.91	5.92	5.90
Income Assistance	4.05	4.36	4.41	4.35	4.32	4.34
Firms	93.13	92.67	92.56	92.70	92.72	92.71
Vacancies	2.98	2.95	2.94	2.95	2.96	2.95
Cost-benefit analysis: Net gain from program						
Partial equilibrium		1,762	1,919	1,686	1,407	1,645
General equilibrium		-1,982	-2,294	-1,905	-1,914	-1,864

Notes: Authors' calculations based on model simulations. The search friction parameters,  $c_a$  and  $c_u$  are re-calibrated in the baseline model for each combination of  $\beta$  and  $z$ . Costs are per capita costs over five years. 1. For the 12 and 35 month impacts the values in the Base column refer to the impact in the data. The other columns refer to model simulations.

Table 7: Alternative SSP policy simulations

	Base Case	SSP	Reduced supplement by 75 %	12 month payment period	24 months waiting period
Labor force composition					
Employment	90.15	89.72	89.99	89.89	89.87
Unemployment	5.80	5.92	5.85	5.87	5.86
Income Assistance	4.05	4.36	4.16	4.23	4.27
Firms	93.13	92.67	92.96	92.85	92.84
Vacancies	2.98	2.95	2.97	2.96	2.97
Cost-benefit: Net gain from program					
Partial equilibrium		1,762	2,067	1,505	1,147
General equilibrium		-1,982	-923	-1,465	-969

Notes: Authors' calculations based on model simulations.

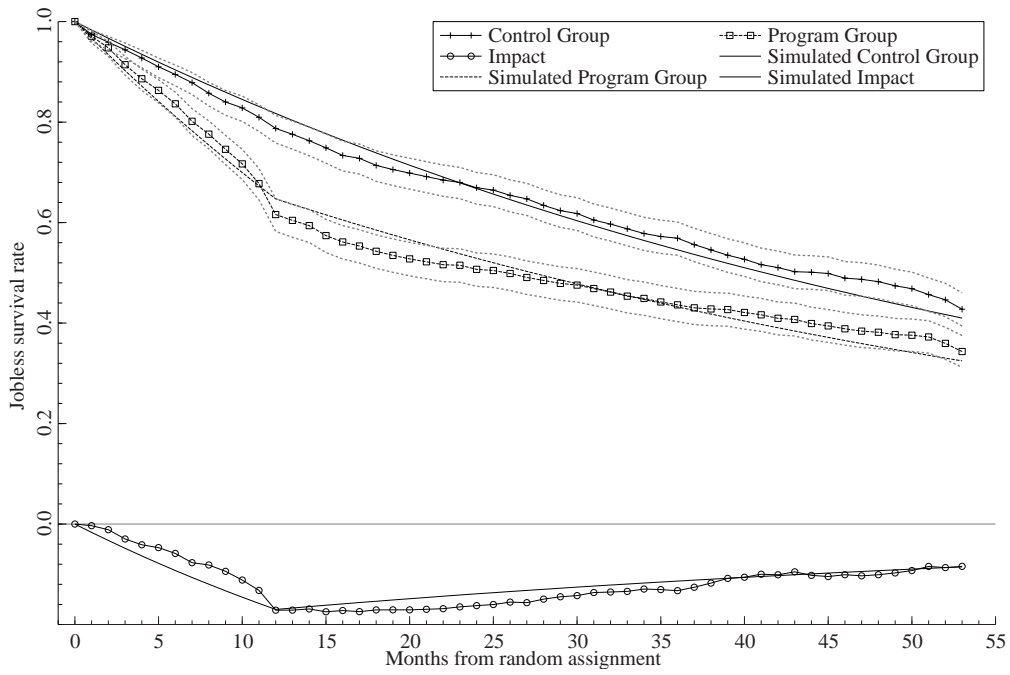


Figure 1: Simulated Partial Equilibrium Impact of SSP. The dotted bands are point wise 95 per cent confidence intervals for the data.

