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Micro-to-Macro Simulation: A Primer With a Labor Market Example

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Simulation models, now widely used in the physical sciences, can also help economists in depicting the actions and interactions of individuals and firms through time. Such models can be built and run on any personal computer. They can illuminate a wide variety of issues that are difficult to analyze with an economist's conventional tool-kit and are especially useful in studying dynamic processes. Microsimulation models allow the analyst to produce simulated aggregate time series that are rigorously consistent with the assumptions made about behavior on the micro level. Thus, simulations provide a means of bridging the micro-macro split in economic analysis.

This article provides an introduction to microsimulation: how it works, how to do it, its potential, and its drawbacks. It then allows readers, even those with no experience in computer programming, to work through the details of a simple microsimulation model. Readers can put this model on their PCs, watch it run through its paces, and experiment with their own modifications. With this model as an example, it should be fairly easy to create programs for new models on other subjects for use in theoretical exploration, empirical research, or classroom demonstrations.

The demonstration model I present depicts the experience of individual workers during recession and recovery in the labor market. As the model runs, its internal "Census Bureau" performs surveys on the microlevel, and sums up to macrolevel variables. The model is simple, but it has some interesting applications. After explaining how to set it up, I use it to explore the effect of unemployment insurance on the level of unemployment, and to point up a common fallacy in current labor market literature.

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A diskette containing the program for the model discussed in this article, plus programs for the microsimulation models of Pryor (1973), Nelson, Winter, and Schuette (1976), and some others is available free from Member Services, Inter-university Consortium for Political and Social Research, University of Michigan, P.O. Box 1248, Ann Arbor, MI 48106. However, you do not need the diskette to follow the discussion in this article, or to try out the program it presents on a PC.

Constructing a Computer-Simulated Scenario and Watching It Play Out

A microsimulation of an economic activity is constructed by assembling an appropriate cast of characters, and fitting out each individual person or firm with a set of behavioral rules. An actor in the simulation will "exist" in the computer's memory space as a collection of pieces of information, rather like the record of an actual person's account in the computer of a brokerage house, which is updated each time a transaction is made. The analyst may derive the behavioral rules for the actors from a theory depicting a utility-maximizing process of choice, from a regression study on Census data, from a laboratory experiment with human subjects, or may simply make up rules that seem reasonably realistic or that are merely serviceable to the analytic task at hand. Wherever the rules come from, all the functional forms and parameter values must be specified for each run of the simulation on the computer.

The analyst must also set highly specific ground rules for the simulated interactions of the individuals (or firms) with each other. Interactions are recorded as they occur. Numerical reports summarizing the action are issued at suitable intervals, as Dow Jones indexes are issued during the trading day, or unemployment rates are issued each month. The analyst uses the reports to try to make generalizations about how the specified micro situation, as well as any exogenous events, have affected the simulated macro outcomes.

Microsimulation models have a number of advantages over conventional methods used by economists. One advantage is the explicitness with which the interactions on the micro level can be depicted. Conventional methods of economic analysis often provide cogent derivations of individuals' contingency plans, but tend to be weak in describing the process that allows all the contingency plans to mesh together. Highly mathematical accounts of the derivation of individuals' behavior rules are not infrequently followed by vague verbal descriptions of what goes on when the individuals come together and interact. This vagueness can lead to error, as has been the case in the labor market issues discussed below.

Simulation can be especially helpful in dealing with problems of information and expectations. The model builder can specify in a precise way the information the actors come to have as the action proceeds, the expectations they form, and how they react to that knowledge and those expectations. The actors can be allowed to be led into mistakes by their decision rules, suffer from their mistakes, and even learn from them.

Another advantage of simulation models is that they can be set up to be completely recursive, as real life is. The elimination of simultaneous equations allows us to get results from a simulation model without having to go through a process of solution. Instead one gets the computer to play out the scenario and analyzes the numerical outcome, which may or may not achieve an equilibrium. Models that don't have to be solved can be changed or added to freely and easily, as exemplified below. Nonlinearities, switches of regime, and other complexities are easily accommodated.

A number of small-scale simulation models have been built to explore subjects that conventional methods handle only awkwardly, if at all. For example, Nelson, Winter, and Schuette (1976) modeled the spread and effects of technical change. Individual firms were depicted discovering and trying out new modes of production, or imitating successful competitors. The hiring, capital purchases, and profits of every firm at each moment in time were kept track of, and parameter values were found that allowed the model's simulated macrodata to track U.S. macrodata on income and productivity.

In other examples, Bergmann (1973) simulated U.S. poverty rates by tracking the incomes of simulated individuals as unemployment rates and wage rates changed in accordance with historical patterns. Pryor (1973) looked at the effect of marriage and inheritance patterns on income distribution through many generations. He simulated individuals picking spouses, accumulating assets, having children, dying, and leaving an inheritance to one or more of the children. His model displays the resulting trends in the degree of inequality by computing simulated time series of Gini coefficients based on the simulated microdata. Pryor's model can be embodied in a program of 75 lines. Large-scale microsimulation models that sum to national income accounts have been built by Eliason for Sweden (1976), by Adelman and Robinson for Korea (1978), and by Bennett and Bergmann for the United States (1986).

