Rochester Center for Economic Research

Microfoundations of Indivisible Labor

Grilli, Vittorio and Richard Rogerson

Working Paper No. 110
November 1987.

University of Rochester

MICROFOUNDATIONS OF INDIVISIBLE LABOR

Vittorio U. Grilli
Yale University and NBER

and

Richard Rogerson
University of Rochester

Working Paper No. 110

November 1987 (revised)
January 1987

Abstract

In this paper we investigate the nature of labor indivisibilities. We present environments in which labor indivisibilities arise endogenously, as the outcome of the individual optimization problem. This result provides a microeconomic foundation to the line of research which assumes this restriction on labor as exogenously given.

I. Introduction

A number of papers have recently appeared which make use of the assumption of indivisible labor, e.g. Rogerson [1988], Grilli and Rogerson [1986], Hansen [1985], Greenwood and Huffman [1985, 1986], Hansen and Sargent [1986], and Prescott [1985]. One feature shared by all of these papers is that the assumption of indivisible labor is built directly into the consumption sets of individuals. However, since in these economies it is costly in terms of welfare to impose this restriction on labor supply, it seems unsatisfactory to leave unanswered the question of what aspect of the economic environment is responsible for this rigidity. This approach will clearly be more interesting if it could be shown that there exist reasonable economic structures in which this kind of restriction arises endogenously, as the result of agents' optimization.

This paper shows that it is possible to introduce nonconvexities in a more fundamental manner and yet obtain the result that individuals behave as if labor supply was exogenously given to be indivisible. In these models individuals are free to supply any fraction of their time endowment as labor, yet in equilibrium it is observed that agents either work zero or a fixed amount of hours $\bar{h}$ that is independent of the state of nature (in this paper a stochastic shock to technology). This last point should be stressed. It is well known that factors such as fixed costs of going to work imply a level of reservation hours for individuals (see e.g. Cogan (1981)). What is important about the result of this paper is the demonstration in a general equilibrium context that the observed level of hours per individual is constant, independent of the aggregate shock, implying that only fluctuations in employment will be observed.

One class of economies relies on non-convexities in preferences and the other class relies on non-convexities in the production technology. It is also demonstrated that simple variations within these classes may affect the equivalence results. In section II we review a simple indivisible labor model. In section III we present a model in which supplying labor implies a fixed cost in terms of utility or time. In section IV we discuss a model in which the available technology is characterized by set-up costs. In section V we provide examples of economies in which the equivelence result does not hold. Section VI concludes the paper with a discussion of the results.

II. Indivisible Labor

This section is based upon the results derived in Rogerson [1984]. The economy consists of a continuum of identical agents uniformly distributed on [0, 1]. There are two goods, time and output. Time is used to produce output according to a production function $\lambda f(h)$, where $0 < h < 1$ is the amount of time devoted to working activities. It is assumed that $f(h)$ is twice continuously differentiable, concave, increasing and satisfies

$$\lim_{h \to 0} f'(h) = \infty, \quad \lim_{h \to 1} f'(h) = 0$$

The parameter λ is a shock to technology, with cumulative distribution function $F(\lambda)$. Preferences are given by $U(c,h) = u(c) - v(h)$; where both $u(c)$ and $v(h)$ are twice continuously differentiable and increasing, $u(c)$ is concave, $v(h)$ is convex, $v(0) = 0$ and

$$\lim_{c \to 0} u'(c) = \infty \qquad \lim_{c \to \infty} u'(c) = 0$$

$$\lim_{h \to 0} v'(h) = 0 \qquad \lim_{h \to 1} v'(h) = \infty$$

Assume that individuals can only choose between working and not working, and that when they work they must work a fixed amount of hours $\bar{h} \in (0,1)$. The essential characteristic of this economy is that the opportunity set of each agent is non-convex, as described in Figure 1. It is shown in Rogerson [1984] that optimal allocations for this economy involve holding lotteries to divide the population between employed and not employed, and that consumption will be equalized across the two different groups of individuals. The introduction of lotteries transforms the non-convex consumption sets into (ex-ante) convex ones and, therefore, allows the achievement of a higher level of welfare (in expected terms). Solving the following program for each λ generates optimal (and equilibrium) allocations:

$$\text{(P-1)} \quad \max_{c,\,\phi} \; u(c) - \phi v(\bar{h})$$
$$\text{s.t.} \quad 0 \leq c \leq \lambda f(\phi \bar{h})$$
$$0 \leq \phi \leq 1$$

In this problem, ϕ is the fraction of agents that work. Note that this problem is essentially the same as that which would be obtained in an economy in which there was no indivisibility but v(h) was linear, in particular $v(h) = v(\bar{h})h$. The important point is that this indivisible labor economy, when the possibility of lotteries is introduced, becomes equivelent, ex-ante, to a divisible labor economy where the representative agents have preferences linear in labor supply.

III. Fixed Cost of Labor Supply

III.a. Fixed Utility Cost

This section considers an environment where individuals face a fixed utility cost of supplying labor. There is a continuum of identical agents uniformly distributed along [0,1] and the production function is $\lambda f(h)$, where λ is the shock to technology. Preferences are given by:

$$U(c, h) = \begin{cases} u(c) - v(h) - \bar{u} & \text{if } h > 0 \\ u(c) - v(o) & \text{if } h = 0 \end{cases}$$

Whereas the previous economy had a non-convexity in the consumption sets of the individual, this economy has a non-convexity in the preferences of the individual. It is important to note that this economy poses no exogenous restrictions on the hours that can be supplied by an individual. Figure 2 gives a graphical representation of a typical indifference set for this economy. When leisure moves from one to something slightly smaller than one, consumption must jump discontinuously to make up for the loss of utility u. Optimal allocations will be generated by solving the following problem for each value of λ:

$$\text{(p-2)} \quad \max_{\phi, c, h} \; u(c) - \phi[v(h) + \bar{u}]$$
$$\text{s.t.} \quad 0 \le c \le \lambda f(\phi h)$$
$$0 \le \phi \le 1$$
$$0 \le h \le 1$$

Again ϕ is the fraction of agents who are employed, h is their labor supply, and use of the fact that $v(0) = 0$ has been made. As before this program implicitly assumes that lotteries are being used to attain the allocation. Everyone faces probability ϕ of working h hours, but consumption is independent of the outcome of the employment lottery. Substituting the production function into the budget constraint and assuming that the solution for ϕ is interior, the following two first order conditions are derived:

$$\text{(III.a.1)} \quad u'(\lambda f(\phi h))\lambda f'(\phi h) = v'(h)$$

$$\text{(III.a.2)} \quad u'(\lambda f(\phi h))\lambda f'(\phi h)h = v(h) + \bar{u}$$

Substituting (III.a.1) into (III.a.2) yields:

$$\text{(III.a.3)} \quad v'(h)h = v(h) + \bar{u}$$

This is an equation in only h. The following proposition shows that this equation determines h uniquely.

