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Human Capital and Search Behaviour

The Self-Sufficiency Project

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Executive Summary

Income support programs, while successful in redistributing income to the poor, often result in substantially weakened work incentives. To address this problem, Canada put in place the Self-Sufficiency Project (SSP) to evaluate a conditional earnings subsidy program that would reduce the very high tax rate implicit in the existing income support system. The project provided cash payments to individuals previously on income assistance (IA) for at least a year who subsequently became employed full time within the following year. The SSP research design was one of random assignment. The basic result from a comparison of program and control groups was that the program resulted in significantly higher employment and lower participation in IA, at least for the duration of the program.

The research to date has provided policy-makers with a great deal of useful information regarding the likely effectiveness of programs such as SSP. However, there remain substantial gaps. One important gap is the sensitivity of the results to the parameters of the program that set the benefit levels and eligibility requirements. It is natural to ask whether outcomes can be improved or substantial government savings reaped by changing some of these program parameters. To address this question, it is necessary to uncover the underlying decisions and behavioural responses that produce the observed differences between the program and control groups in the experiment. This requires an economic model of respondent behaviour.

In this paper, we augment a traditional search model by incorporating human capital, so as to include the two most important avenues in terms of respondent behaviour and long-term outcomes of the program. We estimate our model using the Applicant sample, which consists of individuals randomly chosen from new IA applicants in British Columbia in 1994–95. Our estimates are based on the sample of control group members, using the treatment sample to externally verify the quality of our estimates. In particular, we use estimated parameters for our behavioural model to predict how individuals will respond to the SSP program incentives, comparing those predicted responses with those of the actual treatment group. We find that the predicted patterns for full-time work and earnings from our estimated model compare well with those in the treatment sample, giving us confidence in our model and estimates. Then, using our estimated behavioural model, we evaluate the effects of alternative program configurations via policy simulation.

The first policy experiment examined the length of time the individual is required to stay on IA. The actual policy parameter for the SSP experiment was set at 12 months. Simulations were undertaken for longer (18 months) and shorter (6 months) specified times. The simulations show that, not surprisingly, shortening this phase causes the increase in full-time employment associated with later phases to occur earlier. The general patterns for employment impacts over time, however, are all quite similar.

The second experiment looked at the length of time within which a full-time job had to be found. Our estimates show that individuals in this phase are willing to accept any job offer but are constrained by the slow arrival rate of offers. Lengthening this phase relaxes this constraint and allows more individuals to receive a job offer. Conversely, shortening the period makes it impossible for many individuals to find jobs even though they are willing to accept any offer. Making it easier to receive SSP payments by lengthening this phase increases IA receipt during the first 12 to 16 months after going on IA but substantially raises employment in the ensuing years.

In the third experiment, we examine the length of time the bonus can be received. A longer period for this phase increases the generosity of the program. This causes more individuals to stay on IA for the full 12 months in order to become eligible for payments. However, among those who become eligible to receive a wage bonus if they find full-time work, varying the length of this phase does not affect job offer acceptance decisions. Eligible individuals are willing to accept any job offer. Not surprisingly, extending the length of this phase extends the period for which full-time employment rises for the program group.

Simulations were also conducted for alternative levels of generosity of the bonus. The results suggest that generosity of the program could be reduced while maintaining the same employment gains from the program. A reduced level of generosity results in more individuals accepting jobs in the first 12 months rather than waiting to take advantage of the bonus. Even though the incentive to enter the program is reduced, once qualified, individuals continue to accept all jobs, even for annual benchmark levels as low as $24,000. Thus, for all the levels of bonus generosity we analyze, individuals are constrained in their employment behaviour by the job offer arrival rate rather than refusing offers that do arrive.

The evidence on human capital accumulation suggests that the accumulation is modest and occurs very early on in a job spell. This is consistent with many jobs having a probationary period at entry with a modest wage increase at the end of the probationary period, by which time the human capital has been acquired. The evidence also suggests that this human capital depreciates rapidly once a job is lost.

The SSP experimental results showed that individuals who had been on IA for 12 months could still find full-time work. Giving them some incentive in the form of a wage bonus could affect how many of them find full-time work. What the experimental analyses could not show was how the form of the incentive structure could affect the magnitude of the employment outcomes, since one particular form was chosen for the experiment and applied to all participants. In this paper, we have estimated a structural search model that includes human capital and provides a framework for assessing the sensitivity of the employment outcomes to the policy parameters. One feature of the SSP experiment is that it set a high annual benchmark generosity level, resulting in wage bonuses that approximately doubled wage incomes for the full-time workers receiving them. Our simulations suggest that employment gains could be at least as high as those that occurred in the experiment if the benchmark was reduced from $37,500 to $24,000. These results highlight the importance of estimating a behavioural model and simulating changes in policy parameters. However, they are contingent on the model and sample used for estimation. In particular, future work will focus on endogenizing search intensity and creating a more flexible human capital specification.

1. Introduction

Income support programs of varying levels of generosity are present in all developed countries. Soon after their introduction it was recognized that traditional means-tested income support programs, while successful in redistributing income to the poor, often result in substantially weakened work incentives. Many fear that this feature of the programs can lead to the so-called “welfare trap,” whereby the absence of work incentives creates a permanent dependence on income support for a subsection of the population. Several countries have embarked on welfare reform to address this problem.[1]

Canada put in place a major research project to evaluate a conditional earnings subsidy program that would reduce the very high marginal tax rate implicit in the existing income support system.[2] The project, called the Self-Sufficiency Project (SSP), provided cash payments to individuals previously on income assistance (IA) for at least a year who became employed full time within the following year. Those qualifying for the cash bonus payments received one half the difference between their income and a target income level during periods of full-time employment (defined as 30 hours per week or more). They could receive the bonus for up to three years from the time they first qualified for payments.

The SSP research design was one of random assignment to the program from a sample of eligible IA recipients. The evaluation aspect of SSP has resulted in research reports dealing with many aspects of the program, using a variety of methods.[3] The basic result from a comparison of program and control groups was that the program resulted in significantly higher employment and lower participation in IA, at least for the duration of the program.

The research to date has provided a great deal of useful information to policy-makers regarding the likely effectiveness of programs such as SSP. However, there remain substantial gaps. One important gap is the sensitivity of the results to the parameters of the program.[4] While a simple comparison of program and control group outcomes within the random assignment design provides a means to evaluate a program with the particular parameters of the SSP experiment, it does not enable researchers to evaluate how changes in program parameters would affect individual employment, IA receipt, and earnings. At least four policy parameters are of central interest: the length of the initial IA period required for eligibility, the amount of time allotted to individuals to find their first full-time job after becoming eligible, the duration of the bonus payment period, and the size of bonus payments. It is natural to ask whether outcomes can be improved or substantial government savings reaped by changing the program parameters. These questions cannot be answered within the standard atheoretical program evaluation approach that simply compares the outcomes of treatment and control group members. To address this question, it is necessary to uncover the

[1]See Moffitt (2003) for a recent survey of welfare policies in the United States.

[2]Income support systems vary by province in Canada. The experiment was conducted in the provinces of British Columbia and New Brunswick.

[3]See the Publications section of the Social Research and Demonstration Corporation (SRDC) Web site (http://www.srdc.org) for a full list of the SSP research reports.

[4]A related gap is the possible general equilibrium effects that would result from the introduction of a national program. Lise, Seitz, and Smith (2005a, 2005b) are the first to address this problem in the SSP literature. To fill these gaps, it is necessary to go beyond the experimental results and estimate a behavioural structural model.

underlying decisions and behavioural responses that produce the observed differences between the program and control groups in the experiment. This requires an economic model of behaviour.

In this paper, we begin with the traditional search model (see Mortensen, 1986) as a natural starting point for studying wage and employment responses to the SSP program.[5] However, an important possible avenue for long-term effects of the program on individual earnings is the acquisition of human capital resulting from the higher full-time employment level induced by the program. In order to capture this potentially important feature of the program, we extend the canonical search model (with on-the-job search) to incorporate general human capital acquisition in the form of stochastic "learning-by-doing." We further allow for stochastic depreciation of skills during periods of unemployment/IA receipt.

We estimate our search model with human capital accumulation using the Applicant sample, which consists of individuals randomly chosen from new IA applicants in British Columbia in 1994–95. This sample, taken at entry to IA, allows us to model and study the full SSP set up. Approximately half the sample is assigned control status, experiencing no change in their IA situation, while the other half is given the opportunity to receive cash supplements for full-time work after meeting qualification requirements. Our estimates are based on the sample of control group members, using the treatment sample to externally verify the quality of our estimates. In particular, we use estimated parameters for our behavioural model to predict how individuals will respond to the SSP program incentives, comparing those predicted responses with those of the actual treatment group.[6] We find that the predicted patterns for full-time work and earnings from our estimated model compare well with those in the treatment sample, giving us confidence in our model and estimates. Then, using our estimated behavioural model, we evaluate the effects of alternative program configurations via policy simulation.

Our estimates suggest a modest role for human capital accumulation, with the gains (slightly less than $200 per month) coming very quickly with a new job and depreciating just as quickly on IA. This is consistent with a "probationary period" that exists in most jobs taken by our sample respondents. New job arrival rates are fairly low for the unemployed (about a six per cent monthly arrival rate) and even lower for those already working (a one per cent arrival rate). Job destruction rates are low as well (less than one per cent per month), suggesting that most jobs last at least a few years.

Our estimates imply effects of the SSP program incentives that mimic those observed in a simple comparison of treatment and control group members. More specifically, the cash bonus for full-time work encourages individuals who become eligible for the bonus (by remaining on IA for 12 months) to accept job offers more readily, raising their employment rates. However, the initial period that mandates 12 months of IA before an individual becomes eligible for the bonus payments tends to reduce incentives to accept employment during that period, with the perverse effects on employment growing over this period. Our estimates imply a substantial expected benefit associated with the bonus payments such that individuals on IA who are eligible for the payments are willing to accept any job that they are offered. Only the low estimated job arrival rate prevents them all from finding work

[5]See Lise et al. (2005a, 2005b) and Card and Hyslop (2005) for other references to this theoretical framework and SSP.
[6]See Lise et al. (2005a, 2005b) and Todd and Wolpin (2005) for other analyses using this approach.

immediately. Reasonable changes in the benefit amount (as well as the length of benefit payment period or the length of time allotted for finding a full-time job upon becoming eligible) do not alter the behaviour of those who manage to remain on IA for at least 12 months in order to become eligible. They do, however, affect incentives to accept job offers during the initial 12-month period of required IA receipt. In particular, policy changes that make the program more generous tend to discourage early job acceptance rates by causing individuals to raise their reservation wages. Alternatively, a policy that shortens the initial period of required IA receipt reduces this discouragement effect without sacrificing subsequent encouragement effects of the bonus, once an individual has become eligible to receive payments.

The rest of this paper proceeds as follows. Section 2 develops and discusses a new search model that includes human capital accumulation and depreciation. We discuss the decision problems for both control group members (who face the standard IA system) and the program group members (who face the SSP incentives). Section 3 discusses the SSP Applicant sample used in our estimation, while Section 4 discusses estimation and the estimates of behavioural parameters. In Section 5, we compare the estimated model's predicted patterns for earnings and full-time employment with the patterns observed in the actual data. Using our estimates of the behavioural parameters, we simulate the impacts of changing some of the SSP program parameters in Section 6 and offer some concluding remarks in Section 7.

