EXPERIMENTAL ESTIMATION OF
SUPPLY CURVES OF LABOR AND OF THE EFFECT
OF WELFARE SUBSIDIES ON LABOR SUPPLY

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Abstract

Supply curves of labor are experimentally measured on the basis of estimated indifference curves for leisure-income choices. Empirical indifference curves for most of the 25 individuals tested satisfy the usual convexity assumption, and the derived empirical supply curves are generally "backward bending." The aggregate supply curve also is of the backward bending type, reaching a maximum labor supply at a wage of $4 per hour. Individual and aggregate supply curves are also estimated given welfare subsidies of the lump sum type at subsidy levels of $25 and $50 per week. The reduction in labor supply resulting from these welfare subsidies is estimated at alternative wage levels. For example, at a wage of $4 per hour a subsidy of $25 per week would result in approximately a 40 percent reduction and a subsidy of $50 per week would result in approximately a 64 percent reduction in labor supply.

1. Introduction

This study empirically estimates a supply curve of labor for a group of individuals. In addition to an ordinary supply curve the method employed enables the determination of supply curves when the individuals are provided welfare subsidies on a lump-sum basis, that is, subsidies independent of the income, age, physical status, or employment of the individual.[*]

2. Indifference Curves for Income and Leisure

Empirically constructed indifference curves for income and leisure for each of a group of individuals were used to estimate the individual supply curves of labor.[**] The method of construction for the indifference curves was that developed by MacCrimmon and Toda in their estimation of indifference curves for goods and money.[***]

Figure 1 shows three indifference curves, labelled I_0, I_{25}, and I_{50} respectively, for choices between money income, measured in dollars per week, and leisure, measured in hours per week. The curves are defined for all non-negative levels of money income and for all nonnegative levels of leisure not exceeding 168 (the number of hours in a week).

As in the MacCrimmon and Toda study, the first step in obtaining indifference curves was to obtain reference points for the comparison of alternative combinations of the two goods. In this case of income-leisure choices, however,

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[*] Such lump sum welfare subsidies are currently under consideration as an alternative to the present welfare system in the United States. Under the present system subsidies typically depend on age (e.g. social security), employment (e.g. unemployment compensation), or other conditions applicable to the individual.

[**] For a discussion of indifference curves for income and leisure and implied supply curves of labor see Wold and Jureen (1953) and Scitovsky (1970).

[***] See MacCrimmon and Toda (1969).

these reference points are quite natural. The point (168, 0) is one such natural reference point, referring to the situation in which the person has complete leisure and no money income. The indifference curve passing through this point is labelled I_o. Other points on the line of complete leisure also form natural reference points, referring to situations in which the individual has complete leisure but is entitled to a certain money income as a lump-sum welfare payment. Two such points are identified in Figure 1, those referring to welfare payments of $25 and $50 per week, and the indifference curve passing through this point are labelled I_{25} and I_{50} respectively.

The MacCrimmon-Toda technique is that of estimating indifference curves by pairwise choices, using monotonicity to eliminate entire areas from consideration. The procedure, illustrated in Figure 1 by reference to the (168, 0) point, may be considered the situation without lump-sum welfare payments. To estimate I_o the subject is confronted with pairwise choices between combinations of leisure and money income and the reference point of complete leisure and zero money income. The subject is then asked to state for each combination whether he would prefer it or the reference point. If the combination is preferred it is referred to as an "accepted" combination; if the reference point is preferred the combination is referred to as a "rejected" combination. In Figure 1 A_1 is an accepted combination, being preferred to (168, 0). All points to the right and above A_1 are therefore also accepted, since the individual would presumably prefer more leisure and/or more money income. The shaded area to the right and above A_1 therefore cannot contain any points on the indifference curve. Similarly the shaded areas above and to the right of A_2 and A_3, two other accepted combinations, also cannot contain any points on I_o. By comparable reasoning areas below and to the left of rejected points cannot contain any points on I_o, leading to the shaded areas starting from

R_1, R_2, and R_3 respectively. It is clear that, using this approach, a relatively small number of pairwise choices can exclude enough areas of the diagram to allow the determination of the indifference curve as the boundary between accept and reject regions. Indefference curves I_{25} and I_{50} are obtained similarly as the boundary between accept and reject regions for points compared to the reference points (168, 25) and (168, 50) respectively.

3. The Sample of Individuals

The sample of individuals is believed to be a reasonably representative sample. Various criteria were employed to ensure the representativeness of the sample, as shown in Table 1.

Sex:	
Male	12
Female	13
Marital status and children	
Married	14
Children	9
No Children	5
Unmarried	11
Employment	
Full time	12
Part time	8
Unemployed	5
Age in years	
Range	17-55
Average	28.3
Present or past participation in welfare programs	
Participant	10
Non-participant	15

Table 1: Characteristics of the Sample of 25 Individuals

4. Individual Indifference Curves and Supply Curves of Labor

Indifference curves were constructed for each of the individuals in the sample. Each subject was told that the purpose of the study was to evaluate proposals for welfare reform. He was told that there would be a five day work week, that he could work at most 68 hours per week, that he would be working the chosen hours for at least six months, that he should consider himself in his present situation with regard to living style, etc. and that the job at which he works is one he neither greatly enjoys nor greatly despises. He was then confronted with various alternative leisure-income choices and asked to compare each to the (168, 0) reference point. Combinations were chosen so as to most rapidly estimate the indifference curve I_o. Once the curve was estimated several consistency tests were performed to ensure that the curve was in fact the indifference curve sought. Five other indifference curves were similarly estimated, those referring to subsidies of $25, $50, $75, $100, and $125 per week, the subject being told that he would be entitled to these amounts regardless of his hours of work or income. The six indifference curves were then transferred to a single diagram to obtain the indifference map. Throughout the procedure the subjects were reminded of the important assumptions made and were also checked for consistency.

No part of the experimental procedure required that the indifference curves obtained be convex to the origin, i.e. that there be diminishing marginal rate of substitution between income and leisure as leisure increases. One aspect of this study was to test for the convexity of the indifference curves.