Proposition 1: (III.a.3) has a unique solution for h.

Proof: Recall that v is a twice continuously differentiable function such that: $v(0) = 0$, $v'(h) > 0$, $v''(h) > 0$, $\lim_{h \to 0} v'(h) = 0$,

$\lim_{h \to 1} v'(h) = \infty$

Note that (i) the function $z(h) = v'(h)h$ varies (monotonically) between zero and infinity as h goes from zero to 1 while the function $x(h) = v(h) + \bar{u}$ is continuous, bounded on [0, 1] and equal to $\bar{u} > 0$ when h is equal to zero; and that (ii) $z'(h) > x'(h) > 0$ (for any $h > 0$). (i) guarantees the existence of a solution, $\bar{h}$, while (ii) guarantees that it is unique.//

What is important about this result is the fact that if $\phi < 1$, then individual hours of work are independent of both the technology f(h) and the technology shock λ. Hence, even though there are no restrictions placed on the level of hours an individual can supply, as long as $\phi < 1$ individuals will only be observed (in equilibrium) as supplying either 0 or $\bar{h}$ units. All fluctuations in total hours caused by the technology shock will be accounted for by movements in employment. This economy is observationally identical to one in which labor supply is exogenously given to be indivisible. Proposition one implies that (P-2) can be reformulated as:

$$\text{(P-3)} \quad \max_{\phi,\, c} \; u(c) - \phi[v(\bar{h}) + \bar{u}]$$
$$\text{s.t.} \quad o \leq c \leq \lambda f(\phi\bar{h})$$
$$o \leq \phi \leq 1$$

A strong similarity between (P-3) and (P-1) should be apparent. This economy also behaves as if there were a representative agent with preferences linear in labor supply, in particular $v(h) = [v(\bar{h}) - \bar{u}]h$.

III.b Fixed Time Cost

Instead of having a fixed utility cost $\bar{u}$ imagine now a fixed time cost, $\bar{t}$. This also produces a nonconvexity in preferences. Figure 3 shows a typical indifference set. Assuming nothing else changes, optimal allocations come from solving:

$$\text{(P-4)} \quad \max_{\phi, c, h} \; u(c) - \phi v(h+\bar{t})$$
$$\text{s.t.} \quad o \leq c \leq \lambda f(\phi h)$$
$$o \leq h \leq 1-\bar{t}$$
$$o \leq \phi \leq 1$$

The first order conditions are

$$\text{(III.b.1)} \quad u'(\lambda f(\phi h))\lambda f'(\phi h) = v'(h+\bar{t})$$

$$\text{(III.b.2)} \quad u'(\lambda f(\phi h))\lambda f'(\phi h)h = v(h+\bar{t})$$

Combining these two gives

(III.b.3) $v'(h+\bar{t})h = v(h+\bar{t})$

A proposition completely analogous to proposition 1 could be proven in order to show that, once again, h is uniquely determined independently of technology, and in particular, independently of the shock λ. Proceeding as above it is now easy to see that problem (P-4) can be rewritten so as to imply that the economy behaves as if there were a representative agent with preferences linear in labor supply, i.e. the economy behaves as if labor were indivisible even though agents face no restrictions on the number of hours they may choose to supply.

IV. Set-up Costs in Production

The previous examples were concerned with rigidities in the preferences of the individuals. In this section we want to demonstrate how analogous results are obtained by assuming the existence of rigidities in the technology. Once again the economy consists of a continuum of identical agents distributed on [0, 1]. Preferences are given by $U = u(c) - v(h)$, where these functions have the properties assumed previously. The production side of the economy is now characterized by the existence of set-up costs. The individual has to spend a fixed amount of time h_o on the job, before his work becomes productive. This kind of specification intends to capture the existence of skill-learning process or training procedure. The production function has form $f(h-h_o)$, where $0 < h_o < 1$ and $f(x) = 0$ if $x < 0$.

This economy has a non-convexity in production. Figure 4 illustrates the production opportunities facing an individual. Using a similar argument as in the previous sections will lead to a study of the following problem to generate optimal allocations:

$$\text{(P-5)} \quad \max_{\phi,c,h} \; u(c) - \phi v(h)$$
$$\text{s.t.} \quad o \le c \le \lambda f(\phi(h-h_o))$$
$$o \le h \le 1$$
$$o \le \phi \le 1$$

Substituting the production function into the objective function, and assuming an interior solution for ϕ, we derive the following first order conditions:

$$\text{(IV.1)} \quad u'(\lambda f(\phi(h-h_o))\lambda f'(\phi(h-h_o)) = v'(h)$$

$$\text{(IV.2)} \quad u'(\lambda f(\phi(h-h_o))\lambda f'(\phi(h-h_o))(h-h_o) = v(h)$$

Combining (IV.1) and (IV.2) yields:

$$\text{(IV.3)} \quad v'(h)(h-h_o) = v(h)$$

Proposition 2: (IV.3) has a unique solution in h.

Proof: The proof is identical to the one of Proposition 1, after we note that, because of the assumption $\lim_{c \to o} u'(c) = \infty$, the equilibrium must be characterized by $h > h_o$. Once we restrict the range for h to be $(h_o, 1)$, we note that in this interval the function $z(h) = v'(u)(h-h_o)$ is such that: (i)$z'(h) > v'(h) > 0$ and (ii) $\lim_{h \to h_o} z(h) = 0 < v(h_o)$.

The fact that $\lim_{h \to 1} z(h) = \infty$ together with (ii) guarantees the existence of a solution, while (i) guarantees that it is unique.// Denoting the solution to (IV.3) by $\bar{h}$, problem (P-5) is equivalent to

$$\text{(P-6)} \quad \underset{c,\,\phi}{\text{Max}} \; u(c) - \phi v(\bar{h})$$
$$\text{s.t.} \quad 0 \leq c \leq \lambda f(\phi(\bar{h}-h_0))$$
$$0 \leq \phi \leq 1$$

As before, it is apparent that this economy behaves as if there were a representative agent with preferences linear in labor supply.