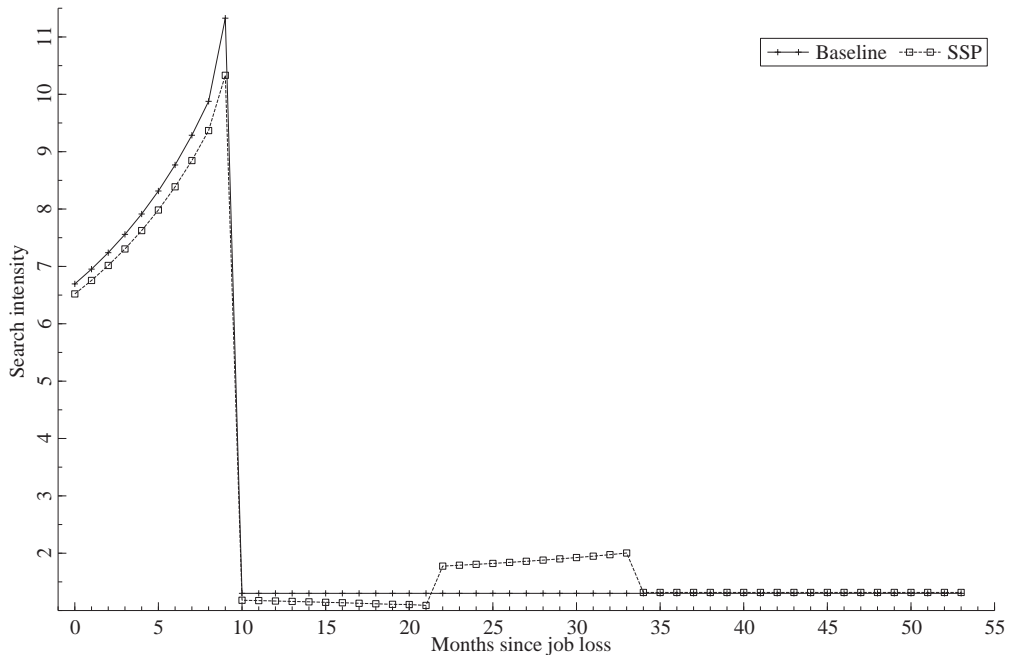


Figure 2: Search Intensity for Those Starting with Maximum Unemployment Benefits

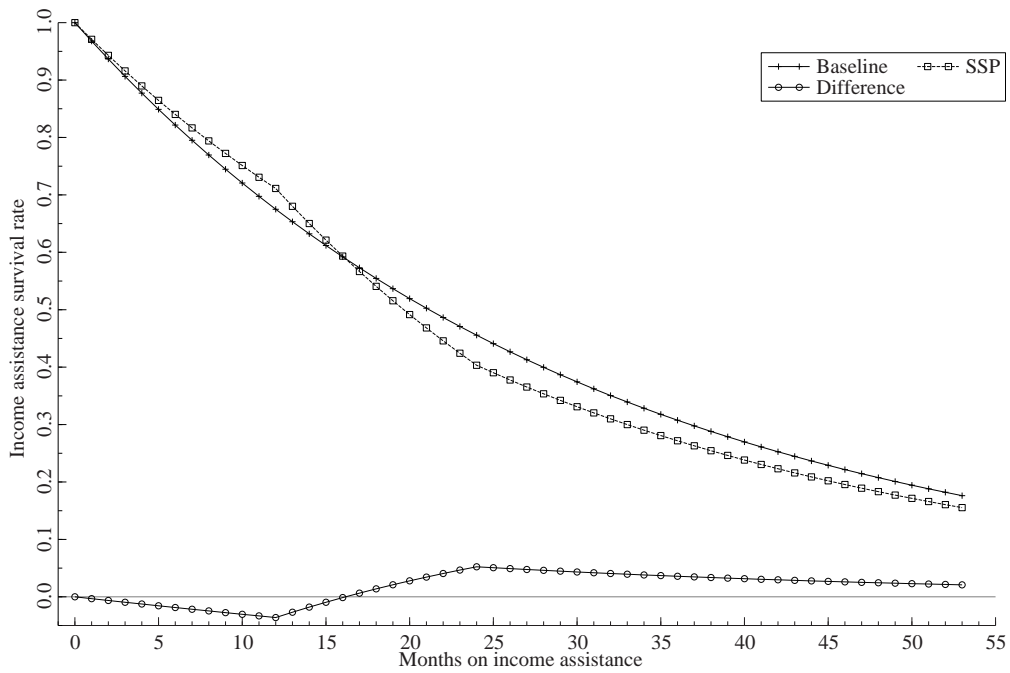


Figure 3: Survival Probability, Starting from Income Assistance

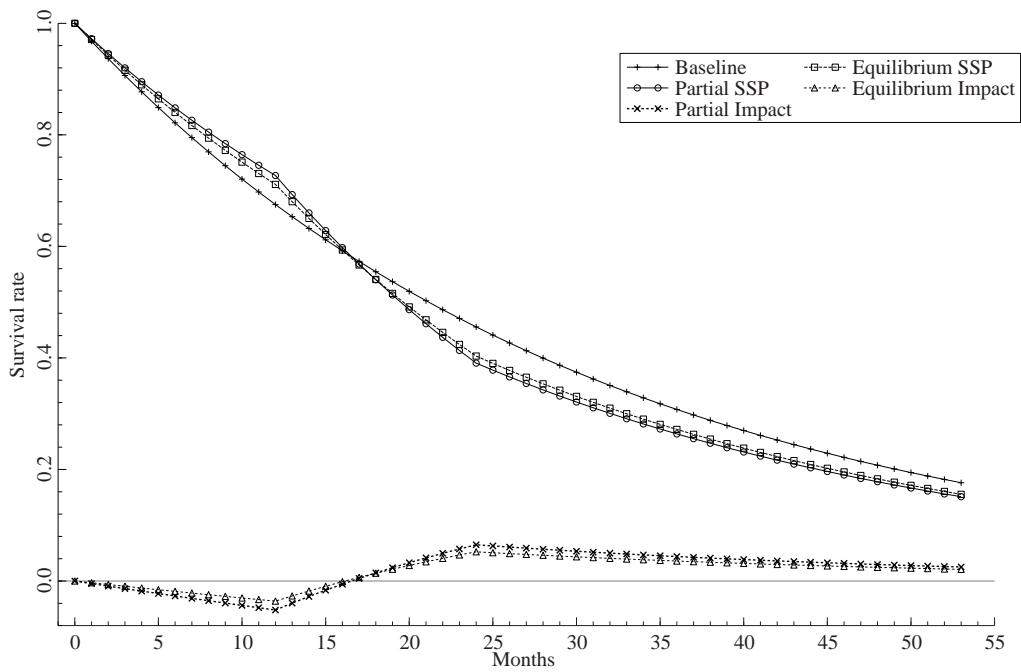


Figure 4: Survival Probability, Partial and Equilibrium Impacts

## A Model with Self-Sufficiency Project

The welfare program and the earnings supplement are modeled as follows. First, in addition to individuals on unemployment insurance, individuals on welfare also face several time constraints. Second, individuals receive supplement payments that are a function of the wage upon obtaining employment.

Within the model, agents maximize expected lifetime income by choosing their labor market state and the intensity with which they search for work if not employed. It is assumed that agents have no information regarding the existence and structure of the SSP until month 12 of their IA spell. Workers bargain with firms over wages that depend on the tenure of the match and on the outside options of both parties. Through this channel, the model generates predictions regarding how starting wages vary depending on whether an individual is entering employment through EI or IA and on whether or not the individual is eligible for the supplement. One goal of the SSP is to provide workers with enough time to experience sufficient wage growth so they have an incentive to stay employed once the earnings supplement expires. On-the-job wage growth, through an increase in the surplus created in worker-firm matches, captures this particular feature of the program and is also incorporated in the model.

It is useful to expand the notation used in the base model in the following way. Let  $i$  index the jobless state an individual is currently in:  $i \in \{\bar{u}, \dots, \underline{u}, \dots, 1, 0, -1, \dots, -T_{in}, \dots, -T_{out}\}$ . Here positive  $i$  indicates the individual is jobless with  $i$  unemployment benefit months remaining. We use  $0 \geq i \geq -T_{out}$  to index the welfare recipients, where the key indices are  $i = 0$  in the first month on welfare,  $i = -T_{in}$  in the first month of SSP eligibility, and  $i = -T_{out}$  in the post eligibility period.