The indifference curves for individuals were used to derive individual supply curves for labor under alternative assumptions as to lump-sum welfare subsidies. The nature of this derivation is also illustrated in Figure 1, with reference to a welfare subsidy of $25 per week. The individual can add to his
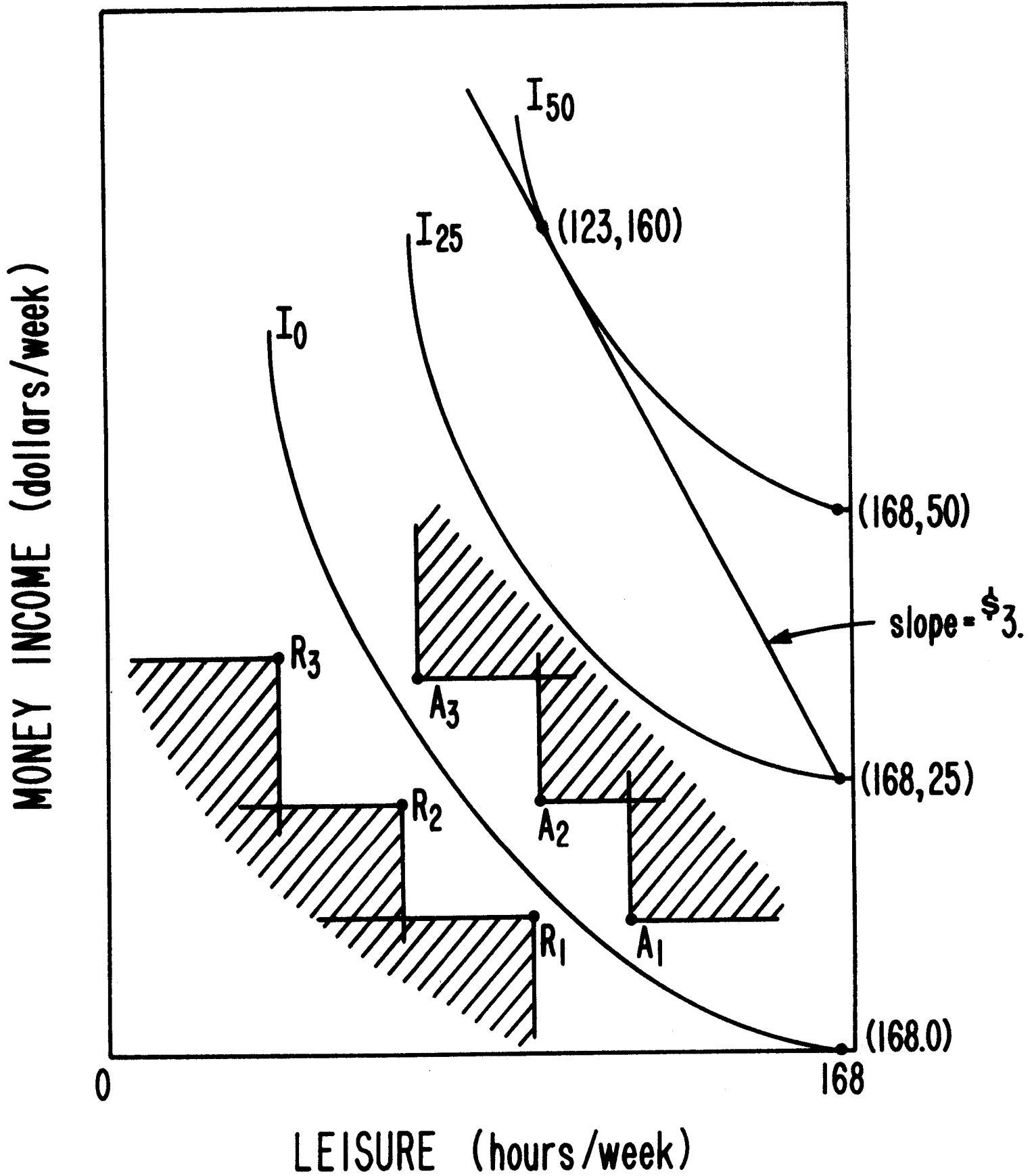
Figure 1: Indifference Curves for Income and Leisure and
Derivation of the Individual Supply Curve of
Labor

weekly income of $25 by working and giving up leisure time, shown geometrically by moving along a line starting at (168, 25) and having slope equal to the wage. The figure illustrates the situation in which the wage is $3 per hour and for which the individual chooses to work $45 hours per week, reaching the (123, 160) point of tangency between the line and an indifference curve (in this case I_{50}).

Varying the wage changes the tangency point, and the curve giving hours of work as a function of the wage is the individual supply curve of labor. Three alternative supply curves were so constructed, those relating to welfare subsidies of 0, $25, and $50 per week, referred to as S_o, S_{25}, and S_{50} respectively.

No part of the experimental procedure required that the supply curves be backward bending in that above a certain wage increasing wages would result in supply of less labor.[*] One aspect of the study was to test for the backward bending nature of the supply curve of labor.

Space precludes presentation of indifference maps and supply curves for all 25 individuals in the sample, but those for four are shown in Figures 2 through 5. Figure 2 refers to a male full time construction worker, age 40, who is married and has two children. The indifference curves satisfy the usual convexity assumption and the supply curves are of the usual backward bending type, reaching a maximum labor supply of 36 hours per week at a wage of $3.20 when there is no subsidy, a maximum of 32 hours per week at a wage of $3.60 when there is a subsidy of $25 per week and a maximum of 29 hours per week at a wage of $4.40 when there is a subsidy of $50 per week.