This is only one type of set-up cost in production. More generally, one may consider that there is a set-up period in which productivity is lower, but not equal to zero. consider the following technology:

$$f(h) = \begin{cases} a_1 h \; ; \; h \leq h_0 \\ a_1 h_0 + a_2 (h-h_0); \; h \geq h_0 \end{cases}$$

where $0 < a_1 < a_2$. Figure 5 shows the production possibiities set. As the diagram illustrates, it is nonconvex. This specification is in the spirit of the motivation that Prescott (1986) gives for the assumption of indivisible labor, although he does not provide a formal proof. As a first step in analysing this case there are some points to be noted. An equilibrium without lotteries which involves asymmetric treatment of individuals may take one of two forms. One is the case where some individuals have $h = 0$ and the rest have $h > h_0$, and the other is where some individuals have $0 < h < h_0$ and the rest have $h > h_0$. It is not possible to simultaneously have some individuals with $h = 0$ and some individuals with $0 < h < h_0$ because as long as $h < h_0$ the non-convexity is irrelevant and identical individuals would not choose different bundles. The next proposition shows that once lotteries are introduced, optimal allocations will not involve some individuals with $0 < h < h_0$ and some individuals with $h > h_0$.

Proposition: Optimal allocations do not simultaneously have workers with $0 < h < h_0$ and $h > h_0$.

Proof: Let h_1 be the hours for workers with $h < h_0$ and h_2 be the hours for workers with $h > h_0$. Let ϕ be the fraction of workers with $h = h_2$. An optimal allocation is determined by:

$$\underset{c, h_1, h_2, \phi}{\text{Maximize}} \quad u(c) - \phi v(h_2) - (1-\phi)\, v(h_1)$$

$$\text{s.t.} \quad c = (1 - \phi)\, a_1 h_1 + \phi(a_1 h_0 + a_2(h_2 - h_0))$$

$$0 \le h_i \le h_0$$

$$h_0 \le h_2 \le 1$$

$$0 \le \phi \le 1$$

Assuming an interior solution the first order conditions are:

$$\text{IV.4} \qquad u'(c)a_1 = v'(h_1)$$

$$\text{IV.5} \qquad u'(c)a_2 = v'(h_2)$$

$$\text{IV.6} \qquad u'(c)(a_2h_2 - a_1h_1) = v(h_2) - v(h_1)$$

Substituting the first two equations into the third gives:

$$\text{IV.7} \qquad v'(h_1)h_1 - v(h_1) = v'(h_2)h_2 - v(h_2)$$

The function $v'(h)h - v(h)$ is monotone in h and hence this equation implies that $h_1 = h_2$, which is a contradiction. This implies that the problem does not have an interior solution, proving the proposition.//

This proves that once lotteries are introduced, the only allocations with asymmetric treatment of individuals are those in which some individuals have $h = 0$ and the rest have $h > h_0$. It should be noted that it is possible for an optimal allocation to have all workers working the same amount h where $0 < h < h_0$. Although this is a possibility, it is not of interest here because in this case the non-convexity is having no impact. As before, we are interested in how alternative forms of nonconvexities affect fluctuations in employment and hours, and therefore assume that parameters are set so that some individuals are not working.

In view of this discussion, optimal allocations for the economy with stochastic technology $\lambda\phi f(h)$ where λ is the stochastic shock and f(h) is as above, are determined by solving the following problem for each value of λ:

$$\underset{c,\ \phi,\ h}{\text{Maximize}}\ u(c) - \phi v(h)$$

$$\text{s.t. } c = \lambda\phi f(h)$$

$$h_0 \le h \le 1$$

$$0 \le \phi \le 1$$

The first order conditions are:

IV.8 $\quad u'(c)\ \lambda f(h) = v(h)$

IV.9 $\quad u'(c)\ \lambda f'(h) = v'(h)$

These equations imply

$$\frac{f(h)}{f'(h)} = \frac{v(h)}{v'(h)}$$

Rearranging gives:

IV.10 $\quad v'(h)f(h) - f'(h)v(h) = 0$

Substituting for f(h) gives:

$$v'(h)\left[a_1\ h_0 + a_2(h-h_0)\right] - a_2v(h) = 0$$

Note that the left hand side has derivative

$$v''(h)\left[a_1\, h_0 + a_2(h-h_0)\right] > 0$$

Therefore this equation has a unique solution. This proves that this economy also behaves as if labor were exogenously given to be indivisible. Hours of work are constant, independent of the shock to technology. This result will generalize to the case where f(h) has the form

$$f(h) = \begin{cases} a_1\, h, & h \leq h_1 \\ a_1 h_1 + a_2(h - h_1), & h_1 \leq h \leq h_2 \\ a_1 h_1 + \ldots + a_{n-1} h_{n-1} + a_n(h - h_{n-1}), & h_{n-1} \leq h \leq h_n \end{cases}$$

where $0 \leq a_1 \leq a_2 \leq \ldots \leq a_n$

As long as ϕ is less than one all movements in total hours will be the result of fluctuations in employment.

V. Fixed Consumption Costs of Working

The alternative non-convexities considered in the previous sections demonstrate that there are structures that are observationally equivalent to indivisible labor economies. While this much has been demonstrated, caution should be exercised with regard to overstating the generality of the result obtained. There are ways in which similar non-convexities may enter the economy that do not produce the same equivalence result. For example, if the fixed cost of working was a consumption cost rather than a utility or time cost, then the equivalence would not hold. Defining by $\bar{c}$ the amount of goods which are lost when labor is supplied, it is clear that the relevant problem defining the optimal allocations would be (assuming the existence of an interior solution):

$$\text{(P-7)} \quad \max_{\phi,c,h} \; u(c) - \phi v(h)$$
$$\text{s.t. } 0 \le c \le \lambda f(\phi h) - \phi\bar{c}$$
$$0 \le h \le 1$$
$$0 \le \phi \le 1$$

The relevant first order conditions are given by:

$$\text{(V.1)} \quad u'(\lambda f(\phi h) - \phi\bar{c})(\lambda f'(\phi h)h - \bar{c})\lambda f'(\phi h) = v'(h)$$

$$\text{(V.2)} \quad u'(\lambda f(\phi h) - \phi\bar{c}) + f'(\phi h) = v'(h)$$

(V.1) and (V.2) do not imply that h is independent of λ. In this case, the technological shock will generally effect both the optimal number of hours of work h^*, and the employment rate ϕ^*.

In particular, if the following specification is used:

$$f(h) = h$$
$$u(c) = c - \frac{1}{2}c^2 \qquad (0 \le c < 1)$$

the first order conditions produce an equation which is quadratic in h and h is given by:

$$h = \frac{(\lambda^2 + \bar{c}) \pm (\lambda^2 - \bar{c})}{\lambda}$$

where the correct solution will depend on the 2nd order conditions. In any case, both of these solutions depend on the realization of λ.