### A.1 Workers

The value of employment for a worker depends on her job tenure  $t$  and program eligibility status  $i$ , where  $i \in \{\bar{u}, \dots, \underline{u}, \dots, 1, 0, -1, \dots, -T_{in}, \dots, -T_{out}\}$ . The number of months an individual with no benefits must work to qualify for unemployment is  $I$ . For every period an individual works after qualifying for benefits,  $i$  increases by 1. The maximum number of benefit months an individual can accumulate is denoted  $\bar{u}$ . If the individual were not working she would therefore be unemployed with  $i$  periods of unemployment benefits remaining,  $i \in \{0, \dots, \bar{u}\}$ . With probability  $\delta$ , jobs are exogenously destroyed in the subsequent month, in which case workers transit to welfare if they have not yet qualified for unemployment benefits,  $i = 0$ , and transit to unemployment otherwise. With probability  $(1 - \delta)$ , workers remain employed in the next month.

It is assumed that individuals who return to work before their unemployment benefits expire retain their remaining unemployment benefit eligibility. Finally, workers experience on the job wage growth for a maximum of  $T$  months, after which the wage remains constant, where it is assumed  $T > \bar{u}$ . The value function for a worker needs to account for job tenure  $t$ , outside option  $i$ , and earnings supplement receipt  $s \in \{0, 1\}$  where  $s = 0$  indicates the worker is not eligible to receive the supplement.

#### A.1.1 Workers that receive supplement payments

Employed workers who receive the supplement obtain labor market earnings and the supplement payment in the current month. The supplement received by the worker is a function of her wage. In particular, the worker receives one-half of the distance between her wage and an exogenous ceiling denoted  $\tilde{w}$ ; in other words she receives the average of her market wage and the wage ceiling.<sup>35</sup> Individuals remain eligible for the supplement for  $T_{end}$  months once they leave Income Assistance and become employed. Therefore, workers continue to receive the supplement as long as the duration

<sup>35</sup>If the individual's earnings are above the ceiling, they do not receive a supplement. For simplicity, we abstract from this case within the model as few individuals had earnings above the supplement ceiling in the data. In the model no individuals have earnings above the supplement ceiling.

of the current employment spell is shorter than the allowed duration of the supplement payment period. With probability  $\delta$  workers are exogenously separated from their jobs at which point they can transit to unemployment if eligible for EI or back to the first period of SSP eligibility ( $i = -T_{in}$ ) if they do not yet qualify for unemployment benefits ( $t < I$ ).<sup>36</sup> Employed persons no longer receiving the supplement ( $t > T_{end}^E$ ) remain employed, or if they are exogenously separated from their job, transit to EI.<sup>37</sup> The value of being employed and in the states described above can be expressed as

$$V^E(t, i, 1) = \begin{cases} \frac{1}{2}[w(t, -T_{in}, 1) + \tilde{w}] + \beta[(1 - \delta)V^E(t + 1, -T_{in}, 1) + \delta V^A(-T_{in})] & \text{if } t < I, \\ \frac{1}{2}[w(t, -T_{in}, 1) + \tilde{w}] + \beta[(1 - \delta)V^E(t + 1, \underline{u}, 1) + \delta V^U(\underline{u})] & \text{if } t = I, \\ \frac{1}{2}[w(t, i, 1) + \tilde{w}] + \beta[(1 - \delta)V^E(t + 1, i + 1, 1) + \delta V^U(i + 1)] & \text{if } \underline{u} < i < \bar{u} \\ \frac{1}{2}[w(t, \bar{u}, 1) + \tilde{w}] + \beta[(1 - \delta)V^E(t + 1, \bar{u}, 1) + \delta V^U(\bar{u})] & \text{if } i = \bar{u} \\ \frac{1}{2}[w(t, \bar{u}, 1) + \tilde{w}] + \beta[(1 - \delta)V^E(t + 1, \bar{u}, 0) + \delta V^U(\bar{u})] & \text{if } t = T_{end}, \end{cases}$$

where  $T_{in}$  is the number of months on welfare required to qualify for the SSP supplement and  $T_{end}$  is the number of months an individual can receive the supplement once employed.