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[*]For a discussion of the backward bending supply curve of labor in terms of income and substitution effects of a rise in wages see Wold and Jureen (1953) and Scitovsky (1970).
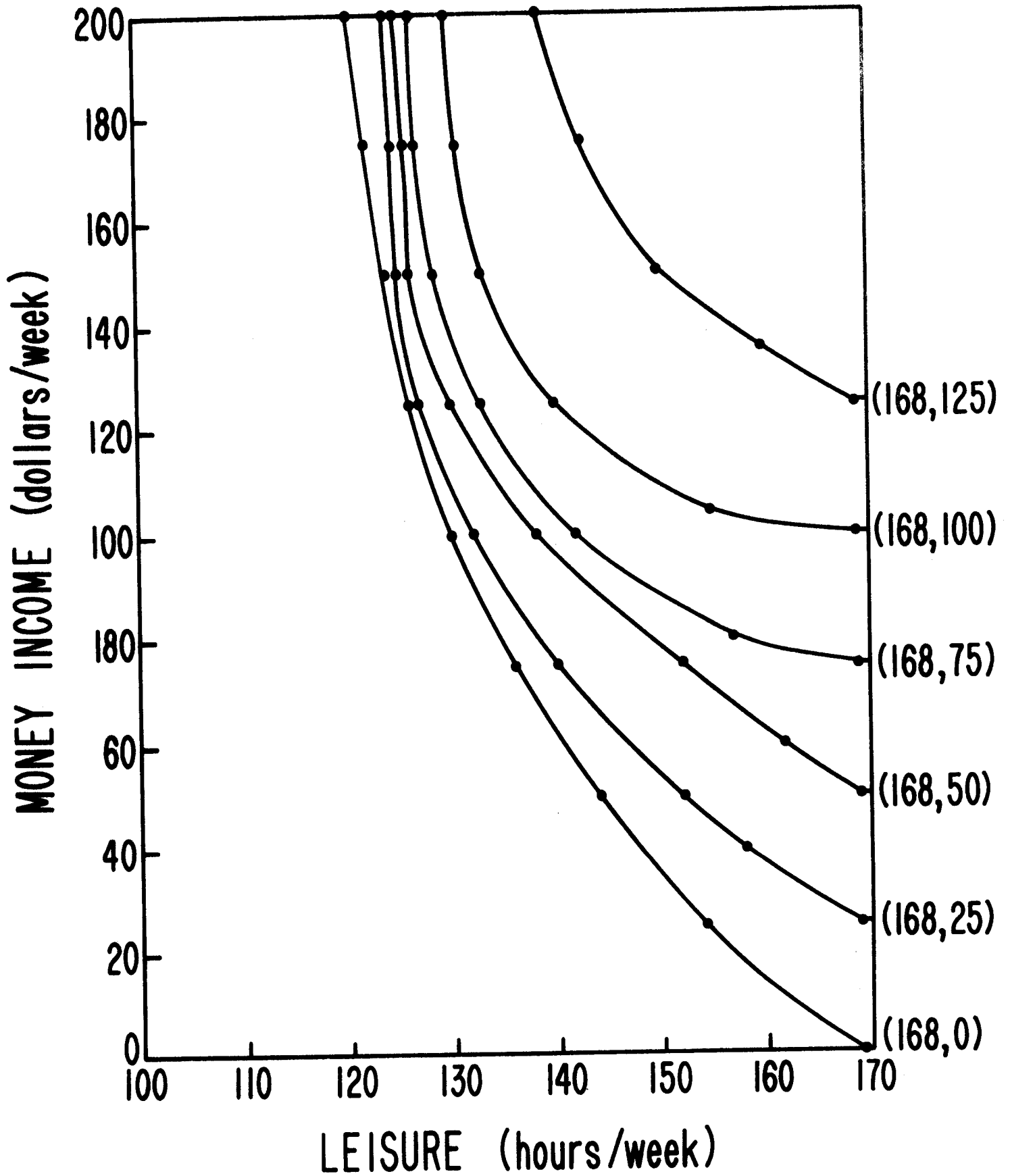
Figure 2A: Indifference Curves for a Construction Worker, Male, Age 40, Married, Two Children
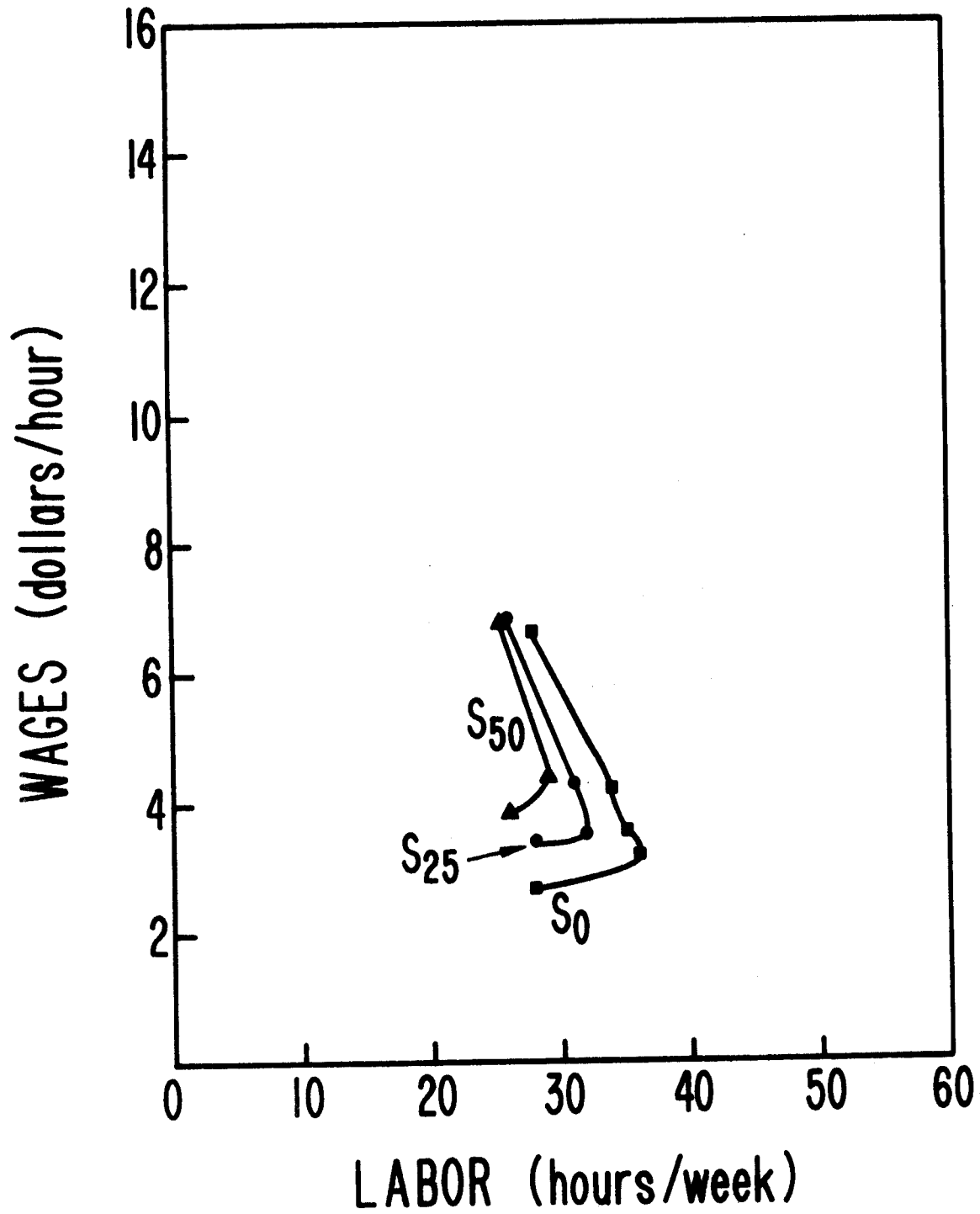
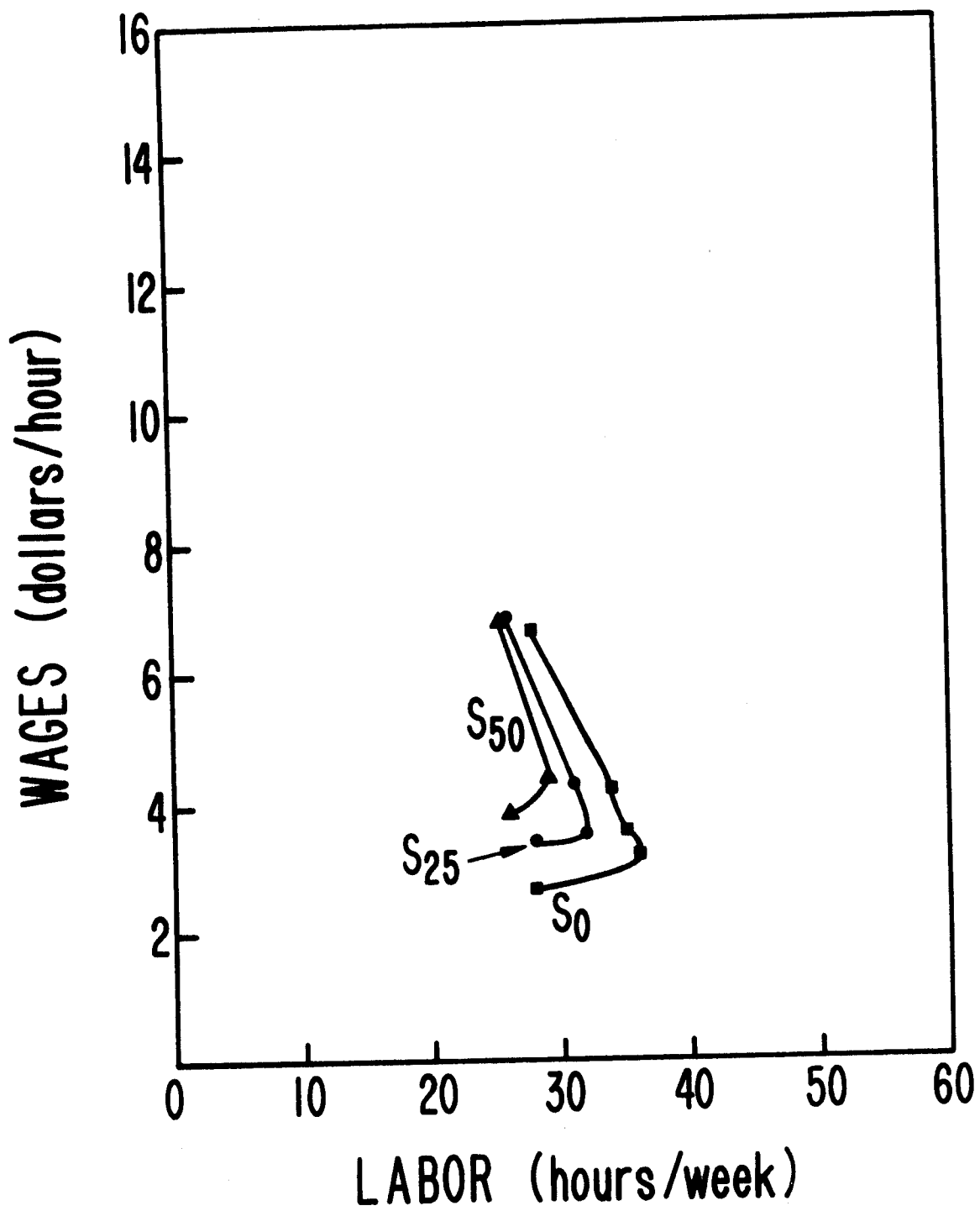Figure 2B: Supply Curves of Labor Implied by Figure 2A