VI. Conclusions

In sections II, III and IV we have examined four classes of static representative agent models with stochastic production in which some type of non-convexity is present. Although the non-convexities were very different in terms of where they appear, it turns out that each of the models produce a common outcome: in response to shocks to technology each of the economies behaves as if there were a representative agent whose preferences are linear in labor supply. The importance of this feature has been demonstrated by the work of Hansen [1985] where he took the indivisible labor model of Rogerson [1985] and showed that the induced linearity of preferences allowed for a substantially better fit between model generated time series and actual time series for the U.S. in the post-World War II period. It may be argued that simply assuming that labor supply is indivisible is unsatisfactory without including features in the model which produce this feature endogenously. The three alternative non-convexities considered in sections III and IV demonstrate that there are several economies which introduce the non-convexity in a more primitive manner but which, nonetheless, produce the same result.

Although very different forms of non-convexities may produce equivalent results, it is by no means the case that qualitatively similar kinds of non-convexities will produce equivalent results. An example in which the equivalence does not hold is provided in section V. Understanding the potential implications which can derive from the study of non-convexities will probably require analyzing many different kinds of environments. One unifying theme will be the use of lotteries to achieve optimal allocations.

References

Cogan, J., (1981). "Fixed Costs and Labor Supply," Econometrica 49, 945-964.

Greenwood, J. and Huffman, G., (1985). "A Dynamic Equilibrium Model of Inflation and Unemployment," The Centre for the Study of International Economic Relations, W.P. No. 8530c.

Greenwood and Huffman (1986). " Modelling the National Rate of Unemployment," Mimeo, University of Western Ontario.

Grilli, V. and Rogerson, R., (1986). "Indivisible Labor Experience and Intertemporal Allocations," RCER, W.P. No. 56.

Hansen, G., (1985). "Indivisible Labor and the Business Cycle," Journal of Monetary Economics, 16, 309-327.

Hansen, G. and Sargent, T. (1986). "Straight Time and Overtime in Equilibrium," presented at the "Real Business Cycle Conference, Lisbon, Portugal, June 1986.

Prescott, E., 1986, "Theory Ahead of Business Cycle Measurement," Staff Report 102, Federal Reserve Bank of Minneapolis.

Rogerson, R., (1988). "Indivisible Labor, Lotteries and Equilibrium," Journal of Monetary Economics, 1988 (forthcoming).