## A.2 Welfare Recipients

Welfare recipients receive welfare benefits ( $b_a$ ) and pay convex ( $z > 1$ ) search costs  $c_a[p(i)^z]$  in the current month. The cost of search is modelled in a manner consistent with Davidson and Woodbury (1993), where  $z$  is the elasticity of search costs with respect to search effort,  $c_a$  is a parameter capturing the disutility of search effort and  $p(i)$  is search effort in period  $i$ . The cost of search depends directly on the intensity with which workers search within the model. Let  $m(i)$  denote the probability a welfare recipient finds a job and transits to employment in the next month. With probability  $(1 - m(i))$  the welfare recipient remains on welfare. Individuals receiving IA become eligible for the earnings supplement after  $T_{in}$  months on IA. Using the same index  $i$  as we used for the number of months of unemployment benefits we define the first month on Income Assistance as  $i = 0$  and continue to count down. Thus, an individual is eligible for the earnings supplement in month  $i = -T_{in}$ , and becomes ineligible in month  $i = -T_{out}$ . They remain eligible for the supplement as long as the duration of their welfare spell is less than the supplement eligibility period ( $-T_{in} \geq i > -T_{out}$ ). For the duration of the time that they are eligible for the supplement, they receive a job offer with probability  $m(i)$  and if an offer is received, they have the option of transiting to employment in the next month or remaining on IA. If they do not receive a job offer, they remain on welfare and, if the eligibility period has not expired, remain eligible to receive the supplement should they secure employment in the following month. If eligibility for the supplement expires in the next month and workers do not receive a job offer, they remain on welfare but are not eligible for the supplement should they receive a job offer. Once eligibility expires, individuals will not be eligible for the earnings supplement for the remainder of their duration on IA. The value function for welfare recipients in the states described above is

$$V^A(i) = \begin{cases} \max_{p(i)} \left\{ b_a - c_a[p(i)^z] + \beta \left[ m(i)V^E(1, i - 1, 0) + (1 - m(i))V^A(i - 1) \right] \right\}, & 0 \geq i > -T_{in} \\ \max_{p(i)} \left\{ b_a - c_a[p(i)^z] + \beta \left[ m(i)V^E(1, i - 1, 1) + (1 - m(i))V^A(i - 1) \right] \right\}, & -T_{in} \geq i > -T_{out} \\ \max_{p(i)} \left\{ b_a - c_a[p(i)^z] + \beta \left[ m(i)V^E(1, 0, 0) + (1 - m(i))V^A(-T_{out}) \right] \right\}, & i = -T_{out} \end{cases}$$

<sup>36</sup>In the actual SSP experiment, once individuals qualified for the earnings supplement they could transit between employment and IA and collect the supplement payments in any month they were employed full time during the 36 months after qualifying. We abstract from this in the model as it would add an unmanageable number of states. Instead we allow those who lose their job prior to qualifying for unemployment benefits to transit back to the first period of SSP eligibility.

<sup>37</sup>It is assumed that  $I < T_{end}$ , which is consistent with the actual EI and IA programs.

### A.3 Firms

In every period, the firm has the option of filling a vacancy, if one exists, by hiring a worker or keeping the vacancy open. If matched with a worker, firms earn profits that depend on the surplus generated by the match and pay wages, determined in equilibrium, that depend on the worker's outside options, the minimum wage, and the worker's SSP supplement status. Profits depend on the worker's tenure to allow match-specific capital to increase the productivity of the match over time. Denote the surplus generated by a worker-firm pair of tenure  $t$  by  $S(t)$ . With probability  $\delta$  the match separates and the firm is left with a vacancy in the following month. Denote the profits of a firm matched with a worker with outside option  $i$ ,  $i \in \{\bar{u}, \dots, \underline{u}, \dots, 1, 0, -1, \dots, -T_{in}, \dots, -T_{out}\}$ , match tenure  $t$ , and SSP supplement eligibility  $s$  by  $\Pi(t, i, s)$ .