Figure 2B: Supply Curves of Labor Implied by Figure 2A

Figure 3 refers to a female full time teacher, age 36, who is married and has one child. The indifference curves are close to linear in some segments, and, while the supply curves S_0 and S_{25} are of the backward bending type, S_{50} exhibits no increasing section. A maximum labor supply of 31 hours is realized at a wage of $6.10 when there is no subsidy.

Figure 4 refers to a female, age 24, who is unmarried and on welfare. Except for one indifference curve, the convexity assumption is satisfied. The labor supply curves are generally increasing for wages exceeding $3.00 per hour.

Figure 5 refers to a male full time aeronautical engineer age 47 who is married and has one child. The indifference map clearly violates the convexity assumption, but this was the only one of the 25 that so clearly violates this assumption. The labor supply curves are generally decreasing curves.

It is clear from the figures that tastes, indicated by indifference curves, vary significantly from one individual to another and that the supply curves similarly vary considerably among the subjects.

6. Aggregate Supply Curves of Labor and the Effects of Welfare Subsidies on the Supply of Labor

The individual supply curves obtained in Section 5 are summed horizontally to obtain aggregate supply curves of labor for all 25 individuals in the sample. Thus, for example, the hours of work supplied by each of the individuals at a wage of $3 per hour are summed to obtain the aggregate labor supply at this wage.