Figure 1

The Production Possibilities Set Facing an Individual In

An Economy With Indivisible Labor

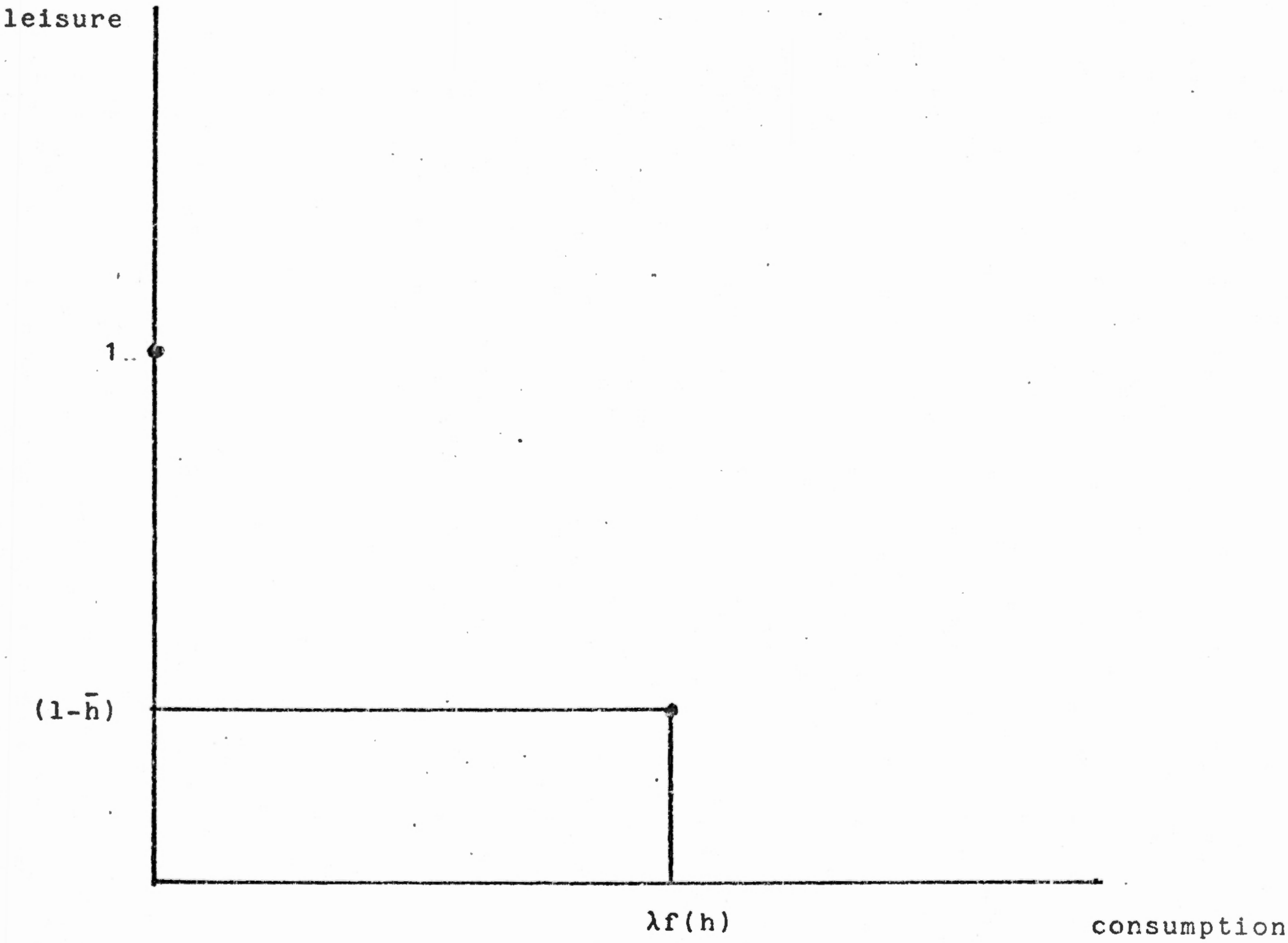


Figure 2

A Typical Indifference Set In An Economy