The expected future profits for matches of job tenure  $t$  with workers with outside option  $i$  and SSP eligibility  $s$  are

$$\Pi^E(t, i, s) = \begin{cases} S(t) - w(t, 0, 0) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, 0, 0)] & \text{if } 0 \geq i > -T_{in}, t < I, \text{ and } s = 0, \\ S(t) - w(t, 0, 0) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \underline{u}, 0)] & \text{if } i = 0, t = I, \text{ and } s = 0 \\ S(t) - w(t, i, 0) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, i + 1, 0)] & \text{if } 0 < i < \bar{u}, t < T, \text{ and } s = 0, \\ S(t) - w(t, \bar{u}, 0) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \bar{u}, 0)] & \text{if } i = \bar{u}, t < T, \text{ and } s = 0 \\ S(t) - w(t, i, 1) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, -T_{in}, 1)] & \text{if } -T_{in} \geq i, t < I, \text{ and } s = 1, \\ S(t) - w(t, -T_{in}, 1) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \underline{u}, 1)] & \text{if } -T_{in} = i, t = I, \text{ and } s = 1 \\ S(t) - w(t, i, 1) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, i + 1, 1)] & \text{if } \underline{u} < i < \bar{u}, t < T, \text{ and } s = 1, \\ S(t) - w(t, \bar{u}, 1) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \bar{u}, 1)] & \text{if } i = \bar{u}, t < T_{end}, \text{ and } s = 1 \\ S(t) - w(T_{end}, \bar{u}, 1) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(t + 1, \bar{u}, 0)] & \text{if } i = \bar{u}, t = T_{end}, \text{ and } s = 1 \\ S(t) - w(t, i, 0) + \beta[\delta\Pi^V + (1 - \delta)\Pi^E(T, \bar{u}, 0)] & \text{if } t \geq T, \end{cases}$$

where match tenure beyond  $T$  no longer increases profits.

If a firm has a vacancy, the value of a vacancy is determined by the probability of meeting an unmatched worker, by the profits the firm expects to make from the match, and by the costs of posting a vacancy ( $\xi$ )

$$\Pi^V = -\xi + \beta \left[ \sum_i q(i) \Pi^E(1, i, s) + \left( 1 - \sum_i q(i) \right) \Pi^V \right],$$

where  $s = 1$  if  $-T_{in} \geq i > -T_{out}$  and  $s = 0$  otherwise.

Firms will post vacancies unless the expected profit from doing so is negative. Thus in the steady state equilibrium the number of firms in the economy will be determined by the condition that the expected profits from posting a vacancy are zero.<sup>38</sup> Note that this also requires a free entry assumption.

### A.4 Search Technology

Assume there is no on-the-job search in the economy. The probability that a jobless individual receives a job offer depends on the probability the worker contacts a firm and the probability a firm has a vacancy.

#### A.4.1 Workers

The probability a firm has a vacancy is simply the total number of vacancies divided by the total number of firms

$$\frac{V}{F}.$$

<sup>38</sup>Production takes place when there is a match between one firm and one worker; the number of firms can alternatively be interpreted as the number of jobs in the economy.

If a firm has a vacancy, it will hire a worker and pay a wage which is the outcome of Nash bargaining between the worker and the firm, discussed in detail below. Applications for jobs arrive according to a Poisson process, where  $\lambda$  is the average number of applications filed by workers at each firm. It is further assumed that firms randomly draw workers from the applicant pool if there is more than one applicant.<sup>39</sup> The probability a worker is offered a job is:

$$\frac{1 - e^{-\lambda}}{\lambda}.$$

The conditional re-employment probabilities for unemployed workers and workers on income assistance can then be expressed as the product of the above components, multiplied by the worker's search effort

$$m(i) = \frac{p(i)V}{\lambda F} (1 - e^{-\lambda}),$$

where

$$\lambda = \frac{1}{F} \left( \sum_{i=1}^{\bar{u}} p(i)U(i) + \sum_{i=-T_{out}}^0 p(i)A(i) \right).$$