Figure 6 presents the aggregate supply curves for the situation in which There are no welfare subsidies and also for the situations in which there is a subsidy of $25 per week and a subsidy of $50 per week, S_0, S_{25}, and S_{50}
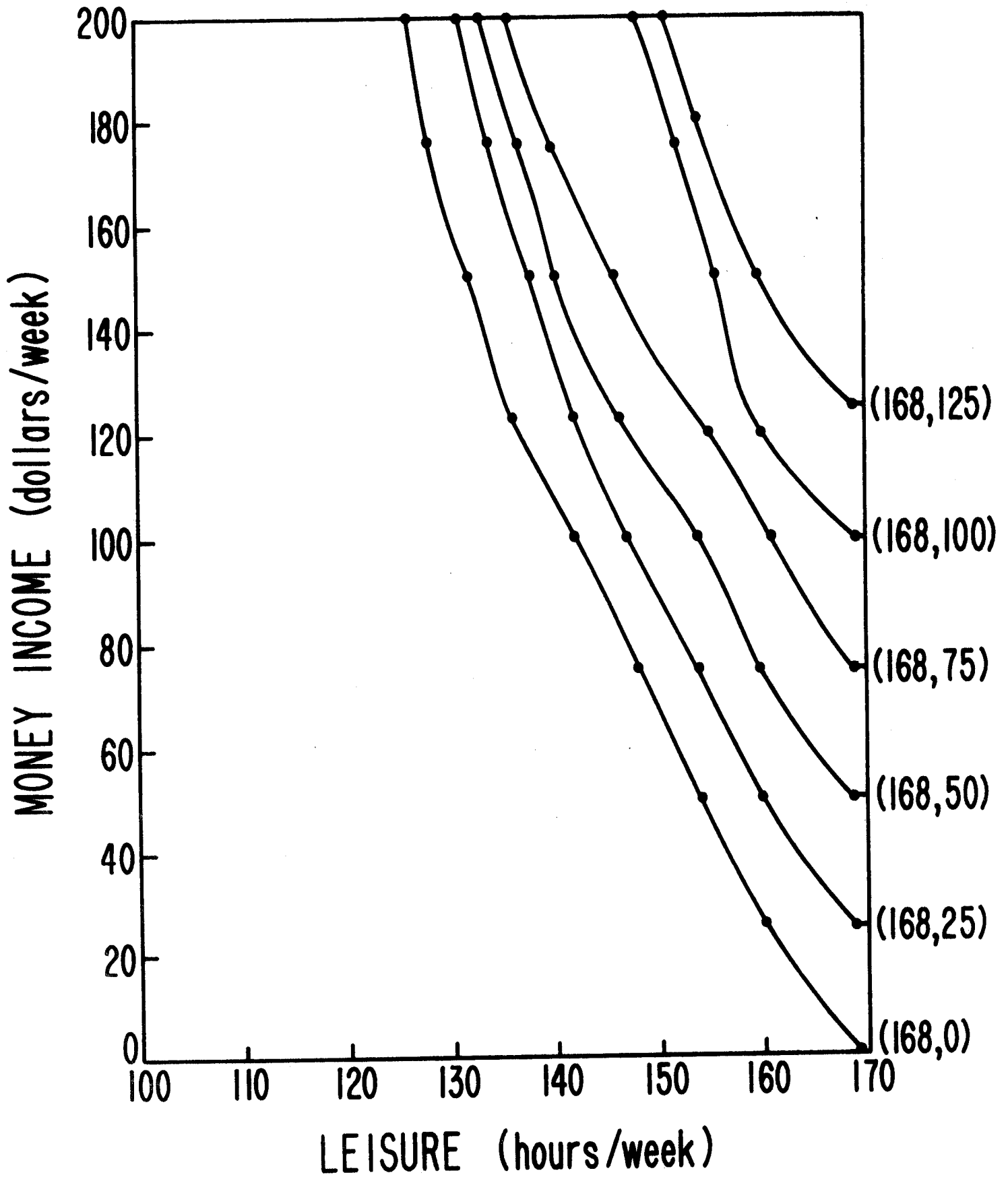
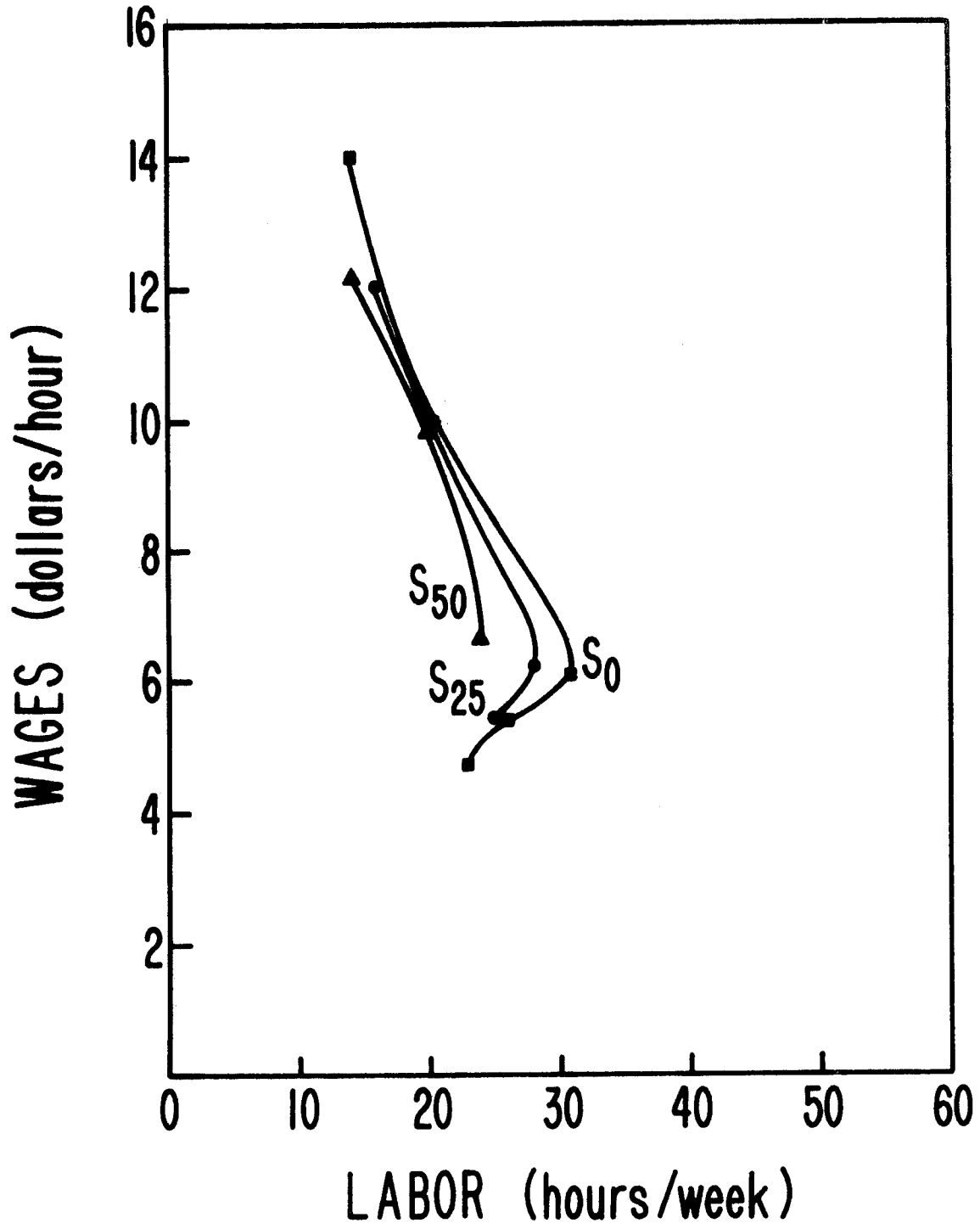Figure 3A: Indifference Curves for a Teacher, Female, Age 36, Married, One Child