2. A Search Model With Human Capital

The standard search framework is an obvious starting point for modelling the behaviour of the program and control groups with regard to income assistance (IA) and work choices over time. However, thus far the research on the Self-Sufficiency Project (SSP) has made little use of this framework.[7] An important limitation of standard search models is that they do not incorporate human capital. Wage growth in search models comes about through finding an employer that will pay more for the same level of human capital. However, in estimating the long-term effects of an incentive program like SSP, it is important to allow for human capital acquisition, since skills acquired over the program period may last long after the program ends. While wage gains acquired from search are lost upon unemployment, general human capital need not be. To the extent that general human capital is an important feature of labour markets for the SSP sample, wage gains associated with increased employment are likely to be long-lasting. To allow for this possibility, we construct a search model that incorporates both the job-search incentive structure implied by the program and human capital accumulation and depreciation. To maintain tractability, we assume that human capital accumulation takes place via stochastic "learning by doing" on the job. Stochastic human capital depreciation takes place during periods of non-employment. Additionally, we assume that all human capital is general and takes on one of two possible levels, unskilled (h = 0) or skilled (h = 1).[8] In addition, as in Card and Hyslop (2005), the choice problem is one with two options: full-time employment or IA. To simplify, "IA" includes being on Employment Insurance (EI) and working part time, which are all assumed to have the same payoff. In keeping with the standard search approach, there is a single "wage" offer distribution for all workers, $F(w)$, where w ranges from $\underline{w}$ to $\overline{w}$. While we do not model permanent individual heterogeneity, wage earnings and individual choices will differ by worker skill level. Unskilled workers receive earnings w during periods of employment, while skilled workers receive an additional payment of ε, earning a total amount of $w+\varepsilon$.[9]

THE PROBLEM FOR THE CONTROL GROUP

We assume that control group members face a stationary decision problem, which only depends on their current skill level, employment state, and wage if employed. During any period of employment, low-skilled workers may become skilled at the end of the period with probability P_u. During periods of non-employment (IA receipt), skilled workers may lose their human capital at the end of the period with probability P_d. We assume that individuals know what happens to their skills before they decide whether or not to accept a new job offer, which starts at the beginning of the next period. Individuals on IA receive a new job offer each period with probability λ_0, which they must accept or decline. As is typical in the search literature, they will use a reservation wage policy, where the reservation wage will depend on their skill level. Employed workers receive a new job offer with probability λ_1, which they

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[7]Card and Hyslop (2005) use a standard discrete time search model as a theoretical guide in their work but do not estimate it. Lise et al. (2005a, 2005b) calibrate a simple equilibrium search model.
[8]Amenities of the job are ignored and search intensity is exogenous.
[9]In effect, all firms pay the same human capital "reward" and compete over the basic wage payment.

may accept by switching employers or decline in order to remain at their current job. They also face an exogenous termination with probability δ, which puts them on IA in the following period. In most cases, workers receiving a new wage offer will choose to stay in their current job if the new offer is worse than their current one, but will switch jobs otherwise. There may be one exception to this policy if the reservation wage for skilled workers, R_U^1, is greater than the reservation wage for unskilled workers, R_U^0. In this case, low-skilled workers who experience an increase in their human capital may choose to quit their current job for IA if their current wage lies between R_U^0 and R_U^1 and they do not receive a new job offer with a wage greater than R_U^1. As we discuss below, this possibility complicates the model somewhat.

Since neither human capital accumulation nor depreciation can take place for an unskilled individual on IA, she[10] need only decide whether to remain on IA, continuing to receive its associated benefits, or accept an offer if it is forthcoming. Individuals on IA will employ a reservation wage policy, accepting offers above the reservation wage and rejecting offers below it. For unskilled workers, R_U^0 represents this reservation wage. The value function for unskilled workers on IA ($\mathcal{U}^0$) therefore reflects the value of non-market time while on IA, z, plus the expected benefits associated with receiving an acceptable job offer next period or remaining on IA. It is of the standard search model form:[11]

$$(1+r)\mathcal{U}^0 = z + \lambda_0 \int_{R_U^0}^{\bar{w}} \mathcal{W}^0(w)dF(w) + [1 - \lambda_0(1 - F(R_U^0))]\mathcal{U}^0,$$

where $\mathcal{W}^0(w)$ is the value while employed at wage w with human capital level 0. Note that the current utility from IA, z, includes IA payments as well as any leisure value and cost savings in child care, commuting, etc. It may also incorporate any stigma effect associated with unemployment.

Skilled individuals on IA face the possibility that their human capital may depreciate. As a result, their value function ($\mathcal{U}^1$) is slightly more complicated:

$$\begin{aligned}(1+r)\mathcal{U}^1 \quad = \quad & z + (1-P_d)[\lambda_0 \int_{R_U^1}^{\bar{w}} \mathcal{W}^1(w)dF(w) + (1-\lambda_0(1-F(R_U^1)))\mathcal{U}^1] \\ & + P_d[\lambda_0 \int_{R_U^0}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0(1-F(R_U^0)))\mathcal{U}^0]\end{aligned}$$

where $\mathcal{W}^1(w)$ is the value while employed at wage w with human capital level 1 and P_d is the probability that human capital depreciates while on IA. As noted earlier, it is assumed that the human capital level at the beginning of the following period is known before any job offers are considered.

[10]Feminine pronouns are used in this paper because more than 90 per cent of single parents who have received income assistance for at least a year — the target group for SSP — are women.

[11]The model is in discrete time; all payments, IA, and wages are assumed to be received at the end of each period. Our empirical application defines a period to be one month. Here, we have suppressed all time subscripts and solved for the stationary solution.

Employed individuals may receive a new job offer with probability λ_1, in which case they must decide whether to accept that job or not. In most cases, this amounts to comparing their current wage with the new wage offer. Workers may be dismissed from their job with probability δ, in which case they enter IA. Finally, they may avoid termination and not receive a new job offer, in which case they will typically remain in their current job.[12]

Unskilled workers may experience an increase in their human capital with probability P_u. The timing of the human capital process is such that individuals know their end of period level of human capital before they must decide what to do in the following period. The value function for employed individuals with human capital level 0 is, therefore

$$(1+r)\mathcal{W}^0(w) = \begin{cases} w + (1-P_u)[\lambda_1 \int_w^{\bar{w}} \mathcal{W}^0(w')dF(w') + \delta\mathcal{U}^0 + [1-\delta-\lambda_1(1-F(w))]\mathcal{W}^0(w)] & \\ +P_u[\lambda_1 \int_w^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 + [1-\delta-\lambda_1(1-F(w))]\mathcal{W}^1(w)] & \text{if } w \geq R_U^1 \\ w + (1-P_u)[\lambda_1 \int_w^{\bar{w}} \mathcal{W}^0(w')dF(w') + \delta\mathcal{U}^0 + [1-\delta-\lambda_1(1-F(w))]\mathcal{W}^0(w)] & \\ +P_u[\lambda_1 \int_{R_U^1}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 + [1-\delta-\lambda_1(1-F(R_U^1))]\mathcal{U}^1] & \text{if } w < R_U^1. \end{cases}$$

For those individuals whose human capital does not appreciate, we have imposed the standard on-the-job search solution that they accept any new job offer that pays a higher wage than the current job. For those whose human capital does appreciate, the on-the-job search reservation rule depends on whether the current wage is above or below the reservation wage for the skilled, R_U^1. If the current wage is above R_U^1 (the top condition), the individual prefers to keep the current job instead of going on IA, and the standard rule applies. If, however, the current wage is below R_U^1, then the individual prefers IA to employment and will only remain employed, albeit at a new job, if a new wage offer is received that exceeds R_U^1. This possibility can only occur if $R_U^0 < R_U^1$, since the wage for an unskilled worker must be greater than R_U^0 for the individual to have accepted that offer in the first place.

Employed individuals with human capital level 1 are not subject to human capital appreciation or depreciation, so the value function for this group is of the standard form:

$$(1+r)\mathcal{W}^1(w) = (w+\varepsilon) + \lambda_1 \int_w^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 + [1-\delta-\lambda_1(1-F(w))]\mathcal{W}^1(w).$$

The solution to the control group's problem is a state-contingent reservation wage strategy. The following optimization equalities:

$$\mathcal{W}^0(R_U^0) = \mathcal{U}^0 \quad (1)$$

$$\mathcal{W}^1(R_U^1) = \mathcal{U}^1 \quad (2)$$

[12] As discussed below, some low-skilled workers whose human capital increases may actually choose to quit their current job if its wage is below R_U^1. These workers may even quit upon receiving a better job offer if that wage is also below R_U^1. In order to remain employed, the wage must be greater than the relevant reservation wage.

yield the reservation wages while on IA. It is straightforward to solve for the IA reservation wages by starting with an initial guess for the value functions and iterating until convergence.[13]

The relationship between R_U^0 and R_U^1 is ambiguous. With no human capital appreciation or depreciation (only fixed skill levels), R_U^1 would be greater than R_U^0 because of the extra earnings payment ε. However, the potential for depreciation ($P_d > 0$) lowers the reservation wage for those with higher human capital, as they want to leave the IA state before losing their skills, and the presence of skill accumulation ($P_u > 0$) lowers the reservation wage of unskilled individuals, as they want to find a job in order to accumulate human capital. Thus, R_U^0 may be greater than R_U^1. Indeed, our empirical estimates suggest that this is the case.

THE PROGRAM GROUP

While the program treatment group faces the same job offer distribution, job arrival rates, and human capital accumulation and depreciation processes, its problem is non-stationary due to the incentives offered by SSP. It is useful to disaggregate the program period into three separate phases. Within each of these phases, decisions are time-dependent. During Phase One, individuals must remain on IA for at least T_1 months. If they find a job before this phase ends, they return to the stationary control problem; otherwise, they move to Phase Two. In this phase, they must find a full-time job within T_2 months to begin receiving a wage bonus. This wage bonus equals half the difference between their earnings and a target monthly income level, *b*. If they do not find a job within this time period, they return to the stationary control problem and never receive a bonus payment. If they find a job, they move immediately to Phase Three of the program, in which they continue to receive bonus payments during any period of full-time employment. This phase lasts T_3 months. The SSP program specifies $T_1 = 12$, $T_2 = 12$, $T_3 = 36$ (all in months) and *b* = \$37,500/12.

We now define individual value functions, which depend on the program phase, period within that phase, and human capital. For individuals with human capital level *j*, define $\mathcal{N}^j(i)$ to be the value function for those who have not been in IA long enough to be eligible for the SSP program *i* months after random assignment (Phase One); $\mathcal{M}^j(i)$ to be the value function for individuals who are now eligible for the SSP program but have not yet met the requirement of finding a full-time job *i* months after eligibility begins (Phase Two); $\mathcal{V}^j(w,i)$ to be the value function for individuals who are employed at wage *w* and receiving the SSP bonus with *i* months of elapsed bonus entitlement (Phase Three workers); and $\mathcal{Q}^j(i)$ to be the value function for individuals who are receiving IA and entitled to receive the SSP bonus with *i* months of elapsed bonus entitlement (Phase Three IA).

The value functions for the Phase One period before eligibility are

$$(1+r)\mathcal{N}^0(i) = \begin{cases} z + \lambda_0 \int_{R_N^0(i)}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_N^0(i))])\mathcal{N}^0(i+1) & \text{if } 1 \le i \le T_1 - 2 \\ z + \lambda_0 \int_{R_N^0(i)}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_N^0(i))])\mathcal{M}^0(1) & \text{if } i = T_1 - 1 \end{cases}$$

[13]In practice, we use a linear-spline approximation for the value functions, $\mathcal{W}^0(w)$ and $\mathcal{W}^1(w)$, with a grid of 5,000 points from a lowest earnings of $\underline{w}$ = 10.0 to a maximum earnings of $\overline{w}$ = 6,000. This approximation is simple and maintains monotonicity of the value functions, a key feature needed for solution.

for individuals with human capital level 0, and

$$(1+r)\mathcal{N}^1(i) = \begin{cases} z + (1-P_d)[\lambda_0 \int\limits_{R_N^1(i)}^{\bar{w}} \mathcal{W}^1(w)dF(w) + (1-\lambda_0[1-F(R_N^1(i))])\mathcal{N}^1(i+1)] \\ +P_d[\lambda_0 \int\limits_{R_N^0(i)}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_N^0(i))])\mathcal{N}^0(i+1)] & \text{if } 1 \le i \le T_1 - 2 \\ \\ z + (1-P_d)[\lambda_0 \int\limits_{R_N^1(i)}^{\bar{w}} \mathcal{W}^1(w)dF(w) + (1-\lambda_0[1-F(R_N^1(i))])\mathcal{M}^1(1)] \\ +P_d[\lambda_0 \int\limits_{R_N^0(i)}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_N^0(i))])\mathcal{M}^0(1)] & \text{if } i = T_1 - 1 \end{cases}$$

for individuals with human capital level 1. As with the controls, the latter must account for the possibility of human capital depreciation. When deciding whether or not to accept a job that will start at the beginning of the next period, the individual must compare the value of working in the next period (here the value of leaving the program and facing the control group's problem) with the value of staying in IA in the next period. The above set up is designed to capture the basic features of the program regarding eligibility.[14]

The Phase One reservation wage solutions for an individual with human capital level j must satisfy

$$\mathcal{W}^j(R_N^j(i)) = \begin{cases} \mathcal{N}^j(i+1) & \text{if } 1 \le i \le T_1 - 2 \\ \mathcal{M}^j(1) & \text{if } i = T_1 - 1. \end{cases}$$

Since $\mathcal{V}^j(w,1) > \mathcal{W}^j(w)$ because of the bonus payment, $\mathcal{M}^j(1) > \mathcal{N}^j(i)$ and $\mathcal{N}^j(i+1) > \mathcal{N}^j(i)$. Therefore, $R_N^j(i) < R_N^j(i+1)$, since $\mathcal{W}^j(w)$ is increasing in w. That is, the reservation wage during the non-eligibility period increases as the individual gets closer to becoming eligible. In addition, because $\mathcal{M}^j(1) > \mathcal{U}^j$, one can show that $R_N^j(T_1) > R_U^j$. By the end of the non-eligibility period the program group has a higher reservation wage than the control group and should be exiting IA at a lower rate.