With Fixed Utility Cost Of Supplying Labor

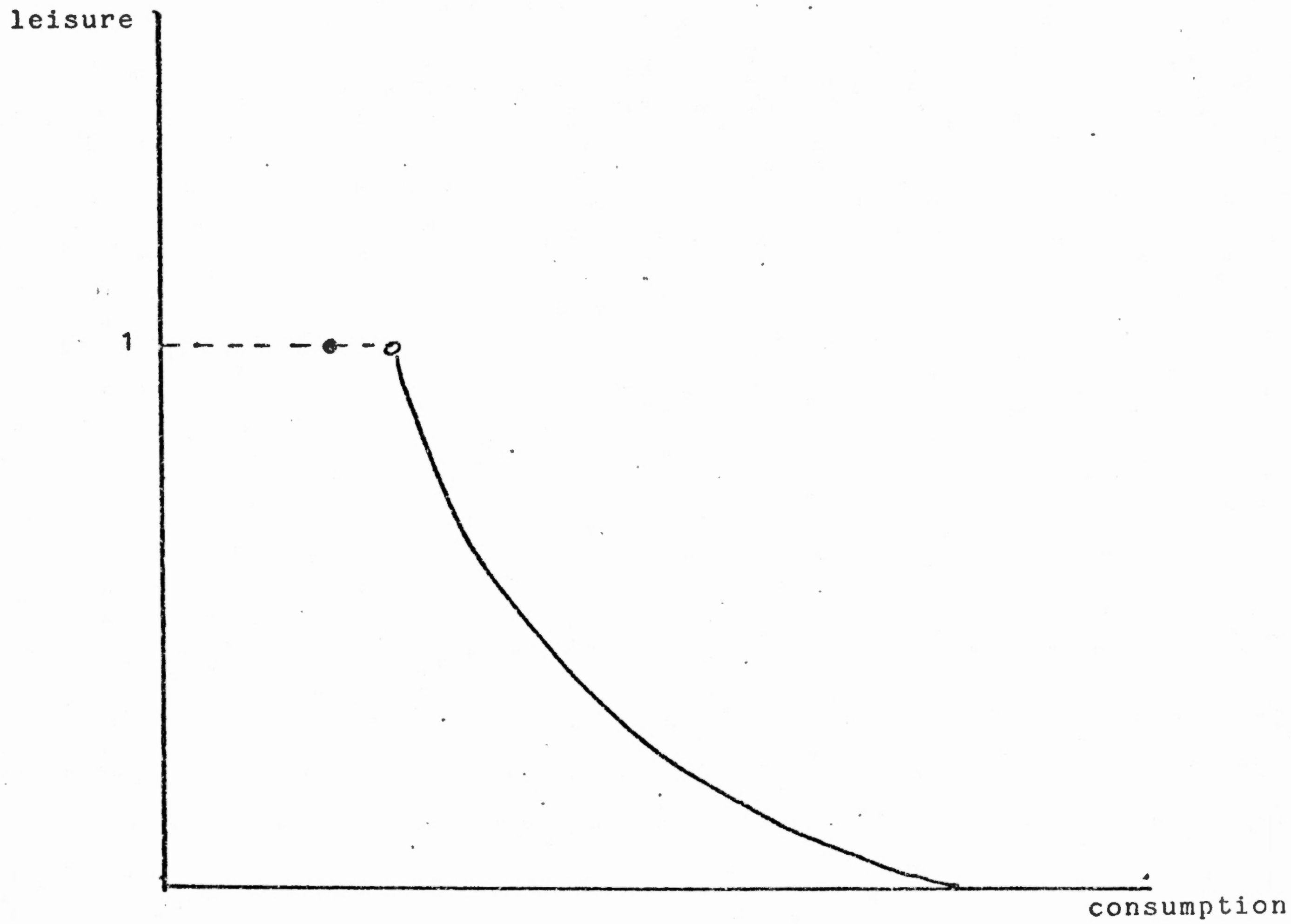


Figure 3

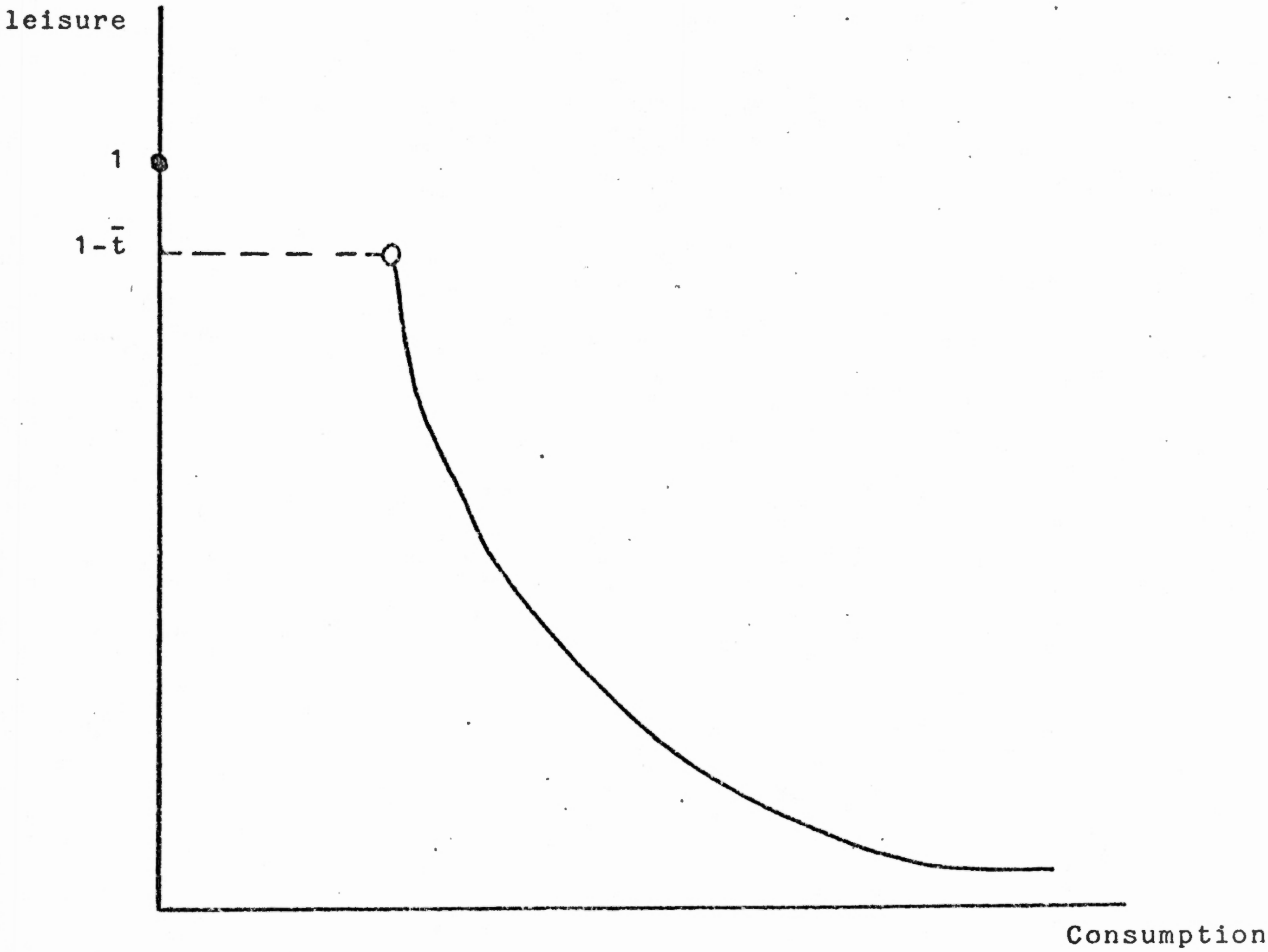


Figure 4

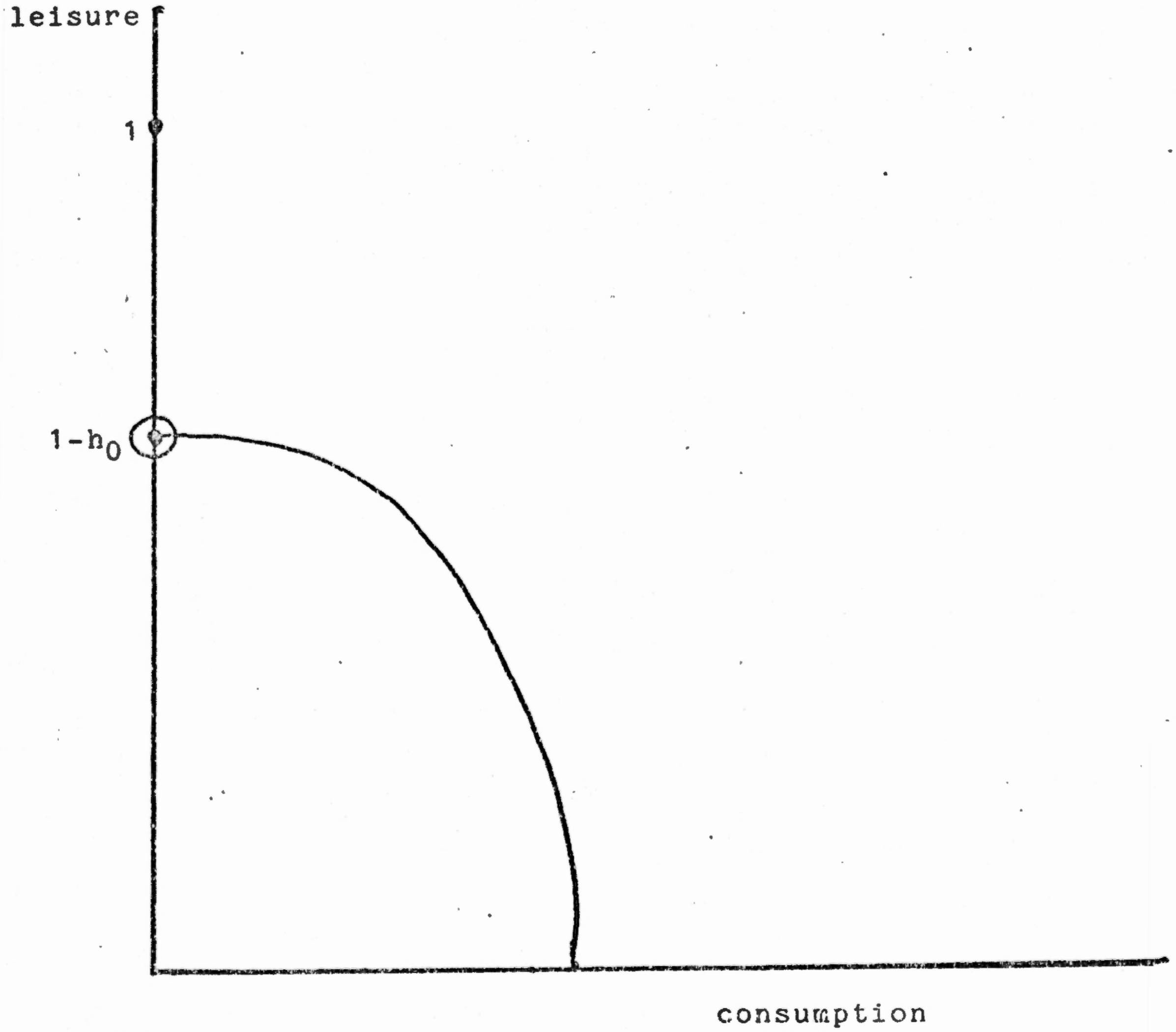
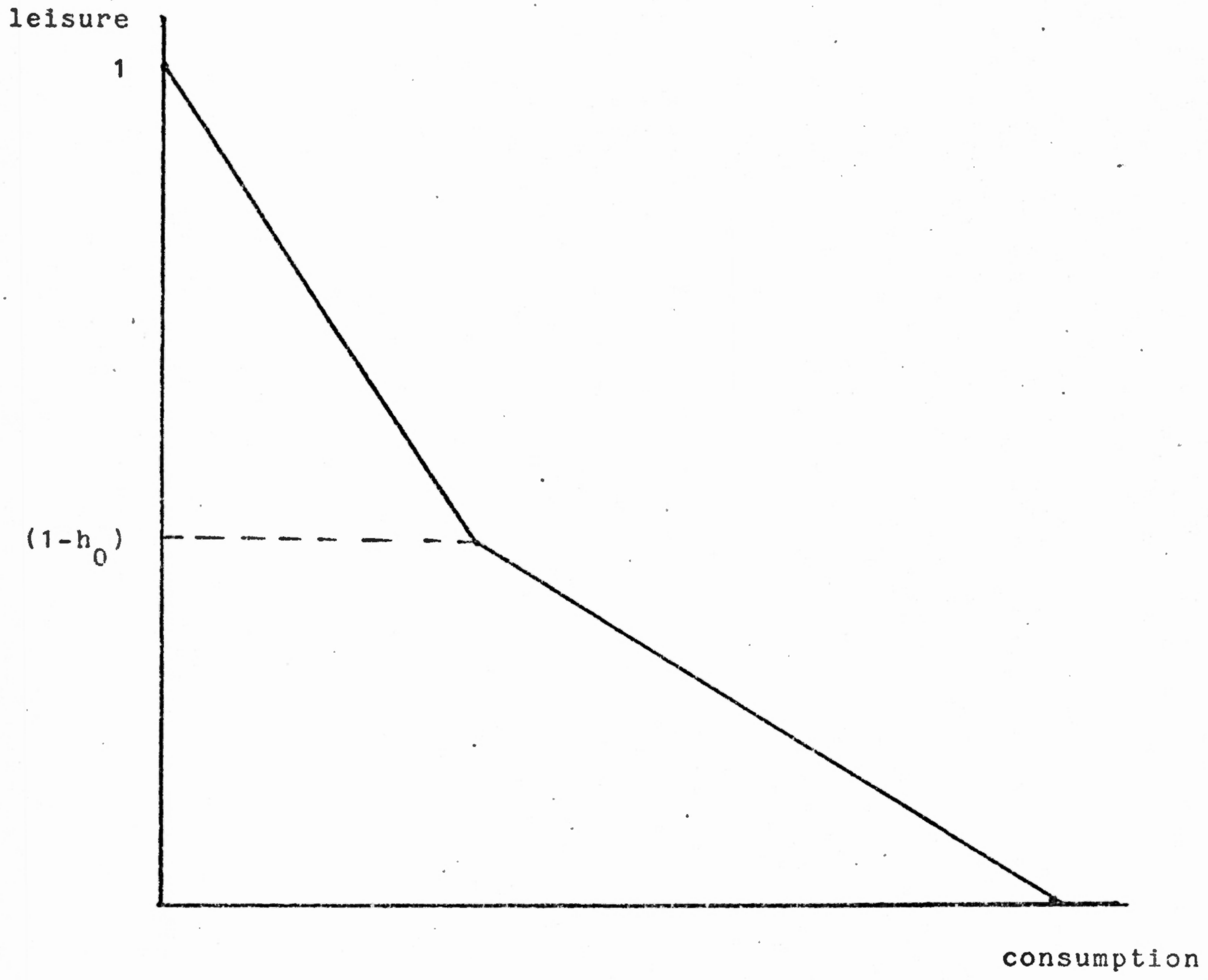