For studies of policy, simulation models offer an opportunity to embed into a formal model a realistic description of how a regulation, tax, or subsidy affects the economic actors. (See Orcutt, Caldwell and Wertheimer, 1976; Haveman and Hollenbeck, 1980). Our delineation here of unemployment insurance shows how a government program with nonlinear rules can easily be added to a simulation model with a very few additional computer instructions. Simulation models can also serve as a theoretical framework for empirical studies, just as conventional models can. Data can be used to estimate a model's parameters and to gauge its goodness of fit (Bergmann, 1974; 1989).

Of course, simulation models have their drawbacks. When using them, the analyst has to give up the formal or informal deduction used in conventional models and has to rely instead on inductive analysis of numerical results. This may be less certain and is certainly less entertaining. Drawing qualitative generalizations from the numerical results is fraught with the possibility of error. The very ease with which new detail can be added to simulation models poses a danger. When the models grow more complex, the job of checking their cogency, of rooting out bugs, and interpreting and generalizing from their results becomes more problematical.

A simulation study can explore what happens when the actors follow optimizing behavioral rules, as in Fair (1974). But simulations can just as easily explore what happens when the actors follow rules of thumb which have not been proved out as optimal. Such simulations may seem sleazy to those economists for whom respectable microeconomics is synonymous with solving optimization problems. They fear that simulation opens the door to a loss of quality control in the profession, if the stringent paradigm of mathematical specification and solution for optima is relaxed.

However, the way to make an optimum decision is not known in many important economic arenas that deserve economists' attention and analysis. Sometimes the actor does not have the information that economic theory assumes, like a reliable demand curve for one's product, or a good line on what one's competitor is likely to do. Sometimes there is too much information around, and it is difficult to process it all. Sometimes the actor cannot be presumed to know the optimization technique. In such cases, simulated experimentation with the effects of varying rules of thumb may be the nearest possible approach to optimization. Some empirical research (Tversky and Kahneman, 1988; Thaler's columns in this *Journal*) suggests that human beings are apt to follow rules that produce results that are inferior to those obtained with rules that economists might devise. Where this is the case, simulations of non-optimal but empirically true behavior patterns should yield more realistic predictions than normative theories that are empirically false.

Obviously, simulation models that depict individuals who endlessly repeat obvious mistakes deserve condemnation, and all models can benefit from criticism. But treating the simulation methodology itself as entirely taboo cuts out a lot of valuable possibilities for exploration. Economists need more tools in our kits, not fewer.

Let me now turn to an example that will display some of the advantages and disadvantages of the simulation methodology. The reader, after studying it, can draw his or her own conclusions.

An Example of Labor Market Simulation

The labor market makes a good subject for simulation, since the results of the search process of individuals are not easy to represent as functions, or to aggregate. The demand side of the market and the interactions of workers with potential employers, which have been left rather vague in much of the current literature, can be fleshed out.

Much conventional analysis of the labor market concentrates on the individual unemployed worker who searches for a job and finds an ample array of vacancies for his or her consideration. In each period, the utility-maximizing worker weighs the benefits of taking one of these available jobs at the offered wage against the benefits of remaining unemployed. Unemployed people are then thought of, following Lucas and Rapping (1969), as a group of workers who could have taken jobs at some wage or other, but chose otherwise. Anything that increases the propensity of some workers to refuse employment is viewed as increasing the number of unemployed.

The microsimulation approach presented here seeks to develop a dynamic portrayal of the action on the microeconomic level that characterizes the behavior of individual workers but also the behavior of employers, rejecting the usual implicit assumption of unlimited job availability. The model also sets a protocol for the interactions of employers and unemployed workers. After these steps have been taken, one can run the simulation program, and watch unemployed workers searching for jobs, interacting with employers who have empty job slots they want to fill.

An unemployment insurance system is added to this simulated labor market, complete with eligibility requirements and limited-time benefits. Then, by running the model again, we can see what difference the unemployment insurance program makes to the unemployment rate. To preview the results, the simulation will show that, contrary to the claims of conventional analysts, refusals of job offers by stipend-receiving malingerers does not in all circumstances increase the number of unemployed people. The simulation avoids a narrow focus on the isolated choice of a single worker, thus bringing to visibility a point that conventional analysts tend to lose sight of as they verbally pass from the micro to the macro: that the refusal of one worker to take a particular job allows another worker a shot at that vacancy.

The Simulation Technique

The core of the model is an extremely simple representation of worker movements into and out of jobs. It is written in BASIC, a close analogue to FORTRAN. Most PC owners have access to the software necessary to build and run BASIC programs.

In this simple model, workers will be homogeneous as to skills and other characteristics, and all will be equally acceptable to employers for all jobs. Considerations relating to wage levels, either on the supply side or the demand side, will be pushed under the rug. (The significance of this formulation is discussed below.) The number of jobs that employers want to fill each week will be exogenously determined: fed into the computer as data. Workers, after a brief period of search, will take any job that is offered. The size of the labor force will be constant. If the analyst desires a more realistic model, all of these features can be changed quite easily.