Having met the eligibility requirement, a program group member must take up a full-time job within $T_2 = 12$ months in order to qualify for the SSP bonus (Phase Two). Prior to qualifying, the value functions for those on IA are given by

$$(1+r)\mathcal{M}^0(i) = \begin{cases} z + \lambda_0 \int\limits_{R_M^0(i)}^{\bar{w}} \mathcal{V}^0(w,1)dF(w) + (1-\lambda_0[1-F(R_M^0(i))])\mathcal{M}^0(i+1) & \text{if } 1 \le i \le T_2 \\ \\ z + \lambda_0 \int\limits_{R_U^0}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_U^0)])\mathcal{U}^0 & \text{if } i = T_2 + 1 \end{cases}$$

for human capital level 0, and

[14] Individuals who are on IA in the 12th month and find a job starting in the 13th month are eligible for the bonus. Thus, $\mathcal{M}(1)$ is appropriate for the continuation value in the 11th month. This specification does not allow for the fact that individuals must only be on IA for 11 of the 12 months and, therefore, could have "test driven" a job for one month "for free."

$$(1+r)\mathcal{M}^1(i) = \begin{cases} z + (1-P_d)[\lambda_0 \int\limits_{R_M^1(i)}^{\bar{w}} \mathcal{V}^1(w,1)dF(w) + (1-\lambda_0[1-F(R_M^1(i))])\mathcal{M}^1(i+1)] \\ +P_d[\lambda_0 \int\limits_{R_M^0(i)}^{\bar{w}} \mathcal{V}^0(w,1)dF(w) + (1-\lambda_0[1-F(R_M^0(i))])\mathcal{M}^0(i+1)] & \text{if } 1 \le i \le T_2 \\ \\ z + (1-P_d)[\lambda_0 \int\limits_{R_U^1}^{\bar{w}} \mathcal{W}^1(w)dF(w) + (1-\lambda_0[1-F(R_U^1)])\mathcal{U}^1] \\ +P_d[\lambda_0 \int\limits_{R_U^0}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_U^0)])\mathcal{U}^0] & \text{if } i = T_2+1 \end{cases}$$

for human capital level 1.[15]

The Phase Two reservation wage solution is such that

$$\mathcal{V}^j(R_M^j(i),1) \quad = \quad \mathcal{M}^j(i+1) \text{ if } 1 \le i \le T_2.$$

Again, since $\mathcal{V}^j(w,1) > \mathcal{W}^j(w)$, it is clear that $\mathcal{M}^j(1) > \mathcal{U}^j$ and $\mathcal{M}^j(i+1) < \mathcal{M}^j(i)$. That is, the value of being in the eligible state declines as the eligibility period expires. Since $\mathcal{V}^j(w,1)$ is increasing in w, $R_M^j(i) > R_M^j(i+1)$, such that the reservation wage declines as the end of the eligibility period approaches. In the last month to find a job to qualify for the bonus, the reservation wage is below the control group's reservation wage (i.e. $R_M^j(T_2-1) < R_U^j$) because $\mathcal{M}^j(T_2) = \mathcal{U}^j$ and $\mathcal{V}^j(w,1) > \mathcal{W}^j(w)$. In addition, after one obtains eligibility the reservation wage drops. That is, $R_M^j(1) < R_N^j(T_2-1)$, because $\mathcal{V}^j(w,1) > \mathcal{W}^j(w)$ and $\mathcal{M}^j(2) < \mathcal{M}^j(1)$.

Once a program group member has qualified for the bonus, she has $T_3 = 36$ months of bonus entitlement during which she can receive the bonus if she has a full-time job. During this part of the program (Phase Three), the value functions for being on IA are given by

$$(1+r)\mathcal{Q}^0(i) = \begin{cases} z + \lambda_0 \int\limits_{R_Q^0(i)}^{\bar{w}} \mathcal{V}^0(w,i+1)dF(w) + (1-\lambda_0[1-F(R_Q^0(i))])\mathcal{Q}^0(i+1) & \text{if } 2 \le i \le T_3-1 \\ \\ z + \lambda_0 \int\limits_{R_U^0}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_U^0)])\mathcal{U}^0 & \text{if } i = T_3 \end{cases}$$

for human capital level 0, and by

[15]It is assumed that program group members must hold the job for a month within the 12 months in order to qualify. Thus if individuals find but do not start jobs in the 12th month, they will not qualify and thus will not receive the bonus in the next month when they start the job.

$$(1+r)\mathcal{Q}^1(i) = \begin{cases} z + (1-P_d)[\lambda_0 \int_{R_Q^1(i)}^{\bar{w}} \mathcal{V}^1(w,i+1)dF(w) + (1-\lambda_0[1-F(R_Q^1(i))])\mathcal{Q}^1(i+1)] \\ +P_d[\lambda_0 \int_{R_Q^0(i)}^{\bar{w}} \mathcal{V}^0(w,i+1)dF(w) + (1-\lambda_0[1-F(R_Q^0(i))])\mathcal{Q}^0(i+1)] & \text{if } 2 \le i \le T_3 - 1 \\ \\ z + (1-P_d)[\lambda_0 \int_{R_U^1}^{\bar{w}} \mathcal{W}^1(w)dF(w) + (1-\lambda_0[1-F(R_U^1)])\mathcal{U}^1] \\ +P_d[\lambda_0 \int_{R_U^0}^{\bar{w}} \mathcal{W}^0(w)dF(w) + (1-\lambda_0[1-F(R_U^0)])\mathcal{U}^0] & \text{if } i = T_3 \end{cases}$$

for human capital level 1. A program member cannot be in the state $\mathcal{Q}$ unless she has already had a job for one month; hence *i* starts at period 2.

The Phase Three reservation wage solution is given by

$$\mathcal{V}^j(R_Q^j(i), i+1) \quad = \quad \mathcal{Q}^j(i+1) \text{ if } 2 \le i \le T_3 - 1.$$

Note that in the final period the reservation wage is equal to the control group's reservation wage, as the individual once again faces the control group's problem. Because $\mathcal{Q}^j(T_3) = \mathcal{U}^j$ and $\mathcal{V}^j(w, T_3) > \mathcal{W}^j(w)$ due to the bonus payment, $R_Q^j(T_3 - 1) < R_U^j$. That is, in the last period in which they can still receive the bonus if they find a job, program group members have a lower reservation wage than the control group. While it is possible to determine that $R_Q^j(T_3 - 2) > R_Q^j(T_3 - 1)$, and therefore that the reservation wage is not constant during the entitlement period, it is possible that the reservation wage follows a non-monotonic path. As the bonus entitlement period progresses, both $\mathcal{V}^j$ and $\mathcal{Q}^j$ decline. Whichever declines more determines whether the reservation wage decreases or increases in order to equalize them. Some simulations have shown the reservation wage first increasing, and then decreasing, rather than the more intuitive "always decreasing" pattern.[16] In what follows, we allow for the possibility that program group members might quit their jobs during the entitlement period and return to IA to look for a better job. This is particularly likely at the start of the bonus period, when an individual may take a job in order to qualify for the bonus and then leave it in order to find a better one by searching from IA. Given the lower reservation wage at the end of the bonus entitlement period, it is also likely that once the entitlement ends, individuals will leave lower-paying jobs (with wages below the reservation wage of the control group) and return to IA.

While employed, the amount of the bonus received is equal to half the difference between an earnings benchmark, *b*, set by the program and the wage earned by the program member.[17] The value function for the full-time employed program group member receiving the bonus in

[16]This result differs from the constant reservation wage result in Card and Hyslop's (2005) search framework, which is due to their assumption that λ_0 and λ_1 are equal. With this equality, the declines in $\mathcal{V}^j$ and $\mathcal{Q}^j$ are the same, so the reservation wage is constant. Empirical estimates of search models almost invariably report significantly different arrival rates in employment and unemployment states. Since we estimate the search model, we prefer to allow for different arrival rates.

[17]The model is written in real terms and *b* is assumed to be constant. In the program, the earnings benchmark was set in nominal terms, but was slightly adjusted over the period of the program from an annual value of $37,500 during 1994 to $37,625 in 1996 to reflect changes in the cost of living and the generosity of IA. The model reflects the adjustment due to cost-of-living changes but abstracts from any adjustment due to changes in the generosity of IA.

the first T_3-1 months with human capital level 0 is given by[18]

$$
(1+r)\mathcal{V}^0(w,i) = \begin{cases}
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{V}^0(w',i+1)dF(w') + \delta \mathcal{Q}^0(i+1) & \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{V}^0(w,i+1)] & \\
+P_u[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{V}^1(w',i+1)dF(w') + \delta \mathcal{Q}^1(i+1) & \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{V}^1(w,i+1)] & \text{if } 1 \le i \le T_3-1 \text{ and} \\
& w \ge \max\{R^1_{\mathcal{Q}}(i), R^0_{\mathcal{Q}}(i)\} \\
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{V}^0(w',i+1)dF(w') + \delta \mathcal{Q}^0(i+1) & \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{V}^0(w,i+1)] & \\
+P_u[\lambda_1 \int\limits_{R^1_{\mathcal{Q}}(i)}^{\bar{w}} \mathcal{V}^1(w',i+1)dF(w') + \delta \mathcal{Q}^1(i+1) & \\
+(1-\delta-\lambda_1[1-F(R^1_{\mathcal{Q}}(i+1))])\mathcal{Q}^1(i+1)] & \text{if } 1 \le i \le T_3-1 \text{ and} \\
& R^0_{\mathcal{Q}}(i) \le w < R^1_{\mathcal{Q}}(i) \\
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{R^0_{\mathcal{Q}}(i)}^{\bar{w}} \mathcal{V}^0(w',i+1)dF(w') + \delta \mathcal{Q}^0(i+1) & \\
+(1-\delta-\lambda_1[1-F(R^0_{\mathcal{Q}}(i))])\mathcal{Q}^0(i+1)] & \\
+P_u[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{V}^1(w',i+1)dF(w') + \delta \mathcal{Q}^1(i+1) & \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{V}^1(w,i+1)] & \text{if } 1 \le i \le T_3-1 \text{ and} \\
& R^1_{\mathcal{Q}}(i) \le w < R^0_{\mathcal{Q}}(i) \\
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{R^0_{\mathcal{Q}}(i)}^{\bar{w}} \mathcal{V}^0(w',i+1)dF(w') + \delta \mathcal{Q}^0(i+1) & \\
+(1-\delta-\lambda_1[1-F(R^0_{\mathcal{Q}}(i))])\mathcal{Q}^0(i+1)] & \\
+P_u[\lambda_1 \int\limits_{R^1_{\mathcal{Q}}(i)}^{\bar{w}} \mathcal{V}^1(w',i+1)dF(w') + \delta \mathcal{Q}^1(i+1) & \\
+(1-\delta-\lambda_1[1-F(R^1_{\mathcal{Q}}(i+1))])\mathcal{Q}^1(i+1)] & \text{if } 1 \le i \le T_3-1 \text{ and} \\
& w < \min\{R^0_{\mathcal{Q}}(i), R^1_{\mathcal{Q}}(i)\}
\end{cases}
$$

where if the ordering of the reservation wages is known, at least one of these cases is ruled out. For month $T_3 = 36$, the value function for human capital level 0 is given by

[18]In practice, the SSP program and our simulation of the program sets bonus payments to zero for individuals earning more than *b* during any period. For expositional purposes only, this restriction is not reflected in the following value functions.