Recall,  $p(i)$  are the contact probabilities of an individual in jobless state  $i$ . The contact probabilities are choice variables for the workers within the model and can be interpreted as search effort. Workers determine the optimal level of search effort by equating the marginal benefit from an increase in search effort with its marginal cost.<sup>40</sup> The optimal level of search effort, for each labor market state and program eligibility combination, is described by:

$$p(i) = \begin{cases} \left( \frac{\beta m(i)}{c_u z} [V^E(1, i-1, 0) - V^U(i-1)] \right)^{\frac{1}{z}}, & i > 1 \\ \left( \frac{\beta m(i)}{c_u z} [V^E(1, i-1, 0) - V^A(0)] \right)^{\frac{1}{z}}, & i = 1 \\ \left( \frac{\beta m(i)}{c_a z} [V^E(1, i-1, 0) - V^A(i-1)] \right)^{\frac{1}{z}}, & 0 \geq i > -T_{in} \\ \left( \frac{\beta m(i)}{c_a z} [V^E(1, i-1, 1) - V^A(i-1)] \right)^{\frac{1}{z}}, & -T_{in} \geq i > -T_{out} \\ \left( \frac{\beta m(i)}{c_a z} [V^E(1, i-1, 0) - V^A(-T_{out})] \right)^{\frac{1}{z}}, & i = -T_{out} \end{cases}$$

#### A.4.2 Firms

From the firm's perspective, the probabilities of meeting potential workers from unemployment and welfare are the fraction of workers from unemployment and welfare that transit to employment, divided by the total number of vacancies

$$q(i) = \frac{m(i)U(i)}{V}, \quad \bar{u} \geq i > 0, \quad \text{and} \quad q(i) = \frac{m(i)A(i)}{V}, \quad 0 \geq i \geq -T_{out}$$

respectively.

### A.5 Equilibrium Wage Determination

After meeting in the labor market, a firm and a worker bargain over wages by making alternating wage offers until both sides find the offer acceptable. It is assumed that both parties have equal bargaining power, but may have different threat points. The equilibrium of this game is the Nash cooperative bargaining solution and results in workers and firms splitting the surplus of a match

<sup>39</sup>Alternatively, we can consider the length of a period tending to zero and work in continuous time, where there is zero probability of more than one application arriving simultaneously.

<sup>40</sup>In determining the marginal cost and benefit of search effort  $\lambda$  is held constant under the assumption that each worker believes her impact is small relative to total labor supply.

evenly. The surplus of the match from the worker's perspective is the difference between employment at the equilibrium wage and the worker's outside option, which depends on their current labor market state and program eligibility, as well as on SSP supplement eligibility. The surplus from the perspective of the firm is the difference between the profits the firm receives at the equilibrium wage and the value of leaving the vacancy open. It is further assumed that the bargaining process is constrained such that the wage can not fall below the minimum wage  $\underline{w}$ . The equilibrium wage is  $\max\{w(t, i, s), \underline{w}\}$ , where  $w(t, i, s)$  solves

$$V^E(t, i, s) - V^j(i) = \Pi^E(t, i, s) - \Pi^V.$$

where  $V^j(i) \in \{V^A(i), V^U(i)\}$  is the value of the outside option  $i$ . In the following section, we define the steady state conditions that govern the evolution of the economy.

## A.6 Steady State Conditions

Let  $E$  denote the steady state number of jobs occupied by workers and  $V$  the number of vacancies. By definition, the total number of jobs in the labor market is equal to the total number of occupied jobs and the total number of vacancies

$$F = E + V.$$

Denote the total number of individuals in the labor market by  $L$ . The total number of individuals can be decomposed into three groups. First the employed, who are distinguished by their current job tenure, their current outside option, and their SSP supplement eligibility status

$$E = \sum_{t=1}^T \sum_i \sum_s E(t, i, s) + \bar{E},$$

where  $\bar{E}$  is the group of workers no longer experiencing on the job wage growth. The second group are on welfare and are distinguished by their welfare duration, which determines their SSP eligibility:

$$A = \sum_{i=-T_{out}}^0 A(i).$$

The final group are unemployed individuals ( $U$ ), who can remain unemployed for up to a maximum of  $\bar{u}$  periods

$$U = \sum_{i=1}^{\bar{u}} U(i),$$

where  $U(i)$  indicates the number of unemployed persons with  $i$  periods of benefits remaining.