Each "week," the actors in the model carry out a round of simulated activities. The micro-level scenario for a week is as follows: First, employers decide on the stock of jobs they wish to have filled this week. Some workers will be laid off, others will quit. The workers to be separated from jobs are picked at random from the ranks of the employed to join the ranks of the unemployed. After the separations have occurred, the unemployed (including some separated in previous periods who have not yet taken jobs) search for job vacancies; some are chosen at random to come to an interview, and some of these agree to become employed. At the end of the weekly activity, the "Census Bureau" surveys the situations of all the simulated individuals. It notes whether they are in a state of unemployment, and how long that state has persisted. It "publishes" simulated macro-data based on its survey: the unemployment rate and the average of unemployment durations.

The individual workers and their activities are "depicted" by the information in the computer's memory spaces. This model will use just two pieces of information about each of them. IEMPST(I) is the current employment status of the Ith worker, which takes the value 0 if the worker is unemployed and the value 1 if the worker is employed. IDATE(I) is the week the Ith worker last moved from employment to unemployment. For example, if the 4th worker makes such a move in the 3rd week of the simulation, IDATE(4) is at that point set equal to 3. In the course of the simulation, the worker's activities take the form of changes in those values. A worker can be "observed" by the analyst at any point in simulated time by asking the computer for a printout of the current value of these two variables for that worker.[1]

One device used in many simulation programs, including this one, is the introduction of an element of randomness to the action. For example, in depicting labor turnover, individual workers are picked at random to leave their jobs and become unemployed, rather than being chosen by some systematic rule, as might be the case in a more complex model.[2] BASIC provides the computer with a routine for the computation of random numbers with uniform distribution between 0 and 1. Whenever the variable RND appears in an instruction the computer is executing, a new random number is computed, and RND takes on the value of that number.

The variable names used in the BASIC program that performs the simulation are listed in Table 1, and the program itself is listed in Table 2. Each line of the program is an instruction, or a set of instructions to the computer.[3] The beginning of the program is devoted to computer setup, so it is more interesting to skip down and examine first the lines of the program which arrange for some individuals to move from employment to unemployment.

Lines 180–210 of the program pick out a particular employed worker and change that worker's status to unemployed:

180 ICHOSE = RND*LABFOR + .5 [A random integer between 1 and LABFOR is generated and stored in the memory location designated to hold the value for

[1]Obviously, for a more detailed model it would be useful to depict additional characteristics of the individual actors. In a labor market model, each individual's race, sex, skill, experience, current reservation wage, and so on, might be kept track of. Initial values for some of these characteristics might be imported from a (real) census database, as pioneered by Orcutt (1960).

[2]Other assumptions might be implemented. For example, those more recently hired, or those marked as having low skills might be given a relatively high chance of leaving. In a model by Nichols (1980) in which jobs and workers are heterogeneous, quits are motivated when workers find out about higher-wage openings for which they consider themselves competent.

[3]Some lines have several instructions, separated by the symbol ":", as in line 70. The computer performs instructions one after the other in the order they appear, unless directed elsewhere by a GOTO, as in line 190. Repetition may be called for, as in line 130, which calls for 69 repetitions of the instructions between 130 and 410. Each variable has a memory space associated with it that stores its current value. Almost all instructions tell the computer to change the value recorded in a single memory space.

Table 1

Variables Used in Labor Market Simulation Programs

DIFEMP	change in employment desired by employers
ELIG(I)	weeks remaining of UI stipend for Ith worker
EL	number that fluctuates between 0 and 6
ICHOSE	ID of worker chosen to change status
IDAT	number that fluctuates between 0 and 4
IDATE(I)	date Ith worker last became unemployed
IEMPST(I)	current employment status of Ith worker
IHIR	number of workers employers wish to hire currently
IPERS	ID of a person
ISEP	number of persons to be separated
IWEEK	week number
K, L	number of times operation done
LABFOR	size of labor force
LEAVS	number of separations if no net change in desired employment
NEMP(I)	quantity of employment desired by employers in Ith week
NFAIL	number of candidates an employer can interview in a week
RATLV	rate of separations of employed workers
RND	newly generated uniform random number between 0 and 1
TIMSUM	summation of values of UTIM
UN	number of persons unemployed
UR	unemployment rate
UTIM	number of weeks since worker's last separation
UTIMAV	average duration of current unfinished spells of unemployment
VAC	number of vacant job slots at end of hiring period

ICHOSE, which will serve as the ID number of the worker chosen to be moved from employment to unemployment.][4]

190 IF IEMPST(ICHOSE)=0 THEN GOTO 180 [If the worker chosen in line 180 is already unemployed, go back and chose another. Otherwise, go on to the next instruction.]

200 IEMPST(ICHOSE)=0 [Change the status of the employed worker chosen to "unemployed."]

210 IDATE(ICHOSE)=IWEEK [Record the current week, IWEEK, as the date of this worker's most recent transition from employment to unemployment.]

The number of workers who move from employment to unemployment in a given week depends on changes in the number of jobs and rates of turnover among workers in jobs. In each week the simulation runs, we want the appropriate number of people to make such a transition in status. That means determining how many times the program should run through lines 180–210, and then instructing the computer to

[4] When a random number between 0 and 1, RND, is multiplied by LABFOR, the size of the labor force, and .5 is added, we get a real number X between .5 and LABFOR + .5. When that number is stored in the memory space for ICHOSE, which has been marked as an integer as a result of instruction 10, BASIC rounds it off to the nearest integer. This procedure produces an ICHOSE that is an integer between 1 and LABFOR.