$$
(1+r)\mathcal{V}^0(w,T_3) = \begin{cases}
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{W}^0(w')dF(w') + \delta\mathcal{U}^0 \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{W}^0(w)] \\
+P_u[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{W}^1(w)] & \text{if } w \geq \max\{R_U^0, R_U^1\} \\
\\
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{W}^0(w')dF(w') + \delta\mathcal{U}^0 \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{W}^0(w)] \\
+P_u[\lambda_1 \int\limits_{R_U^1}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 \\
+(1-\delta-\lambda_1[1-F(R_U^1)])\mathcal{U}^1] & \text{if } R_U^0 \leq w < R_U^1 \\
\\
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{R_U^0}^{\bar{w}} \mathcal{W}^0(w')dF(w') + \delta\mathcal{U}^0 \\
+(1-\delta-\lambda_1[1-F(R_U^0)])\mathcal{U}^0] \\
+P_u[\lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{W}^1(w)] & \text{if } R_U^1 \leq w < R_U^0 \\
\\
w + \frac{b-w}{2} + (1-P_u)[\lambda_1 \int\limits_{R_U^0}^{\bar{w}} \mathcal{W}^0(w')dF(w') + \delta\mathcal{U}^0 \\
+(1-\delta-\lambda_1[1-F(R_U^0)])\mathcal{U}^0] \\
+P_u[\lambda_1 \int\limits_{R_U^1}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 \\
+(1-\delta-\lambda_1[1-F(R_U^1)])\mathcal{U}^1] & \text{if } w < \min\{R_U^0, R_U^1\}
\end{cases}
$$

Lastly, the value functions for those earning the bonus with human capital level 1 are given by

$$
(1+r)\mathcal{V}^1(w,i) = \begin{cases}
w + \varepsilon + \frac{b-w-\varepsilon}{2} + \lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{V}^1(w', i+1)dF(w') + \delta\mathcal{Q}^1(i+1) \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{V}^1(w, i+1) & \text{if } 1 \leq i \leq T_3 - 1 \text{ and} \\
& w \geq R_{\mathcal{Q}}^1(i) \\
\\
w + \varepsilon + \frac{b-w-\varepsilon}{2} + \lambda_1 \int\limits_{R_{\mathcal{Q}}^1(i)}^{\bar{w}} \mathcal{V}^1(w', i+1)dF(w') + \delta\mathcal{Q}^1(i+1) \\
+(1-\delta-\lambda_1[1-F(R_{\mathcal{Q}}^1(i))])\mathcal{Q}^1(i+1) & \text{if } 1 \leq i \leq T_3 - 1 \text{ and} \\
& w < R_{\mathcal{Q}}^1(i) \\
\\
w + \varepsilon + \frac{b-w-\varepsilon}{2} + \lambda_1 \int\limits_{w}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 \\
+(1-\delta-\lambda_1[1-F(w)])\mathcal{W}^1(w) & \text{if } i = T_3 \text{ and } w \geq R_U^1 \\
\\
w + \varepsilon + \frac{b-w-\varepsilon}{2} + \lambda_1 \int\limits_{R_U^1}^{\bar{w}} \mathcal{W}^1(w')dF(w') + \delta\mathcal{U}^1 \\
+(1-\delta-\lambda_1[1-F(R_U^1)])\mathcal{U}^1 & \text{if } i = T_3 \text{ and } w < R_U^1.
\end{cases}
$$

At the end of the entitlement period the problem for the program group becomes the same as that of the control group. The solution to that problem can be solved independently of the program group; hence it is straightforward to solve backwards for the sequence of program group reservation wages. In this case one does not need to guess a form for the value function and then iterate, because if one works backwards starting from the last period, all value functions are known. That is, $R_Q^0(T_3-1)$ and $R_Q^1(T_3-1)$ are functions of the control group value functions, as are $\mathcal{V}^1(w,\mathrm{T}_3), \mathcal{V}^0(w,\mathrm{T}_3), \mathcal{Q}^1(\mathrm{T}_3)$ and $\mathcal{Q}^0(\mathrm{T}_3)$. In turn, the reservation wages and value functions in period T_3-1 are functions of those for period T_3, and so on.

SUMMARIZING BEHAVIOUR OVER THE THREE PHASES OF SSP

The reservation wage path indicates that the structure of the program results in three distinct phases for the program group. Phase One is the phase covered by the requirement that the individual remain on IA for T_1 months. The reservation wage increases monotonically over this phase. Job offers towards the end of the phase have to be particularly attractive to compensate the individual for giving up the prospect of the program wage bonus. Once the requirement to be on IA for T_1 months has been satisfied, the individual moves into Phase Two, in which a full-time job has to be found within T_2 months. On entering this phase, the reservation wage drops relative to its value at the end of Phase One. Since the wage bonus can be received only if the individual has a full-time job, the reservation wage declines monotonically throughout the phase and ends at a level below that of the control group. The incentive to find a job in this phase is clearly strong, since the generous payoff in the form of the wage bonus will be foregone if a full-time job is not found. Finally, if a full-time job is found within T_2 months, the individual enters Phase Three. This phase, which can last up to T_3 months, is the payoff period. When job arrival rates are higher in IA, as most of the empirical search literature suggests (including our own estimates), the job-search incentives in Phase Three are complicated. On the one hand, taking a job early increases the payoff period for the receipt of the wage bonus; on the other hand, waiting to find a job with a higher wage could result in higher overall earnings. On entering Phase Three, the individual's reservation wage may increase relative to the end of Phase Two, since eligibility for the bonus has now been achieved and there are 36 months to take advantage of the bonus payments. The path of the program group's reservation wage is not monotonic over this phase, but must drop below and then end at a level equal to that of the control group by the end of the period. This means that some individuals will quit their jobs and return to IA when Phase Three ends.

Behaviour in the three phases of the SSP experiment is determined by the SSP policy parameters that characterize each phase. For Phase One, the policy parameter is the specified length of time (T_1 months) that the individual must remain on IA. The policy parameter for Phase Two is the specified length of time (T_2 months) within which a full-time job has to be found. Finally, the parameters for Phase Three are the specified bonus eligibility period (T_3 months) and the generosity in the form of the annual earnings benchmark of $37,500 (in monthly terms, b = $3,125). In Section 5, a variety of policy simulations are reported for alternative values of these policy parameters.[19] The model indicates that the full-time employment gains of the experiment can be achieved with a much lower bonus benchmark than $37,500.

[19]Another policy parameter that we do not explore is the number of hours (30) that constitutes a full-time job.

3. Data — The Applicant Sample

The data used in this paper come from the SSP Applicant study. The Applicant study is one of three studies in the Self-Sufficiency Project (SSP). It was initially undertaken to address concerns that a bonus support program requiring applicants to be on income assistance (IA) for a year before becoming eligible for the bonus could result in some individuals staying on IA longer than they otherwise would have, in order to qualify for the bonus. Its subsequent focus was on providing the appropriate sample to assess the effects of an ongoing program providing special incentives for individuals to find full-time jobs after they have been on IA for at least one year (i.e. once the initial stock of long-term IA recipients had worked its way through the program). This constitutes the relevant group for the analysis conducted in this paper.

SAMPLE RECRUITMENT AND INTERVIEWS

The sample for the Applicant study was recruited from adult single parents applying for IA between February 1994 and March 1995. Statistics Canada, using IA administrative records, identified all adult single parents (19 years of age or older) in selected geographic areas of British Columbia, who applied for and received IA and who had not received an IA payment in the preceding six months. Statistics Canada and the BC Ministry of Human Resources then contacted a random sample from these applicants by mail and invited them to participate in a study of "options for people on income assistance." They were also told that about 50 per cent of those agreeing to participate would be assigned into a program group that could become eligible to receive a cash supplement in addition to their earnings. About 80 per cent agreed and were interviewed in a baseline survey that collected information about their personal characteristics. Random assignment was then used to divide those who completed the baseline survey into a program group (1,648 members) and a control group (1,667 members).

Following random assignment, a letter and a brochure from the Social Research and Demonstration Corporation (SRDC) were sent to members of the program group, informing them that if they stayed on IA for a full year they would become eligible for the SSP earnings supplement.[20] A reminder letter was sent six or seven months later. A 12-month follow-up survey was administered by Statistics Canada, and those who satisfied the SSP eligibility requirement were informed that they had done so by mail in the 12th or 13th month after receiving their first IA payment. Over 90 per cent of those who satisfied the eligibility requirements subsequently attended an information session that described the details of the program.

Further interview surveys were undertaken approximately 30, 48, and 72 months after random assignment. By the time of the 72-month interview, attrition reduced the sample sizes to 1,168 for the program group and 1,185 for the control group, representing 72 per cent of

[20]Eligibility required the individual to have received IA for 11 of the 12 months following the initial month of IA receipt (i.e. 12 out of a total of 13 months on IA).

the original sample. The control and program groups had very similar characteristics, as is expected from random assignment. The sample was also almost entirely female. The program and control groups had almost identical work and IA histories. The groups were also very similar in most demographic characteristics, although the program group showed a marginally higher level of education and a significantly lower percentage of the program group had never been married.[21]

ESTIMATION SAMPLE

Only data from the control group are used in estimation of the model. All survey data are translated into monthly spell data divided into full-time work or IA receipt. A spell is coded as full-time work if the individual reported working more than 30 hours a week at any point during the spell and the period of work lasted at least four weeks. In order to focus on active labour market participants, we limited our sample to those who found a full-time job at some point over the 72-month survey period (dropping about 20 per cent of the sample). We eliminated from our sample any individuals who reported a full-time job at the baseline interview date, when all persons should be on IA. Our final estimation sample of control group members consists of 770 persons. We followed these individuals across all surveys until a break occurred in their job history. Unfortunately, we can only construct complete job histories for a few individuals continuously (all the way through the 72 month survey), due to missing or inconsistent starting and stopping dates for employment spells, but we are able to use data on most individuals for a number of years.

Because the wage data appear to be quite noisy, we impose a modest amount of trimming by eliminating wage observations that appear to be outliers. In particular, for full-time employment, total monthly wages were required to be between \$360 and \$4,800. For a 30-hour workweek, these income cut-offs correspond to \$3 and \$40 hourly wages. This eliminates only a small percentage of the wage observations. Even if no wage information is available for a job spell, we still utilize the employment duration data.

[21]See Table 1.1 of Ford, Gyarmati, Foley, and Tattrie (2003, p. 9) for a more detailed description of the sample characteristics.

4. Estimation of the Model

The model was estimated by maximum likelihood, using monthly data from the control sample just described.[22] We do not estimate the monthly interest rate, r, given standard difficulties in identifying this parameter. Our estimates assume that $r = 0.01$. This is purposely high, since we expect that our sample of low-income single women face relatively high interest rates in borrowing. We estimate the value z associated with income assistance (IA) rather than impose it at the average IA payment. We do this because our IA state also includes part-time work and those on employment insurance. Furthermore, z should reflect any cost savings from reduced child care needs or any stigma associated with receiving IA or Employment Insurance (EI). In estimation, we constrain z to be non-negative as we discuss further below. We must also specify a functional form for the wage offer distribution, $F(w)$. Our estimation assumes that wage offers are drawn from a log normal distribution with mean and variance parameters μ_ω and σ^2_ω.[23] Finally, we allow for additive measurement error, so that the observed wage is assumed to equal the true wage (w or $w + \varepsilon$) plus error, where the error is i.i.d. normal with mean zero and standard error σ_ω. Our data are quite noisy, so accounting for measurement error is important. Our estimates imply that the standard deviation of measurement error for monthly earnings is \$425 as compared with approximately \$1,100 in the wage offer distribution.

The parameter estimates are presented in Table 1. All values are given in monthly terms. The upper half of the table reports the usual search model parameters: arrival rates on and off the job, λ_1 and λ_0, the job destruction rate, δ, the value of non-market time, z, and the mean and variance of the true log wage offer distribution, μ_ω and σ_ω, together with the variance of the measurement error for the observed wages, σ_υ.[24] The estimated arrival rates show the usual result: that the job offer arrival rate on the job is lower than the job offer arrival rate while on IA. They also show that job arrival rates in general for this group are not very high. On average, it takes an individual more than 17 months to receive a job offer while on IA. The estimate of δ is very small (0.006), so the jobs that are acquired are very long-lasting.