Figure 5



Rochester Center for Economic Research
University of Rochester
Department of Economics
Rochester, NY 14627

1986-87 DISCUSSION PAPERS

WP#33 OIL PRICE SHOCKS AND THE DISPERSION HYPOTHESIS, 1900 - 1980
by Prakash Loungani, January 1986

WP#34 RISK SHARING, INDIVISIBLE LABOR AND AGGREGATE FLUCTUATIONS
by Richard Rogerson, (Revised) February 1986

WP#35 PRICE CONTRACTS, OUTPUT, AND MONETARY DISTURBANCES
by Alan C. Stockman, October 1985

WP#36 FISCAL POLICIES AND INTERNATIONAL FINANCIAL MARKETS
by Alan C. Stockman, March 1986

WP#37 LARGE-SCALE TAX REFORM: THE EXAMPLE OF EMPLOYER-PAID HEALTH INSURANCE PREMIUMS
by Charles E. Phelps, March 1986

WP#38 INVESTMENT, CAPACITY UTILIZATION AND THE REAL BUSINESS CYCLE
by Jeremy Greenwood and Zvi Hercowitz, April 1986

WP#39 THE ECONOMICS OF SCHOOLING: PRODUCTION AND EFFICIENCY IN PUBLIC SCHOOLS
by Eric A. Hanushek, April 1986

WP#40 EMPLOYMENT RELATIONS IN DUAL LABOR MARKETS (IT'S NICE WORK IF YOU CAN GET IT!)
by Walter Y. Oi, April 1986

WP#41 SECTORAL DISTURBANCES, GOVERNMENT POLICIES, AND INDUSTRIAL OUTPUT IN SEVEN EUROPEAN COUNTRIES
by Alan C. Stockman, April 1986

WP#42 SMOOOTH VALUATIONS FUNCTIONS AND DETERMINANCY WITH INFINITELY LIVED CONSUMERS
by Timothy J. Kehoe, David K. Levine and Paul R. Romer, April 1986

WP#43 AN OPERATIONAL THEORY OF MONOPOLY UNION-COMPETITIVE FIRM INTERACTION
by Glenn M. MacDonald and Chris Robinson, June 1986

WP#44 JOB MOBILITY AND THE INFORMATION CONTENT OF EQUILIBRIUM WAGES:
PART 1, by Glenn M. MacDonald, June 1986

WP#45 SKI-LIFT PRICING, WITH APPLICATIONS TO LABOR AND OTHER MARKETS
by Robert J. Barro and Paul M. Romer, May 1986, revised April 1987

WP#64 INCREASING RETURNS, SPECIALIZATION, AND EXTERNAL ECONOMIES: GROWTH AS DESCRIBED BY ALLYN YOUNG, By Paul M. Romer, December 1986

WP#65 THE QUIT-LAYOFF DISTINCTION: EMPIRICAL REGULARITIES by Kenneth J. McLaughlin, December 1986

WP#66 FURTHER EVIDENCE ON THE RELATION BETWEEN FISCAL POLICY AND THE TERM STRUCTURE, by Charles I. Plosser, December 1986

WP#67 INVENTORIES AND THE VOLATILITY OF PRODUCTION by James A. Kahn, December 1986

WP#68 RECURSIVE UTILITY AND OPTIMAL CAPITAL ACCUMULATION, I: EXISTENCE, by Robert A. Becker, John H. Boyd III, and Bom Yong Sung, January 1987

WP#69 MONEY AND MARKET INCOMPLETENESS IN OVERLAPPING-GENERATIONS MODELS, by Marianne Baxter, January 1987

WP#70 GROWTH BASED ON INCREASING RETURNS DUE TO SPECIALIZATION by Paul M. Romer, January 1987

WP#71 WHY A STUBBORN CONSERVATIVE WOULD RUN A DEFICIT: POLICY WITH TIME-INCONSISTENT PREFERENCES by Torsten Persson and Lars E.O. Svensson, January 1987

WP#72 ON THE CONTINUUM APPROACH OF SPATIAL AND SOME LOCAL PUBLIC GOODS OR PRODUCT DIFFERENTIATION MODELS by Marcus Berliant and Thijs ten Raa, January 1987

WP#73 THE QUIT-LAYOFF DISTINCTION: GROWTH EFFECTS by Kenneth J. McLaughlin, February 1987

WP#74 SOCIAL SECURITY, LIQUIDITY, AND EARLY RETIREMENT by James A. Kahn, March 1987

WP#75 THE PRODUCT CYCLE HYPOTHESIS AND THE HECKSCHER-OHLIN-SAMUELSON THEORY OF INTERNATIONAL TRADE by Sugata Marjit, April 1987

WP#76 NOTIONS OF EQUAL OPPORTUNITIES by William Thomson, April 1987

WP#77 BARGAINING PROBLEMS WITH UNCERTAIN DISAGREEMENT POINTS by Youngsub Chun and William Thomson, April 1987