Table 2

BASIC program of labor market simulation

computer setup

```
10 DEFINT I-N
20 OPEN "results" FOR OUTPUT AS #1
30 DIM IEMPST(1000), IDATE(1000), NEMP(70)
```

set exogenous macrodata

```
40 FOR IWEEK= 1 TO 19 : NEMP(IWEEK)=950 : NEXT
45 FOR IWEEK=20 TO 29 : NEMP(IWEEK)=NEMP(IWEEK-1)-5 : NEXT
50 FOR IWEEK=30 TO 40 : NEMP(IWEEK)=895: NEXT
57 FOR IWEEK=41 TO 50 : NEMP(IWEEK)=NEMP(IWEEK-1)+5 : NEXT
60 FOR IWEEK=51 TO 70 : NEMP(IWEEK)=950: NEXT
70 LABFOR=1000 : RATLV=.015
80 UN=LABFOR-NEMP(1)
```

set initial microconditions

```
90 FOR IPERS=1 TO NEMP(1)
100 IEMPST(IPERS)=1
102 NEXT IPERS
104 FOR IPERS=NEMP(1)+1 TO LABFOR
110 IEMPST(IPERS)=0
111 IDAT=IDAT+1 : IF IDAT >4 THEN IDAT=0
112 IDATE(IPERS)=(-1)*IDAT
120 NEXT IPERS
```

perform weekly scenario: some employed workers become unemployed

```
130 FOR IWEEK=2 TO 70

140 LEAVS=RATLV*(LABFOR-UN)
150 DIFEMP=NEMP(IWEEK)-NEMP(IWEEK-1)
160 IF DIFEMP <0 THEN ISEP=LEAVS-DIFEMP ELSE ISEP=LEAVS
170 FOR K=1 TO ISEP
180 ICHOSE=RND*LABFOR+.5
190 IF IEMPST(ICHOSE)=0 THEN GOTO 180
200 IEMPST(ICHOSE)=0
210 IDATE(ICHOSE)=IWEEK
220 NEXT K
```

some employed workers get jobs

```
230 IF DIFEMP>0 THEN IHIR=LEAVS+DIFEMP ELSE IHIR=LEAVS
240 FOR L=1 TO IHIR
250 ICHOSE=RND*LABFOR+.5
260 IF IEMPST(ICHOSE)=1 THEN GOTO 250
265 IF IDATE(ICHOSE)=IWEEK THEN GOTO 250
270 IEMPST(ICHOSE)=1
290 NEXT L
```

census and printout

```
300 UN=0 : TIMSUM=0
310 FOR IPERS=1 TO LABFOR
320 IF IEMPST(IPERS)<>0 GOTO 370
330 UN=UN+1
340 UTIM=IWEEK-IDATE(IPERS)
350 PRINT IPERS ``/'' UTIM `` '';
360 TIMSUM=TIMSUM+UTIM
370 NEXT IPERS
380 UTIMAV=TIMSUM/UN
390 UR=UN/LABFOR
400 PRINT "simulated macro variables", IWEEK, UR, UTIMAV
405 PRINT #1, "simulated macro variables", IWEEK, UR, UTIMAV

410 NEXT IWEEK

420 END
```

do the required number of run-throughs. These tasks are accomplished in lines 140–170:

140 LEAVS = RATLV*(LABFOR - UN) [The number of persons involved in turnover (other than turnover due to a net change in the number of jobs), LEAVS, is determined. The (exogenously supplied) turnover rate, RATLV, is multiplied by the number of currently occupied job slots, LABFOR-UN.]
150 DIFEMP - "EMP(IWEEK) - NEMP(IWEEK - 1) [The change since the previous week in the number of job slots employers wish to fill is computed.]
160 IF DIFEMP<0 THEN ISEP = LEAVS - DIFEMP ELSE ISEP = LEAVS
[The number of persons going from employment to unemployment this week, ISEP, is calculated. ISEP is set at the number of jobs that have been vacated, LEAVS, unless there has been a net loss of jobs. If that has been the case, ISEP is increased (by subtracting a negative number) by the number of jobs lost.]
170 FOR K = 1 TO ISEP [Perform the disemployment routine ISEP times.]
Then come the four steps already explained above:

```
180 ICHOSE = RND*LABFOR + .5
190 IF IEMPST(ICHOSE) = 0 THEN GOTO 180
200 IEMPST(ICHOSE) = 0
210 IDATE(ICHOSE) = IWEEK
```

and the instruction that serves to mark the end of the disemployment routine:

```
220 NEXT K
```

The movement of workers from unemployment into employment is achieved in an analogous way. The appropriate number of hires is calculated (line 230), and the computer instructed to perform that many (lines 240, 290). The people to be "interviewed" by employers are chosen at random from among the unemployed (lines 250–260). Employers are programmed to accept any interviewed worker who wants a job. But workers who have become unemployed in the current week refuse any job offer (line 265), so as to have time to feel out the market. Workers unemployed at least a week who are chosen for an interview are programmed to accept any offered job, and if chosen their status is changed (line 270).