The value of non-market time is constrained to be non-negative, but the estimate goes to zero. Left unconstrained, a sizeable negative value is estimated. While a negative estimate is not uncommon in the empirical search literature, we are not particularly comfortable with the estimate, since its standard error is orders of magnitude larger than the estimated value. The likelihood value improves only trivially when allowing z to go negative (compared with its value when $z = 0$), while the likelihood becomes considerably worse if z is forced to equal the benefit levels distributed on IA.[25] In practice, it is difficult to identify z in our data once it drops below a few hundred dollars, but it seems likely that z is far below the typical payment

[22]Details of the estimation and likelihood function are given in the Appendix.

[23]In practice, we truncate the wage distribution from below at $\underline{w} = 10$ and above at $\overline{w} = 6{,}000$. These boundaries are well outside the range of observed wage observations in our sample of controls.

[24]Note that μ_w and σ_w are estimated parameters of the log wage offer distribution, while σ_u is the standard deviation of the measurement error in wages rather than log wages.

[25]Unconstrained estimates of z fall below -600, producing a log likelihood of about -18,038. The likelihood value for $z = 0$ is worse by only about 10, while the likelihood value for $z = 927$ is worse by more than 100. Using the unconstrained estimates produces qualitatively similar policy simulations to those described in Section 6, although the effects are muted.

provided by IA. One of the difficulties in estimating z undoubtedly comes from the high degree of measurement error in our data, as reflected in $\sigma_u = 425$. Because of the substantial measurement error, it is difficult to precisely locate the reservation wage, which makes it difficult to pin down z. Our estimates (with $z = 0$) imply reservation wages of $R_U^0 = 897$ and $R_U^1 = 893$, indicating that more skilled workers are willing to accept slightly lower quality jobs than unskilled workers.[26]

Table 1: Estimated Parameter Values

Parameter	Estimated Value	Standard Error*
Search behaviour parameters		
λ_0	0.05751	0.00004
λ_1	0.01026	0.00000
δ	0.00629	0.00000
z	0	—
μ_w	7.01133	0.00608
σ_w	0.051718	0.00096
σ_u	425.04	26.01
Human capital parameters		
ε	188.25	623.93
P_d	1	—
P_u	1	—

Note: *The computation of these standard errors imposed a fixed value of zero for z; fixed values equal to their estimated values (of approximately one) were also imposed for P_d and P_u.

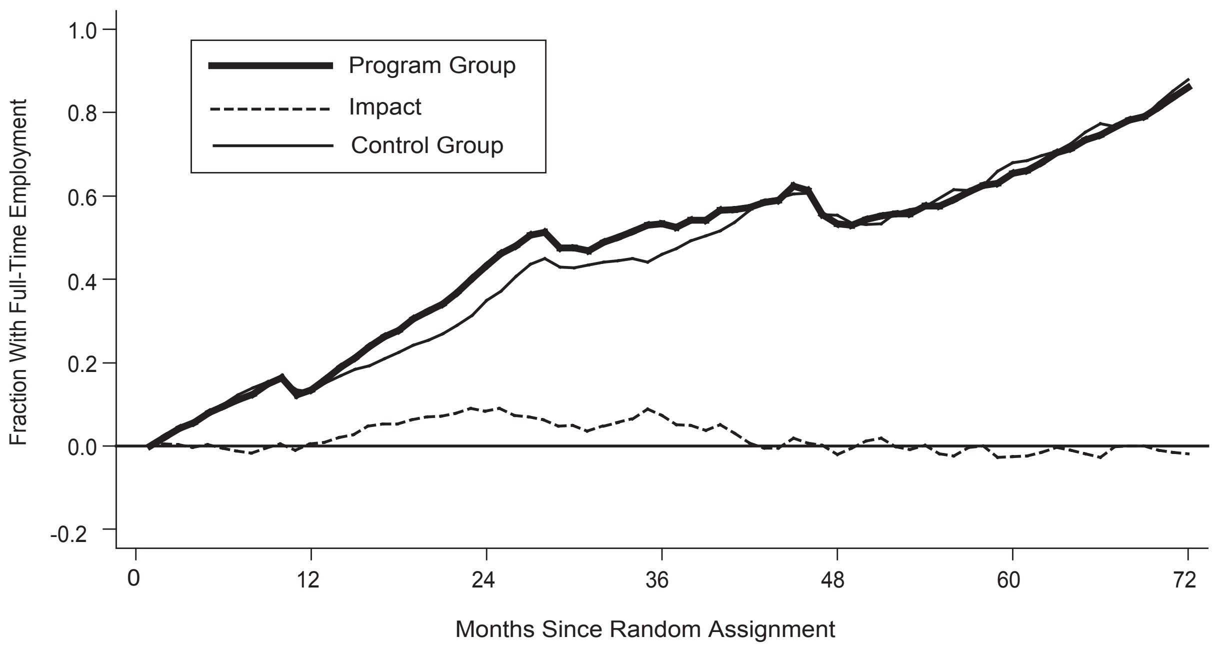
The lower half of the table reports the estimated human capital parameters. There appears to be a modest role for human capital. The point estimate for the additional payment for those with human capital level 1 is a little under $200 per month, but there is a large standard error, so a value of zero cannot be rejected. The stochastic "learning by doing" and depreciation probabilities are both very close to 1. These values are consistent with most individuals entering jobs with a short probationary period before receiving the full wage. Re-entering employment after a spell on IA appears to almost always require this probationary period to reach human capital level 1. These estimates should be viewed with caution, however, since the model specification for the possible role of human capital is highly simplified. An alternative specification may uncover a clearer and more interesting role for human capital.

[26]However, the lowest total wage earnings (including the skill reward) for a skilled worker is $R_U^1 + \varepsilon$, which is greater than R_U^0.

5. Earnings and Full-Time Employment

Figure 1 shows the fractions of the control and program groups that were in full-time employment over the period of 72 months since random assignment. Due to our sampling restrictions (in particular, the fact that we only utilize data from the baseline survey until we observe a break in the employment / income assistance data), there are very few observations beyond 60 months. The full-time employment rates after Month 60 should be read with this in mind. Figure 2 shows the predicted employment rates based on the parameter estimates reported in Table 1. Figures 1 and 2 both show similar patterns for the control and program groups.[27] In particular, a comparison of the control and program groups shows that the Self-Sufficiency Project (SSP) incentives reduced employment over the first 12 months and increased employment for the next three years of bonus receipt. The estimated model (Figure 2) suggests that once the bonus payments run out (four to five years after initial enrolment), employment rates drop slightly among the program group, while the actual data (Figure 1) shows little difference between the program and control groups beyond the four-year mark.

Figure 1: Observed Data



[27]The most obvious difference between the two figures is the continued increase in full-time employment rates beyond 60 months in Figure 1 as compared with the convergence in employment rates in Figure 2. Given the paucity of actual data beyond 60 months, this does not raise much concern.

Figure 2: Simulated Results Using SSP Policy Parameters

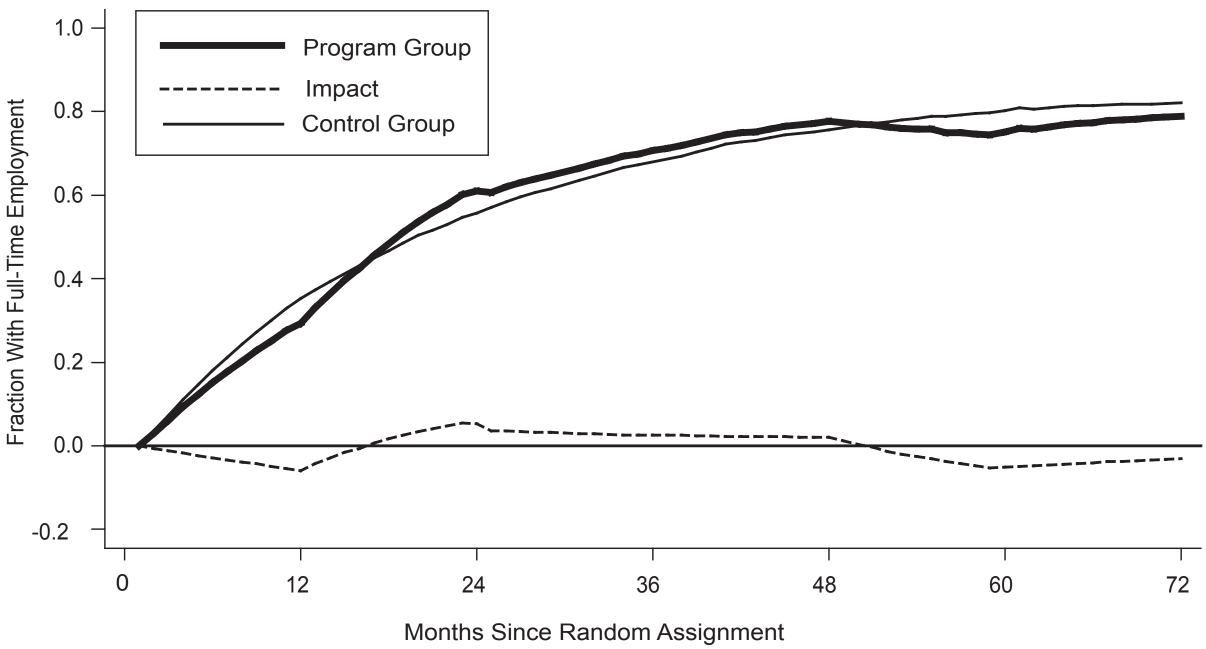


Table 2 presents the earnings differences for those employed full time in the program and control groups (as observed in the data) and compares them with the predictions from the model. We focus on months 30, 48, and 72, months when we are most likely to observe an actual wage measure for individuals in the data. Recall that the model is estimated using data from control group members only, yet the comparison of observed wage data with predicted wages from the model matches quite well in months 30, 48, and 72 for both the control and program groups. It is worth noting, however, that the model tends to under-predict the amount of wage growth when compared with the actual data, which suggests that a richer human capital specification is needed.

Table 2: Average Real Wage and Bonus Income at 30, 48, and 72 Months for Those Employed Full Time

30 Months				48 Months				72 Months			
Program			Control	Program			Control	Program			Control
Wage	Bonus	Total	Total	Wage	Bonus	Total	Total	Wage	Bonus	Total	Total
Observed Data											
1,526.02	615.52	2,141.54	1,809.03	1,584.10	555.99	2,140.09	1,939.71	1,936.13	66.80	2,002.92	2,052.15
Predicted From the Model With the Actual Program Parameters											
1,692.46	407.02	2,099.48	1,781.06	1,733.61	324.02	2,057.63	1,798.53	1,862.44	0	1,862.44	1,829.31

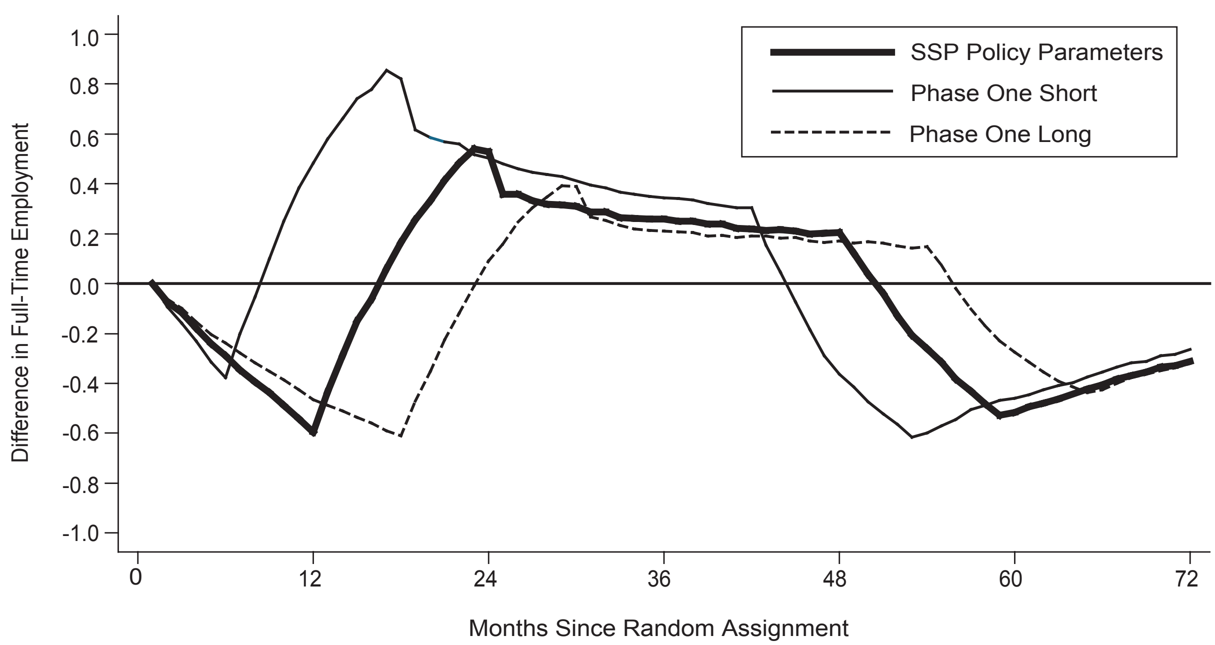
6. Policy Simulations

In this section, the estimates from Section 4 are used to compute simulations for alternative values of the policy parameters governing the three phases of the Self-Sufficiency Project (SSP).