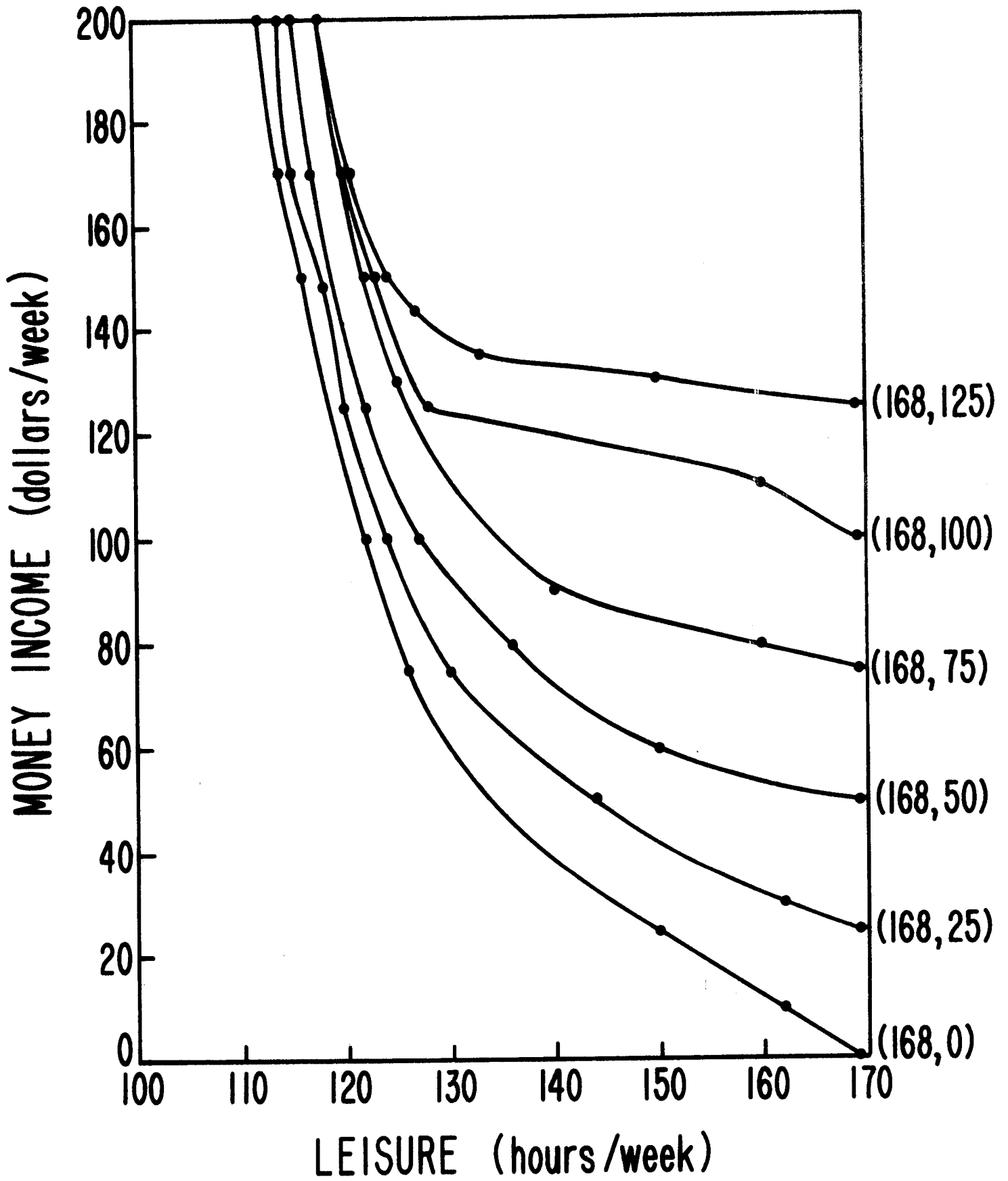Figure 3B: Supply Curves of Labor Implied by Figure 3A

Figure 4A: Indifference Curves for a Welfare Recipient,
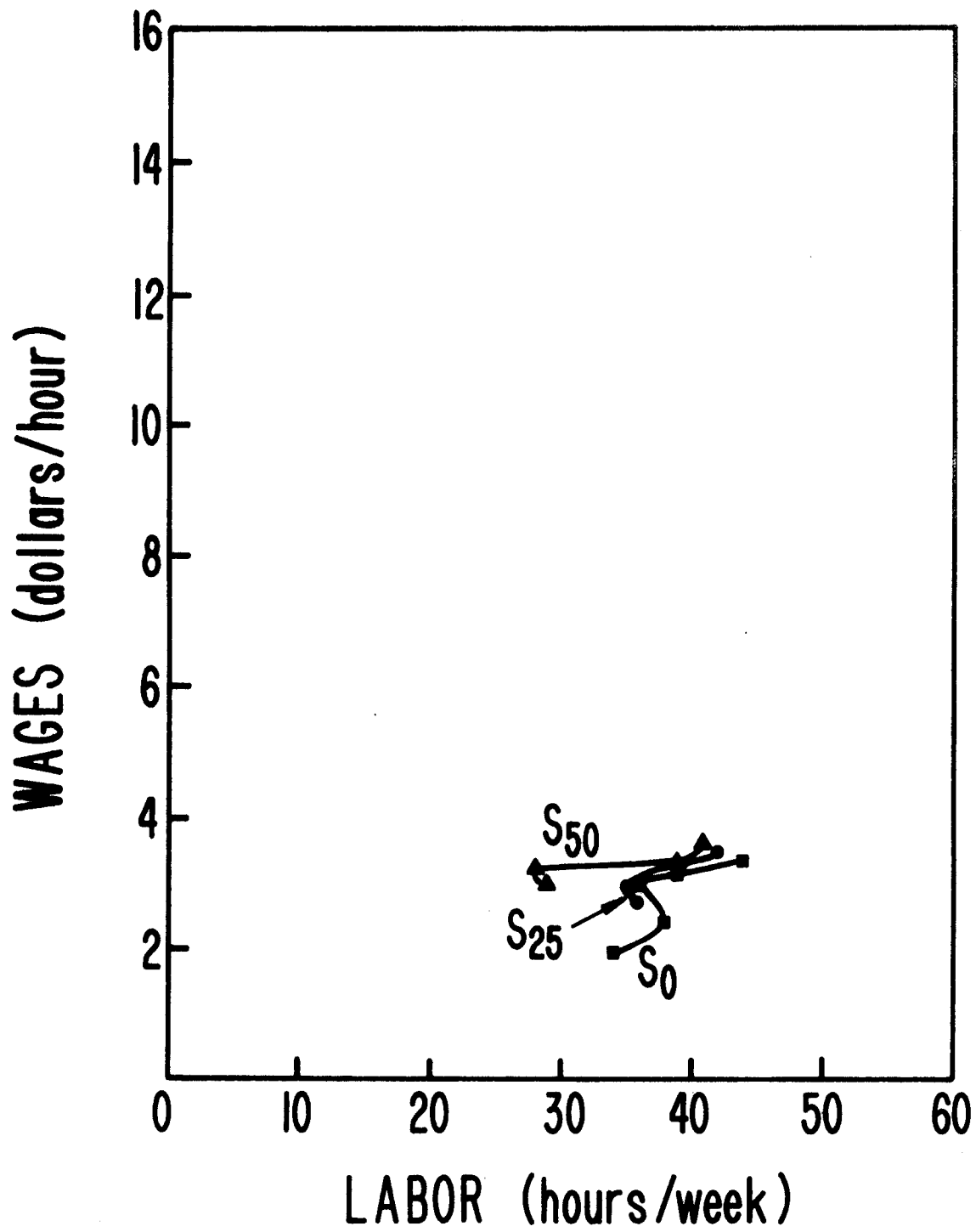Female, Age 24, Unmarried