This depiction of hiring can be thought of as a rudimentary, shorthand account of a search process. Searchers for job openings walk the streets of the business district at random, and the person who happens to be closest to the window in which a sign announcing a vacancy has appeared gets the next interview with the employer who controls the slot.

The program starts with a group of lines which feed the computer the information it needs to start the simulation off. The computer memory is set up (lines 10–30). An exogenous macroeconomic time series giving the number of jobs that employers want filled each week is entered (lines 40–60) into NEMP(IWEEK). In the first 19 weeks, we assume employers wish to employ 950 workers, out of a constant labor force LABFOR of 1000. Thereafter, desired employment falls steadily for 10 weeks, remains steady at 895 for 11 weeks, and then rises again to its old value. Any alternative pattern of fluctuations in labor demand that the researcher wants to test, including actual time series data, can be entered instead.

In lines 90–120, initial values of IEMPST and IDATE are assigned.[5] In line 130, the simulation is set running, with IWEEK taking on the values 2, 3, 4 ... 70, in turn. The commands between lines 130 and 410 are performed each week.

Following the changes in workers' status that constitute each week's activity, a "census" of the computer memory is taken, so that the information may be printed out on the simulated economy's macro-level variables. The counting of the unemployed is done on lines 320–330, which tell the computer to add 1 to the current value of UN for each worker found whose value of IEMPST is 0. UTIMAV, the average duration of unemployment (lines 340, 380), is the macro-level analogue of the micro-level expression IWEEK-IDATE(I).[6]

On line 350, the computer is ordered to printed the ID number of each unemployed worker, and the length of time the current spell of unemployment has lasted for that worker. Printing out microdata provides a check that the program is working properly and provides some insight into the process being simulated. The macrodata generated are sent to the computer's screen on line 400 and sent to a file called "results" on line 405.

Results of Running the Simulation

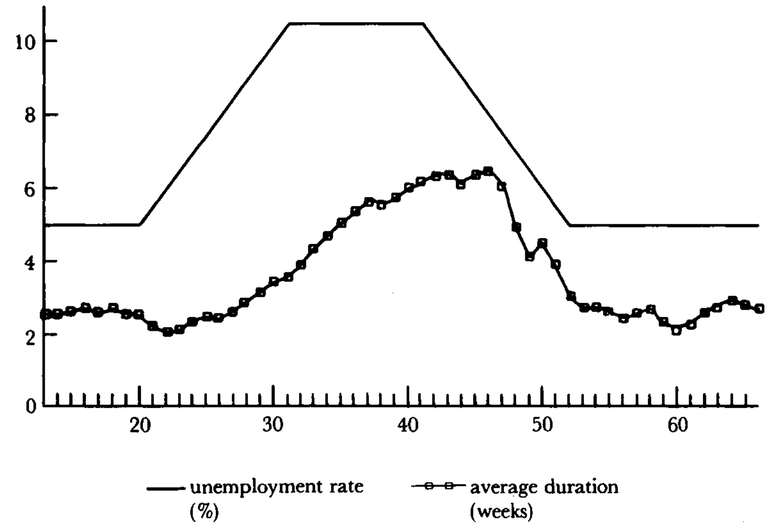
Given the program, the output of the simulation depends on the sequence of values given to NEMP(IWEEK), the number of employees that employers wish to have on board each week, the turnover rate RATLV, and the sequence of random numbers generated. The macroseries shown in Figure 1 were generated by a single run of the model in Table 2.

The fall and subsequent recovery in job availability produces changes in the average length of unemployment spells that are more complex than one might have imagined. As unemployment starts to rise, average duration of uncompleted spells falls for a time. This results from the increase in the number of newly unemployed people, whose spells so far are short. However, unemployed workers experience increasing difficulty in re-entering employment, as more of them are vying for a slightly smaller number of openings. So average duration starts to increase. Durations start to fall only after the recovery in demand has been going on for some time, but then fall rapidly.

[5] Better initial conditions on the microeconomic level can be generated by running the simulation for a considerable number of time periods at an appropriate setting of the exogenous variables, and printing the microeconomic information about the actors into a data file at the end of the last period. In subsequent runs, this file can be read in, and can replace lines 90–120. If this technique is used, care must be taken to insure that the macro and micro conditions that one starts off with are consistent.

[6] Of course, the simulation's Census Bureau can be programmed to print the average length of completed spells. This is a good exercise for the novice.

Figure 1
Unemployment Rates and Average Durations from the Simulation Model in Table 2



In this first version of the model, all jobs employers wish to fill are filled, so the unemployment rate has no random element. However, there is a random element to the average duration. The unemployed group is small, and if those people picked at random out of that group to go into jobs have unusually long or short durations, the average duration of those remaining unemployed shifts down or up in response. The reported duration series could be smoothed out by running the simulation repeatedly with different sequences of random numbers and averaging out the duration series or by increasing the size of the population represented.

The conventional analysis implicitly assumes that the number of open job slots could increase so as to take care of all unemployed workers, if only the unemployed (or the employers) would bid the wage down to a sufficiently low level. Of course, the simulation could be rewritten to allow for varying wage bids, and for elasticity in the supply of and demand for labor. But in that case, unemployment would occur solely on account of the job refusals induced by line 265, and would reflect only the number of recent separations. Durations would no longer reflect any difficulty in getting reemployed, because such difficulty would have been assumed away.