PHASE ONE SIMULATIONS

The Phase One policy parameter is the specified length of time the individual is required to stay on income assistance (IA). The actual policy parameter for the SSP experiment was set at 12 months. Simulations were undertaken for longer and shorter specified times: *Phase One Long*: minimum 18 months on IA, and *Phase One Short*: minimum 6 months on IA. The sensitivity of the fraction with full-time employment to variations in the Phase One length is illustrated in Figure 3.

Figure 3: Phase One Length Experiments



The simulations show that, not surprisingly, shortening Phase One causes the increase in full-time employment associated with phases Two and Three to occur earlier. The general patterns for employment impacts over time, however, are all quite similar. The implications for average total earnings (including bonus payments to those qualifying for SSP payments) associated with full-time work are modest, as shown in Table 3. A shorter Phase One (relative to the actual SSP 12 month period) tends to raise average total earnings at Month 30 by nearly $60 but lowers earnings by $120 in Month 48 and $26 as of Month 72 (when bonus payments have ceased). Shortening Phase One causes individuals to raise their initial reservation wages, as qualification for bonus payments is made easier. Along with the SSP bonus payments, a shorter Phase One period leads to higher average earnings early on. But the fact that more individuals qualify for the bonus means that more individuals accept very low-wage jobs during phases Two and Three in order to receive bonus payments. As such, earnings are lower at Month 48 and Month 72. While reducing the Phase One period tends to have fairly large effects on earnings, extending this period to 18 months has fairly modest effects on the average earnings of employed workers.

Table 3: Simulated Program Group Average Real Wage Plus Bonus Income at 30, 48, and 72 Months for Those Employed Full Time Under Alternative Policy Parameters

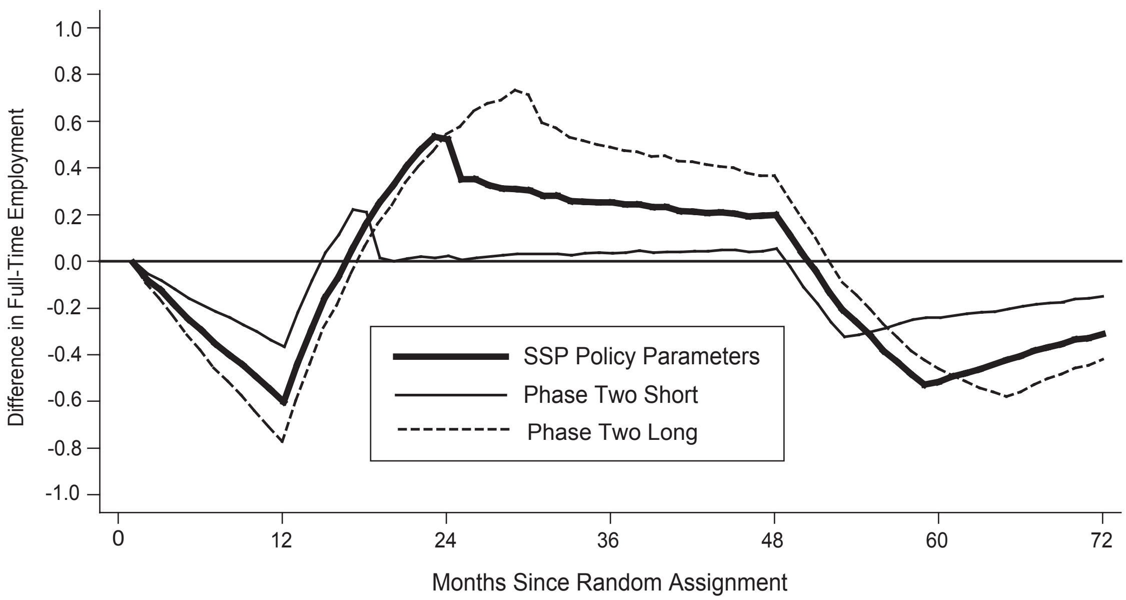
Simulated Policy	30 Months	48 Months	72 Months
Actual SSP Program Parameters	2,099	2,058	1,862
Phase One: Short (6 months)	2,141	1,938	1,846
Long (18 months)	2,075	2,031	1,867
Phase Two: Short (6 months)	1,965	1,941	1,845
Long (18 months)	2,188	2,137	1,868
Phase Three: Short (24 months)	2,080	1,835	1,853
Long (48 months)	2,120	2,074	1,870
Parsimonious ($30,000)	1,930	1,923	1,852
Parsimonious ($24,000)	1,815	1,832	1,845
Generous ($40,000)	2,161	2,108	1,866

PHASE TWO SIMULATIONS

Phase Two in the SSP experiment is characterized by the requirement that a full-time job be found within 12 months. Simulations were undertaken for longer and shorter specified times: *Phase Two Long*: find a job within the next 18 months, and *Phase Two Short*: find a job within the next 6 months. The sensitivity of full-time employment rates to these policy changes is shown in Figure 4.

The estimated job arrival rate while on IA (reported in Table 1) is only 0.058. The reservation wage at the beginning of Phase Two is at its lower bound ($\underline{w}$). Thus, individuals are willing to accept any job offer but are constrained by a relatively low job arrival rate. Lengthening Phase Two relaxes this constraint and allows more individuals to receive a job offer. Conversely, shortening the period makes it impossible for many individuals to find jobs even though they are willing to accept any offer. The implications for the earnings of the program group are shown in Table 3. Overall, Figure 4 and Table 3 suggest that making it easier to receive SSP payments by lengthening Phase Two would both increase IA receipt during the first 12 to 16 months after going on IA and substantially raise employment in the ensuing years. The employment gains tend to be delayed, given the larger initial drop during Phase One. Due to bonus payments, average earnings among full-time workers would increase substantially by Month 30, with the effects gradually fading over the next few years.

Figure 4: Phase Two Length Experiments

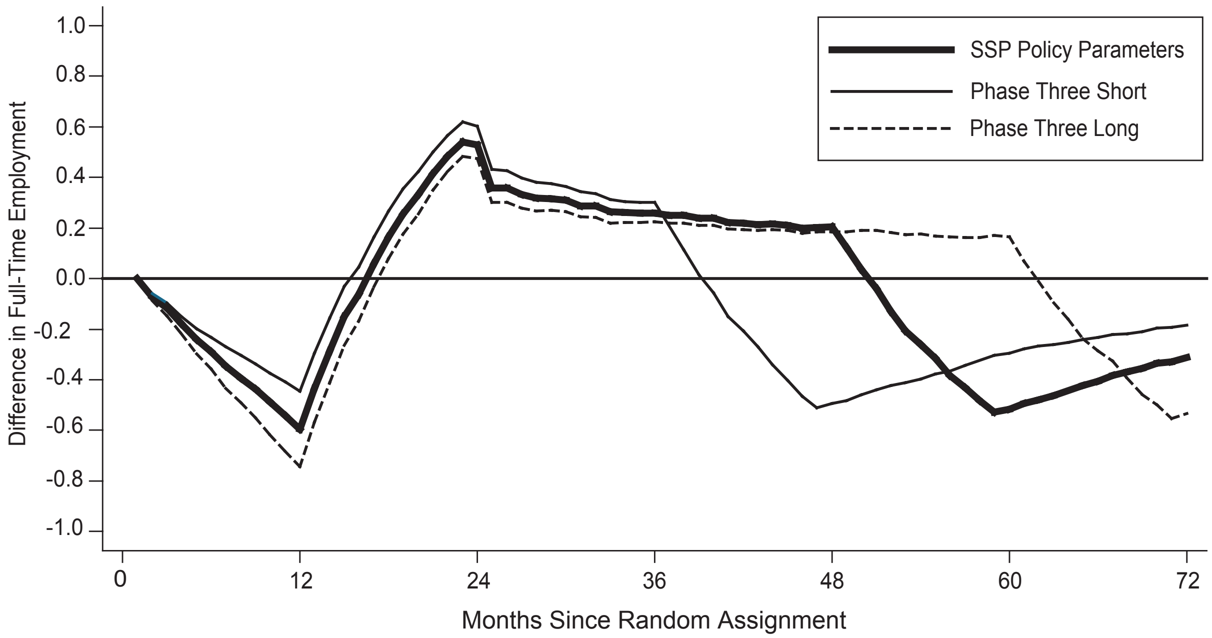


PHASE THREE SIMULATIONS

The receipt of the wage bonus occurs only in Phase Three. In the SSP experiment there is a maximum of 36 months during which the bonus can be received, and the generosity is based on an annual benchmark of $37,500 (in monthly terms, b = $3,125). Simulations were undertaken for longer and shorter specified potential bonus receipt periods: *Phase Three Long*: maximum 48 months bonus period, and *Phase Three Short*: maximum 24 months bonus period. Figure 5 shows the effect of changing the length of Phase Three.

A longer period for Phase Three increases the generosity of the program. This causes more individuals to stay on IA for the full 12 months in order to become eligible for payments. However, among those who become eligible to receive a wage bonus if they find full-time work, varying the length of Phase Three does not significantly affect job offer acceptance decisions — given the current SSP parameters, our estimates suggest that everyone is willing to accept any job and cannot lower their reservation wage any further. Not surprisingly, extending the length of Phase Three extends the period during which full-time employment rises for the program group. Effects on earnings (see Table 3) are fairly modest, except for the 48-month period when Phase Three is shortened to just 24 months. The substantial drop in earnings at 48 months is a direct response to when bonus payments are cut off. With the current SSP parameters, most individuals who have met the eligibility requirements can still receive bonus payments in Month 48. When Phase Three is shortened to 24 months, very few continue to receive bonus payments by Month 48. This offers a sense of the direct role played by the SSP bonus payments in augmenting income levels for full-time workers.

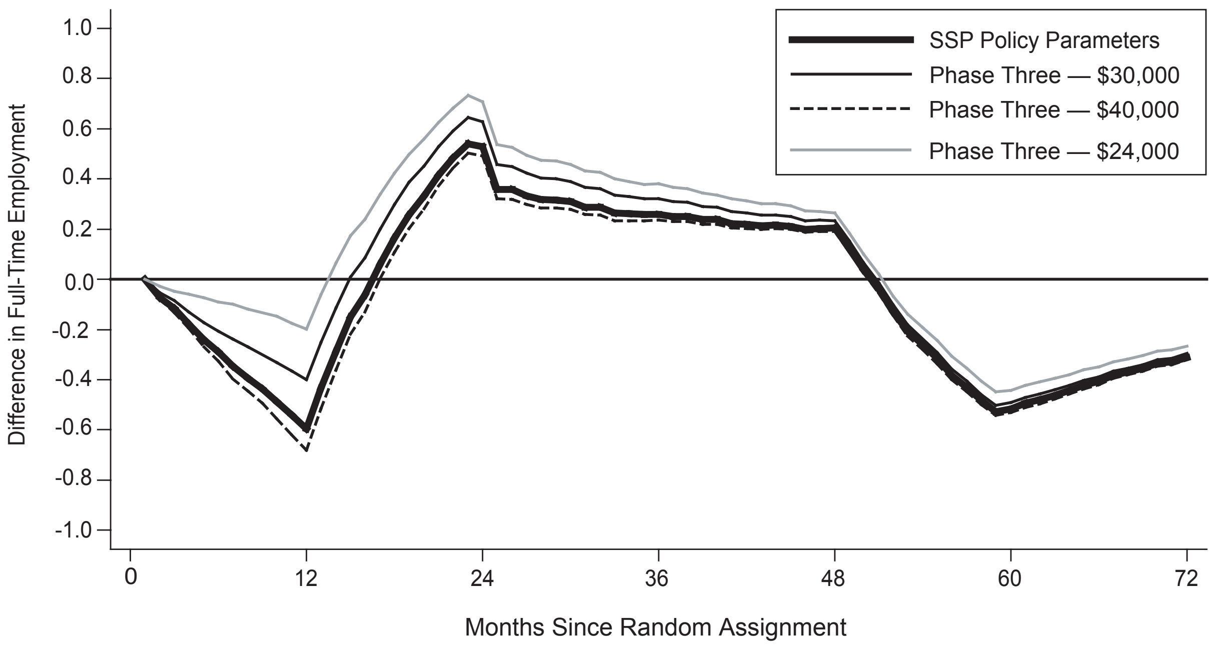
Figure 5: Phase Three Length Experiments



We also consider simulations for alternative levels of generosity of the bonus: *Phase Three Generous*: annual benchmark = $40,000, *Phase Three Parsimonious: $30,000*: annual benchmark = $30,000, and *Phase Three Parsimonious: $24,000*: annual benchmark = $24,000. The results of these simulations are probably the most transparent and are given in Figure 6 and the final three rows of Table 3. It is clear from Figure 6 that the generosity of the program could be greatly reduced while providing the same employment gains. A reduced level of generosity results in more individuals accepting jobs in the first 12 months instead of waiting to take advantage of the bonus. Even though the incentive to enter the program is reduced, once qualified, individuals continue to accept all jobs even for annual benchmarks as low as $24,000. Thus for all levels of bonus generosity we analyze, individuals are constrained in their employment behaviour by the job offer arrival rate rather than refusing offers that do arrive.[28] Not surprisingly, more generous bonus payments result in higher average total earnings for months 30 and 48. Once bonus payments have ended, average earnings are quite similar for all earnings benchmark levels.