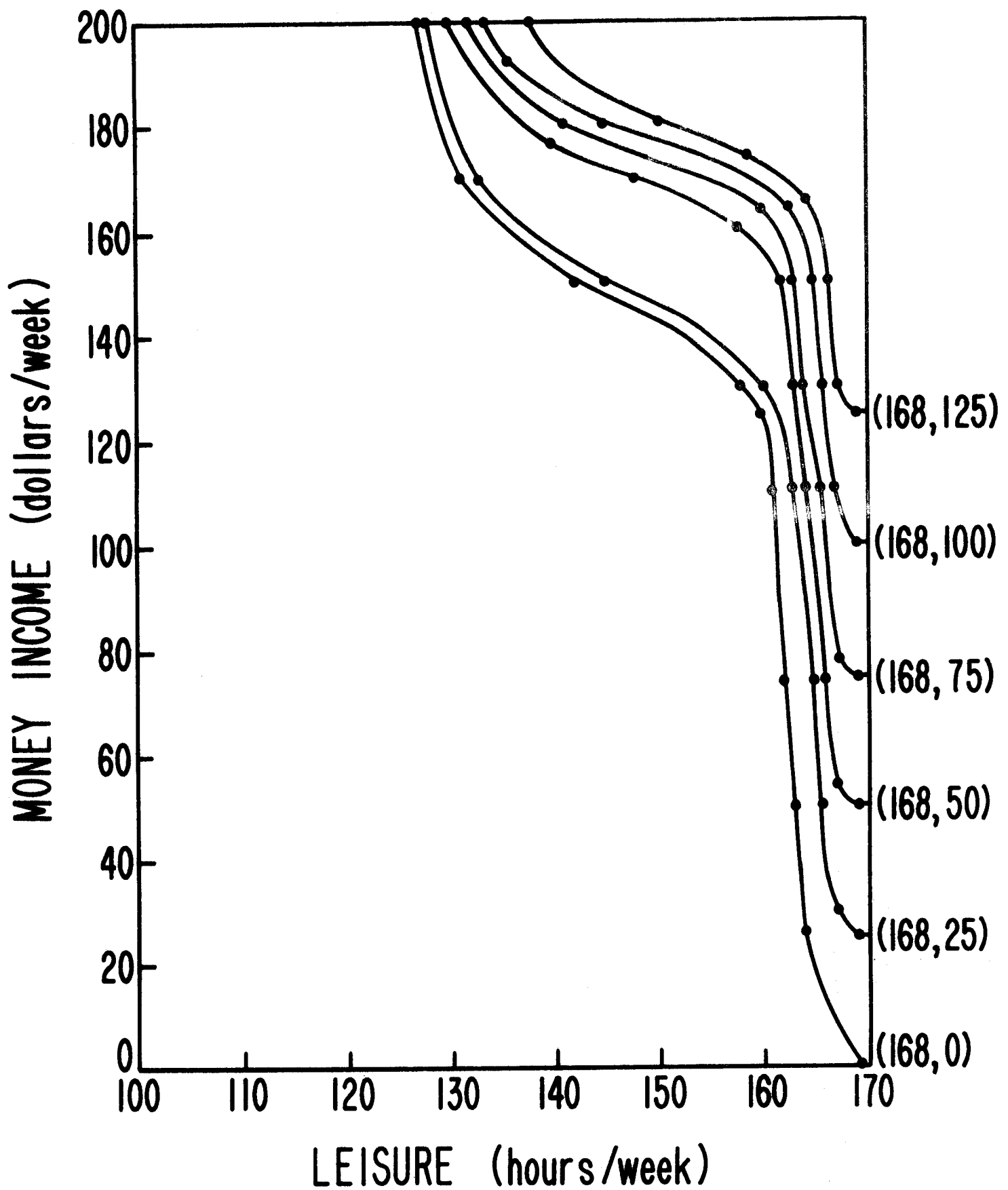Figure 4B: Supply Curves of Labor Implied by Figure 4A