The simulation presented here, by leaving wage offers out of the picture, implicitly casts the unemployed as passive "wage takers" and employers as "wage makers," who do not adjust wages downward when there is unemployment. This may well be more realistic than the conventional approach, and comport better with the "efficiency wage" ideas now current (for example, see the articles collected in Akerlof and Yellen, 1986).

Putting Unemployment Insurance into the Model

When practitioners of the conventional approach tackle the effect of unemployment insurance on the rate of unemployment, they concentrate on the effect of unemployment insurance coverage on the duration of unemployment for current individual workers. A utility-maximizing unemployed worker will factor the availability of unemployment benefits into the decision as to whether to take one of the open job slots or to prolong his or her spell of unemployment. Common sense suggests that these substantial stipends motivate some covered workers into prolonging their unemployment, and regression analysis of microdata on unemployed workers supports this.

The implication is then drawn that each person who stays out of work because of the availability of an unemployment insurance stipend thereby constitutes a net addition to the stock of unemployed persons. Those taking this approach and drawing this implication include Feldstein (1973), Hamermesh (1977), Baily (1977), Clark and Summers (1982), and Topel (1985).[7] However, the simulation will demonstrate that this one-for-one increase does not necessarily occur.

Our labor market simulation program can be easily amended to add an unemployment insurance regime, and to study its effects on the level of unemployment. Table 3 shows the new program, which is the old program of Table 2 with some new lines interpolated in bold-faced type.

I have created for each worker a new piece of information, ELIG(I), the weeks of unemployment insurance that the Ith worker is currently eligible for. Each week the simulation runs, the value of ELIG is altered for each worker according to the assumed rules governing eligibility. I will assume that an employed worker gets a week of eligibility for each three weeks of employment, to a maximum of 6 weeks. The model can keep track of each worker's value of ELIG by adding four lines:

311 IF IEMPST(IPERS)=1 THEN ELIG(IPERS)=ELIG(IPERS) + 1/3 [Each week, an employed worker earns an additional eligibility credit of 1/3 of a week.]

312 IF IEMPST(IPERS)=0 THEN ELIG(IPERS)=ELIG(IPERS)-1 [Each week, an unemployed person uses up one week of eligibility.]

313 IF ELIG(IPERS)>6 THEN ELIG(IPERS)=6 [Number of weeks of eligibility cannot exceed 6.]

314 IF ELIG(IPERS)<0 THEN ELIG(IPERS)=0 [Number of weeks of eligibility cannot be negative.]

The next step is to make workers with unemployment insurance coverage pickier about the jobs they will accept. To do so in a simple way, let us make an extreme

[7]Many of these authors also discuss the probability that the existence of unemployment insurance raises the unemployment rate in a second way—it motivates employers to conduct temporary layoffs that would not occur without it. A simulation model that took account of that possibility might have to model employers' weighting of the likelihood of laid-off workers taking another job given the expected timing of callbacks, the firm's investment in these workers' training, and the benefits of having a large crew at times of peak load.

assumption and suppose that out-of-work persons malinger by refusing any job offer whatever until their remaining eligibility for unemployment insurance is down to one week. An employer may fill a job slot with a non-malingerer, if one can be found. But if the employer cannot fill a job after a certain number of interviews (here set at 10), the job remains vacant until the next period. This can be expressed by adding the following lines:

241 NFAIL = 0 [NFAIL is a variable used to keep track of the number of times the employer tries unsuccessfully to fill the job. At the initiation of the effort to fill each job, NFAIL is set back to zero.]
266 IF ELIG(ICHOSE) <2 THEN GOTO 270 [If the chosen worker has less than 2 periods of eligibility left, the worker consents to take the job offer. In this case, control passes to line 270, an instruction to reemploy that worker. Otherwise, the instruction on line 267 is performed.]
267 NFAIL=NFAIL+1 [Control has passed to this instruction (rather than line 270) because the worker chosen is malingering, and not yet ready to accept a job. The number of times the employer has tried to fill this job, NFAIL, is recorded as increased by 1.]
268 IF NFAIL<10 THEN GOTO 250 ELSE GOTO 290 [If there have been fewer than 10 unsuccessful tries to fill this job, the employer chooses another out-of-work candidate to interview by passing to line 250. If 10 tries have been made, the job will remain vacant until next week. In this case, control will pass to statement 290, and efforts commence to fill the next job.]

We interpolate a line to compute the number of held-over vacancies:

372 VAC=NEMP(IWEEK) - (LABFOR-UN) [Vacancies, VAC, are calculated as the difference between the employment desired by employers, NEMP(IWEEK), and the number of workers actually in jobs.]

In the next week, when the hiring routine is performed, the number of hires employers desire should be augmented by the number of vacancies. This is done by adding a line:

231 IHIR = IHIR + VAC [The hires that employers would like to make is increased by the number of jobs left vacant at the end of the previous week.]