[28]Of course, lowering the bonus payment substantially more would eventually cause eligible individuals to raise their reservation wage above the minimum such that they reject some offers.

Figure 6: Phase Three Bonus Experiments



7. Conclusions and Future Work

The Self-Sufficiency Project (SSP) experimental results showed that individuals who had been on income assistance (IA) for 12 months could still find full-time work. Giving them some incentive in the form of a wage bonus could affect how many of them do find full-time work. What the experimental results could not show was how the form of the incentive structure could affect the magnitude of the employment outcomes, since one particular form was chosen for the experiment and applied to all participants. In this paper, we have estimated a structural search model that includes human capital and provides a framework for assessing the sensitivity of the employment outcomes to the policy parameters. By simulating the outcomes for alternative incentive structures it is possible to provide evidence that is essential for efficient policy design. One feature of the SSP experiment that is emphasized by Ford et al. (2003) is that it set a high annual benchmark generosity level resulting in wage bonuses that approximately doubled wage incomes for full-time workers receiving them. Our simulations suggest that employment gains could be at least as high as occurred in the experiment if the benchmark was reduced from $37,500 to $24,000. Lowering the bonus payment tends to reduce the program's incentive to remain on IA for 12 months in order to qualify for the bonus, while it has little effect on incentives to accept all job offers once an individual has become eligible to receive the bonus.

The research reported in this paper shows that in the context of SSP it is possible to successfully estimate a search model that includes human capital and incorporates the relevant program parameters that affect participant behaviour, and that highly policy relevant simulation results can be produced. The results suggest clear benefits to exploring participant behaviour more deeply in order to shape policy in the most efficient way. The results in this paper are dependent on the particular specification adopted as the structural model and its estimated behavioural implications. An important next step is to establish greater confidence in these results by relaxing some of the simplifying assumptions adopted in this paper. One major avenue to be explored is the effect of allowing for endogenous job-search intensity. In particular, it is likely that the job-search intensity of program participants in Phase Two is higher than that suggested in this paper, which assumes that program participants search at the same intensity as the control group. Another important task is to examine behaviour at a more disaggregated level by explicitly incorporating observed heterogeneity in the form of education level and the presence of pre-school aged children. Finally, it would be fruitful to include data on the program group in estimation to improve efficiency and aid in identification of the model. With this future work, it will be possible to provide a clearer picture for the design of programs similar to SSP.

Appendix: Likelihood Function

This Appendix derives the likelihood function used in estimation. We first derive the likelihood in general terms and then specify conditional probabilities as derived from the theoretical model.

Let $H^j = (t_1, IA_1, W_1, h_1^b, t_2, IA_2, W_2, h_2^b, ..., t_j, IA_j, W_j, h_j^b)$ represent the history of all spell lengths t, spell types IA, wage observations (may be more than one for job spells or none when on IA), and beginning human capital levels h^b through spell j. Now, consider the probability of observing the sequence of spell lengths, spell types, and wages $(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J)$ given an initial human capital level, h_1^b and initial income assistance (IA) status, IA_1 (note that W_1 is absent since IA_1=1 for the entire SSP Applicant sample):

$$\begin{aligned} &Pr(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J | h_1^b, IA_1) \\ &= \sum_{h_2^b} \cdots \sum_{h_J^b} Pr(t_1, t_2, IA_2, W_2, h_2^b, t_3, IA_3, W_3, h_3^b, ..., t_J, IA_J, W_J, h_J^b | h_1^b, IA_1) \\ &= \sum_{h_2^b} \cdots \sum_{h_J^b} \prod_{j=2}^{J} Pr(t_j, IA_j, W_j, h_j^b | H^{j-1}) Pr(t_1, W_1 | IA_1, h_1^b). \end{aligned} \quad (1)$$

The first equality brings in the unobserved initial human capital levels from all spells 2, ..., J and "integrates" over them. (Below, we will also integrate over initial human capital, h_1^b.) The second simply uses the chain of conditional probabilities to represent the probability of all observed spell lengths and types.

Consider the conditional probabilities for spells 2, ..., J:

$$Pr(t_j, IA_j, W_j, h_j^b | H^{j-1}) = Pr(t_j, W_j | IA_j, h_j^b, IA_{j-1}, W_{j-1}) Pr(IA_j | h_j^b, IA_{j-1}, W_{j-1}) Pr(h_j^b | H^{j-1}). \quad (2)$$

This chain of conditional probabilities reflects the fact that histories prior to spell j - 1 do not affect the outcomes of spell j once the relevant j - 1 information is taken into account. Given the context of general human capital (i.e. no firm specific human capital losses upon job switches), $h_j^b = h_{j-1}^e$, where h_{j-1}^e is the human capital level at the very end of spell j - 1.[29] This probability is given by

$$Pr(h_j^b | H^{j-1}) = \left[\frac{Pr(t_{j-1}, W_{j-1} | h_{j-1}^e, IA_{j-1}, h_{j-1}^b, IA_{j-2}, W_{j-2})}{Pr(t_{j-1}, W_{j-1} | IA_{j-1}, h_{j-1}^b, IA_{j-2}, W_{j-2})} \right] Pr(h_{j-1}^e | IA_{j-1}, h_{j-1}^b)$$

where we use Bayes' Rule and the fact that spell histories prior to j - 2 are irrelevant after conditioning on appropriate information from periods j - 1 and j - 2. Incorporating this result into equation (2), we obtain

$$\begin{aligned} Pr(t_j, IA_j, W_j, h_j^b | H^{j-1}) \quad = \quad & Pr(t_j, W_j | IA_j, h_j^b, IA_{j-1}, W_{j-1}) Pr(IA_j | h_j^b, IA_{j-1}, W_{j-1}) \\ & \times \left[\frac{Pr(t_{j-1}, W_{j-1} | h_{j-1}^e, IA_{j-1}, h_{j-1}^b, IA_{j-2}, W_{j-2})}{Pr(t_{j-1}, W_{j-1} | IA_{j-1}, h_{j-1}^b, IA_{j-2}, W_{j-2})} \right] Pr(h_{j-1}^e | IA_{j-1}, h_{j-1}^b). \end{aligned}$$

[29]Note that h_j^b is the level of human capital that determines wages during the period, while h_j^e is the level of human capital at then end of the period taken into the state of the next period. h_j^e may differ from h_j^b, since human capital may change at the end of each period.

Substituting the above expression for all periods j = 2, ..., J into equation (1) gives[30]

$$\begin{aligned}
&Pr(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J | h_1^b, IA_1)\\
&= \sum_{h_2^b} \cdots \sum_{h_J^b} Pr(IA_2 | h_2^b, IA_1 = 1) Pr(t_1 | h_1^e, IA_1 = 1, h_1^b) Pr(h_1^e | IA_1 = 1, h_1^b)\\
&\times \left[\prod_{j=3}^{J} Pr(IA_j | h_j^b, IA_{j-1}, W_{j-1}) Pr(t_{j-1}, W_{j-1} | h_{j-1}^e, IA_{j-1}, h_{j-1}^b, IA_{j-2}, W_{j-2}) Pr(h_{j-1}^e | IA_{j-1}, h_{j-1}^b) \right]\\
&\times Pr(t_J, W_J | IA_J, h_J^b, IA_{J-1}, W_{J-1}). \qquad (3)
\end{aligned}$$

The initial terms of this equation reflect the fact that IA_1=1 for the entire SSP Applicant sample and the fact that the spell length for an IA spell does not depend on prior spell characteristics.

INCORPORATING MEASUREMENT ERROR

Now, suppose true wages for a subset of periods in job spell j are observed but measured with error. We observe $W_j = W_j^T + u_j$ for spell j, where W_j^T reflects the corresponding true wages that period and u_j represents the vector of i.i.d. measurement error terms. In this case, the likelihood becomes

$$\begin{aligned}
&\mathcal{L}(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J | h_1^b, IA_1)\\
&\quad = \int Pr(t_1, t_2, IA_2, W_2^T, W_2, t_3, IA_3, W_3^T, W_3, ..., t_J, IA_J, W_J^T, W_J | h_1^b, IA_1) dW^T, \qquad (4)
\end{aligned}$$

where

$$\begin{aligned}
&Pr(t_1, t_2, IA_2, W_2^T, W_2, t_3, IA_3, W_3^T, W_3, ..., t_J, IA_J, W_J^T, W_J | h_1^b, IA_1)\\
&= \sum_{h_2^b} \cdots \sum_{h_J^b} Pr(IA_2 | h_2^b, IA_1 = 1) Pr(t_1 | h_1^e, IA_1 = 1, h_1^b) Pr(h_1^e | IA_1 = 1, h_1^b)\\
&\times \left[\prod_{j=3}^{J} Pr(IA_j | h_j^b, IA_{j-1}, W_{j-1}^T) Pr(t_{j-1}, W_{j-1}^T, W_{j-1} | h_{j-1}^e, IA_{j-1}, h_{j-1}^b, IA_{j-2}, W_{j-2}^T) Pr(h_{j-1}^e | IA_{j-1}, h_{j-1}^b) \right]\\
&\times Pr(t_J, W_J^T, W_J | IA_J, h_J^b, IA_{J-1}, W_{J-1}^T). \qquad (5)
\end{aligned}$$

This is nearly identical to the probability defined in equation (3) after including W^T as well as W everywhere. Additionally, we must compute the joint probability of spell length, observed wages, and true wages for each spell instead of the joint probability of only spell length and observed wages — this simply involves bringing in the probability of measurement error as we show below. In our analysis, we assume that measurement error each period is normally distributed with mean zero and standard deviation σ_u, letting $\phi(\cdot)$ represent the standard normal pdf. Note that true wages and observed wages (and therefore measurement error) are irrelevant for IA spells.

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[30]Note that in obtaining this likelihood, the $\Pr(t_j, W_j | IA_j, h_j^b, IA_{j-1}, W_{j-1})$ terms cancel for all $j \neq J$ as these values are in the numerator for $\Pr(t_j, IA_j, W_j, h_j^b | H^{j-1})$ and the denominator for $\Pr(t_{j+1}, IA_{j+1}, W_{j+1}, h_{j+1}^b | H^j)$.

UNKNOWN INITIAL HUMAN CAPITAL LEVELS

We do not know h_1^b for anyone, but we know IA_1=1 for everyone in our SSP sample. We therefore assume that $\Pr(h_1^b = 1) = \pi$. Incorporating this into the likelihood with measurement error produces our estimated likelihood:

$$\begin{aligned} &\mathcal{L}(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J | IA_1 = 1) \\ = \quad &\pi\mathcal{L}(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J | h_1^b = 1, IA_1 = 1) \\ &+(1-\pi)\mathcal{L}(t_1, t_2, IA_2, W_2, t_3, IA_3, W_3, ..., t_J, IA_J, W_J | h_1^b = 0, IA_1 = 1). \end{aligned}$$

This π can be estimated along with other parameters of the model. On the other hand, we can derive π as a function of other model parameters if we assume our sample is drawn randomly from individuals newly on IA in a steady state environment.[31] Our estimates are based on the latter approach; however, the results are quite similar if π is estimated instead.