WP#78 THE ECONOMICS OF RISING STARS by Glenn M. MacDonald, April 1987

WP#79 STOCHASTIC TRENDS AND ECONOMIC FLUCTUATIONS by Robert King, Charles Plosser, James Stock, and Mark Watson, April 1987

WP#80 INTEREST RATE SMOOTHING AND PRICE LEVEL TREND-STATIONARITY
by Marvin Goodfriend, April 1987

WP#81 THE EQUILIBRIUM APPROACH TO EXCHANGE RATES
by Alan C. Stockman, revised, April 1987

WP#82 INTEREST-RATE SMOOTHING
by Robert J. Barro, May 1987

WP#83 CYCLICAL PRICING OF DURABLE LUXURIES
by Mark Bils, May 1987

WP#84 EQUILIBRIUM IN COOPERATIVE GAMES OF POLICY FORMULATION
by Thomas F. Cooley and Bruce D. Smith, May 1987

WP#85 RENT SHARING AND TURNOVER IN A MODEL WITH EFFICIENCY UNITS OF HUMAN CAPITAL
by Kenneth J. McLaughlin, revised, May 1987

WP#86 THE CYCLICALITY OF LABOR TURNOVER: A JOINT WEALTH MAXIMIZING HYPOTHESIS
by Kenneth J. McLaughlin, revised, May 1987

WP#87 CAN EVERYONE BENEFIT FROM GROWTH? THREE DIFFICULTIES
by Herve' Moulin and William Thomson, May 1987

WP#88 TRADE IN RISKY ASSETS
by Lars E.O. Svensson, May 1987

WP#89 RATIONAL EXPECTATIONS MODELS WITH CENSORED VARIABLES
by Marianne Baxter, June 1987

WP#90 EMPIRICAL EXAMINATIONS OF THE INFORMATION SETS OF ECONOMIC AGENTS
by Nils Gottfries and Torsten Persson, June 1987

WP#91 DO WAGES VARY IN CITIES? AN EMPIRICAL STUDY OF URBAN LABOR MARKETS
by Eric A. Hanushek, June 1987

WP#92 ASPECTS OF TOURNAMENT MODELS: A SURVEY
by Kenneth J. McLaughlin, July 1987

WP#93 ON MODELLING THE NATURAL RATE OF UNEMPLOYMENT WITH INDIVISIBLE LABOR
by Jeremy Greenwood and Gregory W. Huffman

WP#94 TWENTY YEARS AFTER: ECONOMETRICS, 1966-1986
by Adrian Pagan, August 1987

WP#95 ON WELFARE THEORY AND URBAN ECONOMICS
by Marcus Berliant, Yorgos Y. Papageorgiou and Ping Wang, August 1987

WP#96 ENDOGENOUS FINANCIAL STRUCTURE IN AN ECONOMY WITH PRIVATE INFORMATION
by James Kahn, August 1987

WP#97 THE TRADE-OFF BETWEEN CHILD QUANTITY AND QUALITY: SOME EMPIRICAL EVIDENCE
by Eric Hanushek, September 1987

WP#98 SUPPLY AND EQUILIBRIUM IN AN ECONOMY WITH LAND AND PRODUCTION
by Marcus Berliant and Hou-Wen Jeng, September 1987

WP#99 AXIOMS CONCERNING UNCERTAIN DISAGREEMENT POINTS FOR 2-PERSON BARGAINING PROBLEMS
by Youngsub Chun, September 1987

WP#100 MONEY AND INFLATION IN THE AMERICAN COLONIES: FURTHER EVIDENCE ON THE FAILURE OF THE QUANTITY THEORY
by Bruce Smith, October 1987

WP#101 BANK PANICS, SUSPENSIONS, AND GEOGRAPHY: SOME NOTES ON THE "CONTAGION OF FEAR" IN BANKING
by Bruce Smith, October 1987

WP#102 LEGAL RESTRICTIONS, "SUNSPOTS", AND CYCLES
by Bruce Smith, October 1987

WP#103 THE QUIT-LAYOFF DISTINCTION IN A JOINT WEALTH MAXIMIZING APPROACH TO LABOR TURNOVER
by Kenneth McLaughlin, October 1987

WP#104 ON THE INCONSISTENCY OF THE MLE IN CERTAIN HETEROSKEDASTIC REGRESSION MODELS
by Adrian Pagan and H. Sabau, October 1987

WP#105 RECURRENT ADVERTISING
by Ignatius J. Horstmann and Glenn M. MacDonald, October 1987

WP#106 PREDICTIVE EFFICIENCY FOR SIMPLE NONLINEAR MODELS
by Thomas F. Cooley, William R. Parke and Siddhartha Chib, October 1987

WP#107 CREDIBILITY OF MACROECONOMIC POLICY: AN INTRODUCTION AND A BROAD SURVEY
by Torsten Persson, November 1987

WP#108 SOCIAL CONTRACTS AS ASSETS: A POSSIBLE SOLUTION TO THE TIME-CONSISTENCY PROBLEM
by Laurence Kotlikoff, Torsten Persson and Lars E. O. Svensson, November 1987

WP#109 EXCHANGE RATE VARIABILITY AND ASSET TRADE
by Torsten Persson and Lars E. O. Svensson, Novmeber 1987

WP#110 MICROFOUNDATIONS OF INDIVISIBLE LABOR
by Vittorio Grilli and Richard Rogerson, November 1987

WP#111 FISCAL POLICIES AND THE DOLLAR/POUND EXCHANGE RATE: 1870-1984
by Vittorio Grilli, November 1987

To order copies of the above papers complete the attached invoice and return to Christine Massaro, W. Allen Wallis Institute of Political Economy, RCER, 109B Harkness Hall, University of Rochester, Rochester, NY 14627. Three (3) papers per year will be provided free of charge as requested below. Each additional paper will require a $5.00 service fee which must be enclosed with your order. For your convenience an invoice is provided below in order that you may request payment from your institution as necessary. Please make your check payable to the **Rochester Center for Economic Research.** **Checks must be drawn from a U.S. bank and in U.S. dollars**.

W. Allen Wallis Institute for Political Economy

Rochester Center for Economic Research, Working Paper Series

OFFICIAL INVOICE

Requestor's Name ______________________________

Requestor's Address ______________________________

____

____

____

Please send me the following papers free of charge (**Limit: 3 free per year**).

WP# _______ WP# _______ WP# _______

I understand there is a $5.00 fee for each additional paper. Enclosed is my check or money order in the amount of $___________. Please send me the following papers.

WP# _______ WP# _______ WP# ______

WP# _______ WP# _______ WP# ______

WP# _______ WP# _______ WP# ______

WP# _______ WP# _______ WP# ______