Results of Running the Unemployment Insurance Simulation

Figure 2 compares simulated unemployment rates when malingering is absent and when it is present due to the availability of unemployment insurance. Malingering does have a positive effect on the unemployment rate under some circumstances, but the effect is shown by the simulation model to be dependent on the degree of slack in the labor market. In the tighter labor market periods, when employers want to fill jobs that would employ all but 5 percent of the labor force, the heavy malingering behavior we have assumed in the simulation raises the measured unemployment rate to 6.2 percent. In the slacker period, where employers would prefer to employ all but

Table 3
Simulation of Labor Market with Unemployment Insurance

10 DEFINT I-N	computer setup
20 open "results.vi" FOR OUTPUT AS #1	
30 DIM IEMPST(1000), IDATE(1000), NEMP(70), ELIG(1000)	
40 FOR IWEEK=1 TO 19 : NEMP(IWEEK)=950 : NEXT	set exogenous
45 FOR IWEEK=20 TO 29 : NEMP(IWEEK)=NEMP(IWEEK-1)-5 : NEXT	macrodata
50 FOR IWEEK=30 TO 40 : NEMP(IWEEK)=895 : NEXT	
57 FOR IWEEK=41 TO 50 : NEMP(IWEEK)=NEMP(IWEEK-1)+5 : NEXT	
60 FOR IWEEK=51 TO 70 : NEMP(IWEEK)=950 : NEXT	
70 LABFOR=1000 : RATLV=.015	
80 UN=LABFOR-NEMP(1)	
90 FOR IPERS=1 TO NEMP(1)	set initial microconditions:
100 IEMPST(IPERS)=1 : ELIG(IPERS)=6	
102 NEXT IPERS	
104 FOR IPERS=NEMP(1)+1 TO LABFOR	
110 IEMPST(IPERS)=0	
111 IDAT=IDAT+1 : IF IDAT>4 THEN IDAT=0	
112 IDATE(IPERS)=(-1)*IDAT	
115 EL=EL+1 : IF EL>6 THEN EL=0	initial eligibility status set
117 ELIG(IPERS)=EL	
120 NEXT IPERS	
130 FOR IWEEK=2 TO 70	perform weekly scenario:
140 LEAVS=RATLV*(LABFOR-UN)	some employed workers
150 DIFEMP=NEMP(IWEEK)-NEMP(IWEEK-1)	become unemployed
160 IF DIFEMP <0 THEN ISEP=LEAVS-DIFEMP ELSE ISEP=LEAVS	
170 FOR K=1 TO ISEP	
180 ICHOSE=RND*LABFOR+.5	
190 IF IEMPST(ICHOSE)=0 THEN GOTO 180	
200 IEMPST(ICHOSE)=0	
210 IDATE(ICHOSE)=IWEEK	
220 NEXT K	
230 IF DIFEMP>0 THEN IHIR=LEAVS+DIFEMP ELSE IHIR=LEAVS	some unemployed
231 IHIR=IHIR+VAC	workers get jobs
240 FOR L=1 TO IHIR	
241 NFAIL=0	
250 ICHOSE=RND*LABFOR+.5	
260 IF IEMPST(ICHOSE)=1 THEN GOTO 250	
265 IF IDATE(ICHOSE)=IWEEK THEN GOTO 267	
266 IF ELIG(ICHOSE)<2 THEN GOTO 270	some unemployed
267 NFAIL=NFAIL+1	malinger
268 IF NFAIL<10 THEN GOTO 250 ELSE GOTO 290	
270 IEMPST(ICHOSE)=1	
290 NEXT L	
300 UN=0 : TIMSUM=0	census and printout
310 FOR IPERS=1 TO LABFOR	
311 IF IEMPST(IPERS)=1 THEN ELIG(IPERS)=ELIG(IPERS)+1/3	adjustment of
312 IF IEMPST(IPERS)=0 THEN ELIG(IPERS)=ELIG(IPERS)-1	eligibility status

Table 3
(Continued)

```
313 IF ELIG(IPERS)>6 THEN ELIG(IPERS)=6
314 IF ELIG(IPERS)<0 THEN ELIG(IPERS)=0
320 IF IEMPST(IPERS)<>0 GOTO 370
330 UN=UN+1
340 UTIM=IWEEK-IDATE(IPERS)
350 PRINT IPERS ``/'' UTIM `` '';
360 TIMSUM=TIMSUM+UTIM
370 NEXT IPERS
372 VAC=NEMP(IWEEK)-(LABFOR-UN)                vacancies from
380 UTIMAV=TIMSUM/UN                             malingering tallied
390 UR=UN/LABFOR
400 PRINT "simulated macro variables", IWEEK, UR, UTIMAV
405 PRINT #1, "simulated macro variables", IWEEK, UR, UTIMAV

410 NEXT IWEEK

420 END
```

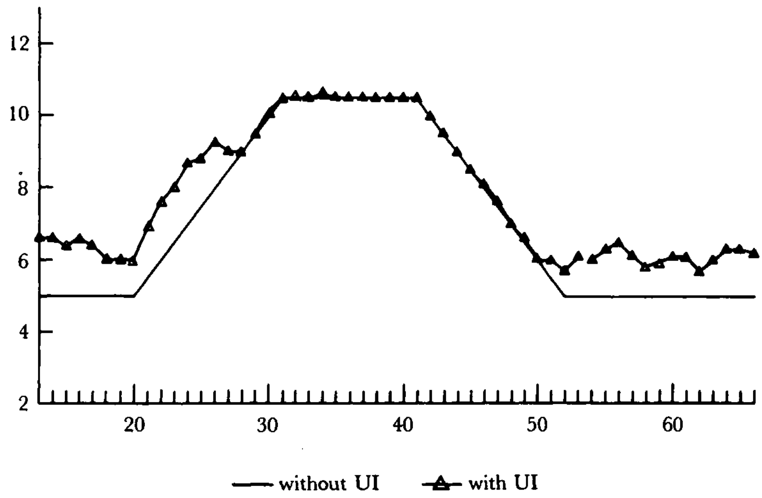
10.5 percent, malingering does not increase measured unemployment at all. This conclusion also holds for much of the recovery period.