PROBABILITIES AS DETERMINED BY THE MODEL

We now specify the formulas for the conditional probabilities in equation (5) as derived from the theoretical model. In order to simplify the exposition, this appendix assumes that $R_U^1 \le R_U^0$, so that individuals never quit a job voluntarily. We do not impose this assumption in our estimation, although it does not appear to be violated for reasonable parameterizations of the model. An extended appendix that derives probabilities in the more general case (i.e. when R_U^1 may be greater than R_U^0) is available from the authors upon request.

Starting with the human capital transition probabilities, we have

$$Pr(h_j^e = 1 | IA_j, h_j^b) = \begin{cases} 0 & \text{if } IA_j = 1 \text{ and } h_j^b = 0 \\ (1-P_d)^{t_j} & \text{if } IA_j = 1 \text{ and } h_j^b = 1 \\ 1-(1-P_u)^{t_j} & \text{if } IA_j = 0 \text{ and } h_j^b = 0 \\ 1 & \text{if } IA_j = 0 \text{ and } h_j^b = 1 \end{cases}$$

and $\Pr(h_j^e = 0 | IA_j, h_j^b) = 1 - Pr(h_j^e = 1 | IA_j, h_j^b)$.

The transition probabilities across IA states are given by

$$Pr(IA_j = 1 | h_j^b, IA_{j-1}, W_{j-1}^T) = \begin{cases} \frac{\delta}{\delta + \lambda_1(1 - F(w_{j-1}^T))} & \text{if } IA_{j-1} = 0 \\ 0 & \text{if } IA_{j-1} = 1 \end{cases}$$

and $\Pr(IA_j = 0 | h_j^b, IA_{j-1}, W_{j-1}^T) = 1 - Pr(IA_j = 1 | h_j^b, IA_{j-1}, W_{j-1}^T)$.

---

[31]The parameter π can be determined by equating the flows into and out of IA for both human capital types and then calculating the fraction of those on IA who have human capital equal to 1. A bit of arithmetic yields

$$\pi = \frac{P_d + (1-P_d)\lambda_0(1-F(R_U^1))}{P_d + (1-P_d)\lambda_0(1-F(R_U^1)) + P_d\delta(\frac{1-P_u}{P_u})}$$

when $R_U^1 \le R_U^0$. If $R_U^1 > R_U^0$, this must be modified to incorporate the probability that an individual quits her job for IA when her human capital increases.

Finally, we can specify the probabilities for the durations and wages associated with all spells. The only censored spell is the last (*J*th) spell. Thus, we address censoring when we specify the formulas for the *J*th spell. The probabilities for the remaining *J* - 1 spells are conditional on both the beginning and ending human capital levels (see equation (5)). For IA_j=1 spells, there are only three possible beginning and ending human capital combinations: 0 at the beginning and end, 1 at the beginning and end, and 1 at the beginning and 0 at the end. Given these three possible combinations, the IA spell probabilities $\Pr(t_j, W_j \mid h_j^e, IA_j = 1, h_j^b, IA_{j-1}, W_{j-1})$ are given by

$$Pr(t_j, W_j^T, W_j|0,1,0,IA_{j-1},W_{j-1}^T) = (1-\lambda_0(1-F(R_U^0)))^{t_j-1}[\lambda_0(1-F(R_U^0))],$$

$$Pr(t_j, W_j^T, W_j|1,1,1,IA_{j-1},W_{j-1}^T) = (1-\lambda_0(1-F(R_U^1)))^{t_j-1}[\lambda_0(1-F(R_U^1))],$$

$$Pr(t_j, W_j^T, W_j|0,1,1,IA_{j-1},W_{j-1}^T) = \sum_{k=0}^{t_j-1} \frac{(1-P_d)^k P_d}{1-(1-P_d)^{t_j}}(1-\lambda_0(1-F(R_U^1)))^k$$
$$\times(1-\lambda_0(1-F(R_U^0)))^{t_j-1-k}\lambda_0(1-F(R_U^0)),$$

where in the last case we sum over all the possible periods in which the human capital could have declined. (Note that $IA_{j-1} = 0$ for all IA_j=1 spells and that W_{j-1}^T does not affect these probabilities.) W_j^T and W_j are irrelevant for those on IA, so these probabilities only reflect the probability of the spell length, t_j.

For job spells (IA_j=0), there are also three possible beginning and ending human capital combinations: 0 at the beginning and end, 1 at the beginning and end, and 0 at the beginning and 1 at the end. Because the true wage depends on current human capital, the discussion is simplified by combining the probability of job spell lengths and true wages with the measurement error part of the likelihood. When there are l_j wage observations for job spell *j* (where wage observation w_i is observed in period p_i),

$$Pr(t_j, W_j^T, W_j|0,0,0,IA_{j-1},W_{j-1}^T) = \left(\frac{1}{\sigma_u}\right)^{l_j}\left[\prod_{i=1}^{l_j}\phi\left(\frac{w_i - w_j^T}{\sigma_u}\right)\right]\left[\frac{f(w_j^T)}{1-F(R_U^0)}\right]^{IA_{j-1}}\left[\frac{f(w_j^T)}{1-F(w_{j-1}^T)}\right]^{1-IA_{j-1}}$$
$$\times(1-\lambda_1(1-F(w_j^T))-\delta)^{t_j-1}(\lambda_1(1-F(w_j^T))+\delta)$$

$$Pr(t_j, W_j^T, W_j|1,0,1,IA_{j-1},W_{j-1}^T) = \left(\frac{1}{\sigma_u}\right)^{l_j}\left[\prod_{i=1}^{l_j}\phi\left(\frac{w_i - \varepsilon - w_j^T}{\sigma_u}\right)\right]\left[\frac{f(w_j^T)}{1-F(R_U^1)}\right]^{IA_{j-1}}\left[\frac{f(w_j^T)}{1-F(w_{j-1}^T)}\right]^{1-IA_{j-1}}$$
$$\times(1-\lambda_1(1-F(w_j^T))-\delta)^{t_j-1}(\lambda_1(1-F(w_j^T))+\delta).$$

The probability of job spells with human capital changing are more complicated, since they require summing over all possible paths associated with each period in which human capital may have increased:

$$\begin{aligned} Pr(t_j, W_j^T, W_j|1,0,0,IA_{j-1},W_{j-1}^T) &= \sum_{k=0}^{t_j-1}\left(\frac{1}{\sigma_u}\right)^{l_j}\left[\prod_{i=1}^{l_j}\phi\left(\frac{w_i-\varepsilon\mathbf{1}(p_i>k+1)-w_j^T}{\sigma_u}\right)\right] \\ &\times\left[\frac{f(w_j^T)}{1-F(R_U^0)}\right]^{IA_{j-1}}\left[\frac{f(w_j^T)}{1-F(w_{j-1}^T)}\right]^{1-IA_{j-1}}\left[\frac{(1-P_u)^kP_u}{1-(1-P_u)^{t_j}}\right] \\ &\times(1-\lambda_1(1-F(w_j^T))-\delta)^{t_j-1}(\lambda_1(1-F(w_j^T))+\delta). \end{aligned}$$

Note that changing human capital levels does not change the exit probabilities, but it does change how one treats the wage observations. These equations reflect the fact that true wages, W_j^T, equal either w_j^T or $w_j^T+\varepsilon$ depending on the individual's skill level at the time.[32]

Probabilities $\Pr(t_J, W_J^T, W_J \mid IA_J, h_J^b, IA_{J-1}, W_{J-1}^T)$ for the Jth spell differ slightly due to censoring — they do not condition on the ending human capital level. When the last spell is an IA spell, the probability takes the form

$$\begin{aligned} Pr(t_J, W_J^T, W_J|1,0,IA_{J-1},W_{J-1}^T) &= (1-\lambda_0(1-F(R_U^0)))^{t_J-1} \\ Pr(t_J, W_J^T, W_J|1,1,IA_{J-1},W_{J-1}^T) &= \sum_{k=0}^{t_J-1}(1-P_d)^kP_d^{I(k<t_J-1)}(1-\lambda_0(1-F(R_U^1)))^k(1-\lambda_0(1-F(R_U^0)))^{t_J-k-1}, \end{aligned}$$

where the second probability includes the possibility that human capital declines sometime during the IA spell. When the last spell is a job spell,

$$\begin{aligned} Pr(t_J, W_J^T, W_J|0,1,IA_{j-1},W_{J-1}^T) &= \left(\frac{1}{\sigma_u}\right)^{l_J}\left[\prod_{i=1}^{l_J}\phi\left(\frac{w_i-\varepsilon-w_J^T}{\sigma_u}\right)\right]\left[\frac{f(w_J^T)}{1-F(R_U^1)}\right]^{IA_{j-1}}\left[\frac{f(w_J^T)}{1-F(w_{J-1}^T)}\right]^{1-IA_{j-1}} \\ &\times(1-\lambda_1(1-F(w_J^T))-\delta)^{t_J-1} \end{aligned}$$

$$\begin{aligned} Pr(t_J, W_J^T, W_J|0,0,IA_{J-1},W_{J-1}^T) &= \sum_{k=0}^{t_J-1}\left(\frac{1}{\sigma_u}\right)^{l_J}\left[\prod_{i=1}^{l_J}\phi\left(\frac{w_i-\varepsilon\mathbf{1}(p_i>k+1)-w_J^T}{\sigma_u}\right)\right] \\ &\times\left[\frac{f(w_J^T)}{1-F(R_U^0)}\right]^{IA_{J-1}}\left[\frac{f(w_J^T)}{1-F(w_{J-1}^T)}\right]^{1-IA_{J-1}} \\ &\times(1-P_u)^kP_u^{I(k<t_J-1)}(1-\lambda_1(1-F(w_J^T))-\delta)^{t_J-1}. \end{aligned}$$

COMPUTATIONAL ISSUES

We cannot analytically integrate over all potential "true" wage (or w^T) values. Instead, we use Monte Carlo integration methods to compute the likelihood given by equation (4). This entails drawing D sequences of wage offers for each individual and taking the mean of the calculated likelihoods across all D draws. In estimation, we use D = 7,500.

[32]When $R_U^0 < R_U^1$, it is necessary to account for the possibility that someone accepts a job she would quit if her human capital increased.

We want our likelihood to be smooth and continuous to make estimation easier and to allow for gradient-based methods. Rather than drawing wage observations from the log normal distribution, discarding those that fall below the appropriate reservation wage, we instead draw sequences of random numbers between 0 and 1 for each person. Treating these sequences as quantiles in a distribution, we can determine an associated wage from the appropriate conditional distribution (conditional on being greater than the reservation wage or the previous job spell's wage) using the inverse of the cdf function for a conditional log normal distribution.

To see how this works, let q represent the random draw from the $U[0,1]$ distribution (reflecting the quantile of the wage distribution). Given wages are drawn from a random normal distribution with mean μ_w and standard deviation σ_w, we need to find the true wage associated with

$$q = \Phi\left(\frac{log(w^T) - \mu_w}{\sigma_w}\right).$$

This yields a true wage draw

$$w^T = exp\{\sigma_w \Phi^{-1}(q) + \mu_w\}.$$

If we further assume that the wage distribution is truncated from below by $\underline{w}$ and above by $\overline{w}$, then the wage associated with q must satisfy

$$q = \frac{\Phi\left(\frac{log(w^T)-\mu_w}{\sigma_w}\right) - \underline{\Phi}}{\bar{\Phi} - \underline{\Phi}},$$

where $\overline{\Phi} = \Phi(\frac{\log(\overline{w}) - \mu_w}{\sigma_w})$ and $\underline{\Phi} = \Phi(\frac{\log(\underline{w}) - \mu_w}{\sigma_w})$. This gives us a true wage draw of

$$w^T = exp\{\sigma_w \Phi^{-1}[q(\bar{\Phi} - \underline{\Phi}) + \underline{\Phi}] + \mu_w\}.$$

During computation, $\underline{w}$ will be either R_U (if $IA_{j-1} = 1$) or $w^T_{j\text{-}1}$ (if $IA_{j\text{-}1}$=0), while $\overline{w}$ reflects an assumed upper wage level in the economy.

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