The total number of individuals in the labor market can therefore be expressed as the sum of the above components

$$L = E + A + U.$$

Using the above definitions, we can describe the conditions governing the steady state, where the flows in and out of every labor force state must be equal over time. The steady state conditions for each state and eligibility combination are discussed in turn below.

### A.6.1 Employment

As above, let  $m(i)$  denote the probabilities that jobless individuals from jobless state  $i$  match with a firm with a vacancy. The flow into the first period of employment includes those workers from welfare and unemployment who receive job offers. They are indexed by their respective outside options and their SSP eligibility as this will determine their progression of benefit entitlements. In

subsequent periods, the inflow consists of workers who were employed in the previous period and who were not exogenously separated from their jobs

$$\begin{aligned}
E(1, i, 0) &= m(i)U(i), \quad \bar{u} \geq i > 0 \\
E(1, i, 0) &= m(i)A(i), \quad 0 \geq i > -T_{in} \\
E(1, i, 1) &= m(i)A(i), \quad -T_{in} \geq i > -T_{out} \\
E(1, i, 0) &= m(i)A(i), \quad i = -T_{out} \\
E(t, i, 0) &= (1 - \delta)E(t - 1, i - 1, 0), \quad 1 < t < T, i > 0 \text{ and } s = 0 \\
E(t, i, 1) &= (1 - \delta)E(t - 1, i - 1, 1), \quad 1 < t < T_{end}, \text{ and } s = 1 \\
E(t, i, 0) &= (1 - \delta)E(t - 1, i - 1, 1), \quad t = T_{end}, \text{ and } s = 1 \\
\delta \bar{E} &= (1 - \delta)E(T, \bar{u}).
\end{aligned}$$

### A.6.2 Welfare

The flow into the first period of Income Assistance includes those employed workers who were exogenously separated from their jobs and ineligible for unemployment benefits and unemployed workers no longer eligible for unemployment benefits. The flow into first period of SSP eligibility includes those on welfare who have been on welfare long enough to qualify, plus those who were exogenously separated from jobs in which they were receiving the SSP supplement but not yet eligible for unemployment benefits. The flows into all other periods of income assistance consist of those workers in the previous period of income assistance who did not match with an employer. Finally, those individuals who did not find employment before SSP eligibility expired transit to  $A(-T_{out})$ , where the flow in and out of this state must be equal.

$$\begin{aligned}
\delta \sum_{t=1}^I E(t, 0, 0) + (1 - m(1))U(1) &= A(0) \\
\delta \sum_{t=1}^I E(t, -T_{in}, 1) + (1 - m(-T_{in} + 1))A(-T_{in} + 1) &= A(-T_{in}) \\
(1 - m(i + 1))A(i + 1) &= A(i), \quad 0 > i > -T_{out}, \text{ and } i \neq -T_{in} \\
(1 - m(-T_{out} + 1))A(-T_{out} + 1) &= m(-T_{out})A(-T_{out}).
\end{aligned}$$

### A.6.3 Unemployment

Employed workers who are separated from their jobs and who are eligible for the maximum months of unemployment benefits flow into the first period of unemployment,  $U(\bar{u})$ . For  $U(i)$  where  $0 < i < \bar{u}$ , the inflow consists of unemployed workers from the previous period who did not find jobs, and workers separated from their jobs who qualify for less than the maximum number of benefit months. All workers flow out of the unemployment state when benefits run out due to the time limitations in the unemployment insurance program

$$\begin{aligned}
\delta \sum_t E(t, \bar{u}, 0) &= U(\bar{u}) \\
\delta \sum_t \sum_i E(t, i, 0) + \delta \sum_{t \geq I} \sum_i E(t, i, 1) + (1 - m(i + 1))U(i + 1) &= U(i) \quad \text{if } 0 < i < \bar{u}.
\end{aligned}$$

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