It must be emphasized that this simulation is "theoretical" in the sense that no effort has been made to produce a realistic account of job availability, or of separations, or of the unemployment insurance system itself. The simulation results thus allow only a qualitative conclusion. Nevertheless, they do present a proof that lengthened durations of unemployment for unemployment insurance beneficiaries need not necessarily translate into an increase in the number of unemployed persons, as conventional theoretical analysts of the labor market have claimed.

The parameter NFAIL, the maximum number of interviews an employer can hold in a hiring period, is clearly influential in the numerical result. We could conduct a sensitivity analysis by running the model with differing values of NFAIL to gauge its effect. Obviously, the larger is the value given to NFAIL, the lower is the effect of malingering on the unemployment rate. If NFAIL were infinite—as it implicitly is in the program of Table 2—malingering would have no effect on measured unemployment in all but the tightest labor markets. If this model was fit to actual time series macrodata, NFAIL could be one of the parameters whose values were chosen to optimize goodness of fit of the unemployment and duration series. Then it might be said that we had "estimated" NFAIL empirically.

The conventional analysis neglects the fact that a malingerer's refusal of a job offer makes that job available to a non-malingerer. So an act of malingering does not

Figure 2
Unemployment Rates with and without an Unemployment Insurance System, from the Simulation Model in Table 3.



necessarily create unemployment beyond what is caused by a shortage of job openings, provided there is a good supply of non-malingerers in the market.[8]

The explanation of the different effect of malingering at different unemployment levels is readily apparent.[9] The number of non-malingerers available to take jobs differs, depending on the degree of slack in the labor market. The addition of a line in the program (not shown) allows a survey of the proportion of non-malingerers among the unemployed. In the tighter labor market periods, only about 22 percent of the unemployed were willing to take jobs. In the slack period, 60 percent of a much larger pool of unemployed are willing.

The slacker the labor market, the larger will be the number of people who have been out of a job for long enough to have exhausted their unemployment insurance benefits (or be close to having done so), and who would welcome a job. In slack markets, malingering merely changes the order in which unemployed people reenter employment. It has the effect of reserving whatever job openings there are for those who have been out of work the longest. It promotes uniformity of experience among

[8]Clark and Summers (1982) and Topel (1985) did run simulations of the Orcutt type, using the work history records of actual individuals derived from a survey. Estimates based on regressions were made of what the behavior of each individual would have been in the absence of unemployment insurance. However, their simulations look at individuals and their unemployment spells one at a time, and neglect the way one worker's actions affect another's opportunities.

[9]Hamermesh (1977) and Clark and Summers (1982) speculated that the state of the labor market would affect the extent to which unemployment insurance raised the level of unemployment, and suggested that high unemployment leads to a low impact of unemployment insurance. The simulation study presented here can be thought of as a systematic exploration of this hypothesis.

the unemployed. Malingering reduces the right-hand tail of the distribution of durations of unfinished spells.

Of course, a malingerer, a person not actively seeking work, should not be counted unemployed according to the official definition of that term, but should be labelled as out of the labor force. Since many of the out-of-work people counted as unemployed in the simulation are malingerers, the "true" unemployment rate is much lower than the measured rate throughout the period. However, if unemployment insurance were abolished, and malingering on this account ended, measured employment would change only by the amounts shown in Figure 2.

Final Comments

The focus of the simulation presented here is not, "How will utility maximizing individuals behave?" Rather, I have specified a particular behavioral pattern for the actors and asked, "What will the mechanical result of their interactions be?" Even though the actors are not depicted as fervid optimizers, the simulation does shed light on the pattern of spell durations over the cycle and on the effect of unemployment insurance on unemployment rates, which were goals of the analysis.

Of course, one could construct a model in which the simulated actors behaved with greater rationality. For example, one might try to depict them optimizing the degree of their malingering. They might be shown calculating, as the expiration date of their unemployment insurance benefits grows nearer, the probability that the failure to accept an offer now will lead to a period of unemployment without benefits later. The analyst might assume that a mathematical derivation of the optimal malingering rule is within the workers' capabilities. Unfortunately, it is not within the present author's.

But it is unlikely that a simulation model with actors more inclined toward finding and following optimal rules of behavior would give answers that differ qualitatively from those given by this model. The nonoptimizing actors of this model were servicable for the analysis we aimed at. The reader should remember, moreover, that the simulation model with nonoptimizing actors provided better insights about how unemployment is generated than the conventional models depicting allegedly optimizing actors.

■ *Much of the work underlying this paper was done while I was a member of the Department of Economics of the University of Maryland at College Park, where I was immeasurably helped by generous access to computers of all kinds.*

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