Figure 5A: Indifference Curves for an Aeronautical Engineer, Male, Age 47, Married, One Child
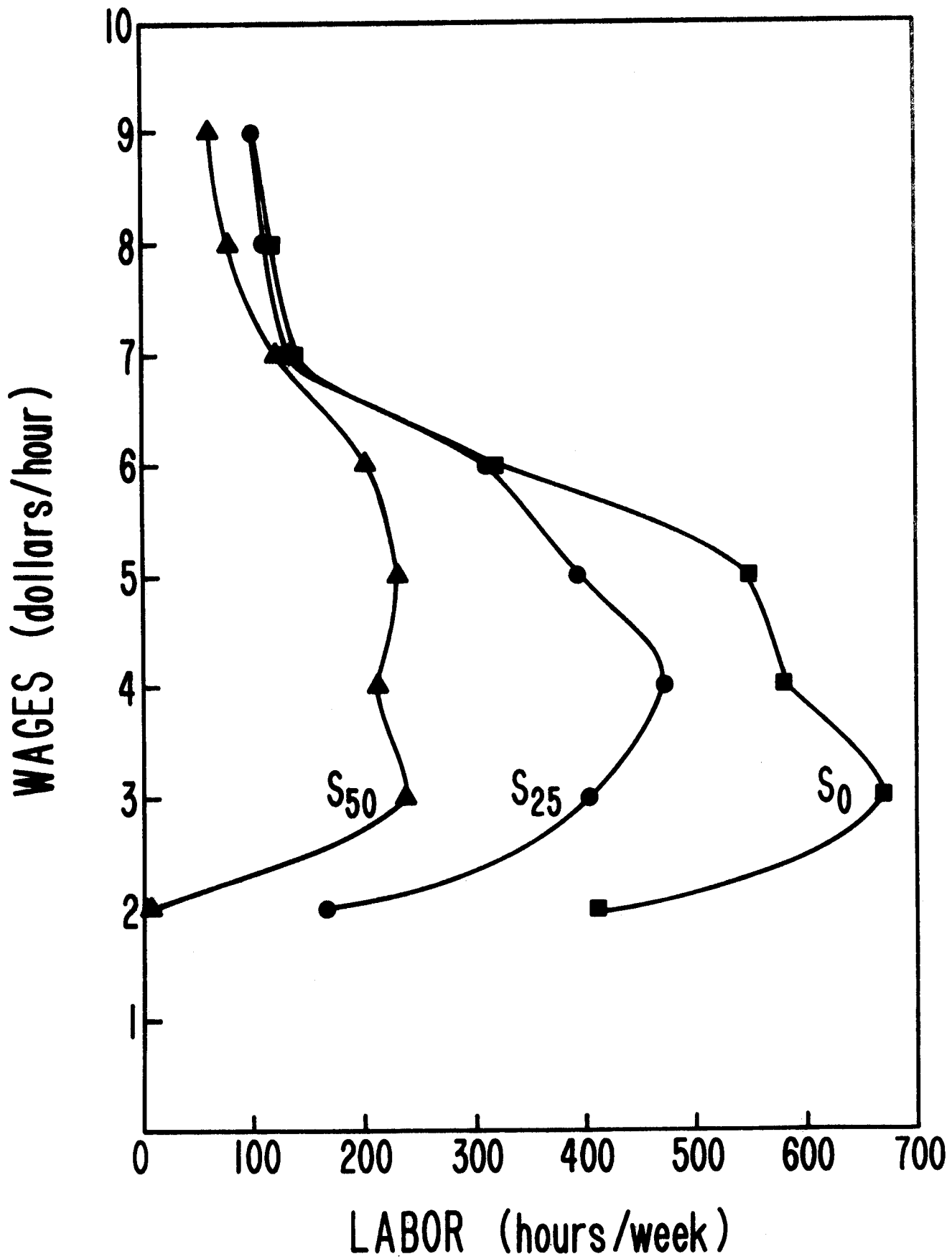
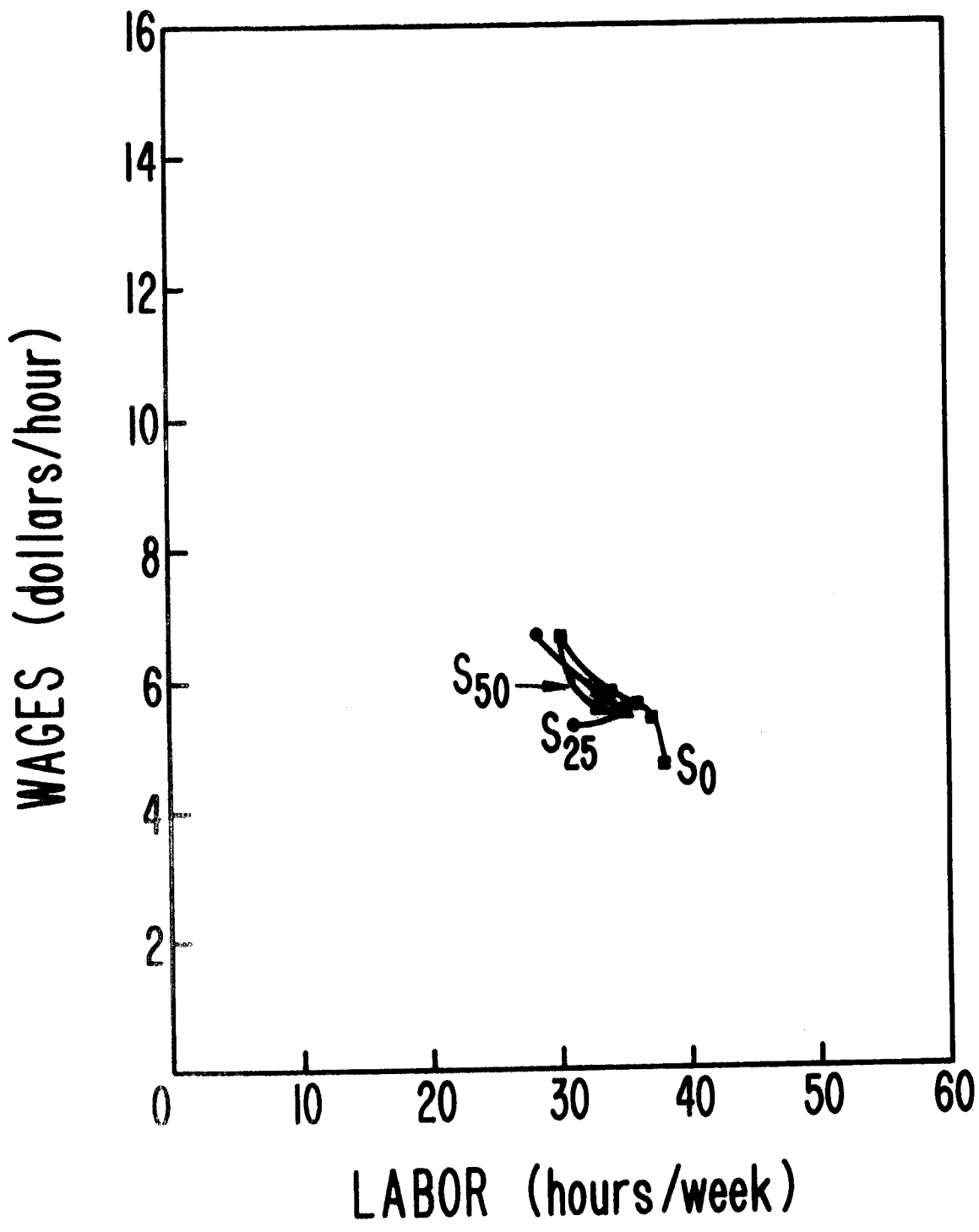Figure 6: Aggregate Supply Curves of Labor for 25 Subjects

Figure 5B: Supply Curves of Labor Implied by Figure 5A

respectively. All three are of the backward bending type, reaching maximum labor supply at $3 per hour in the unsubsidized case, at $4 per hour in the case of a subsidy of $25 per week, and at $3 per hour (and also at $5 per hour) in the case of a subsidy of $50 per week. In the unsubsidized case the average hours worked at the maximum labor supply is approximately 27 hours per week. At very high wage rates all three curves tend to converge, as would be anticipated since at such wages the subsidy differences would represent relatively little as compared to wages.

The effect of the subsidy on labor supply can be summarized as in Table 2, showing the percentage reduction in aggregate hours as compared to the unsubsidized situation. The reduction is very substantial at low wages, falling to relatively small amounts at higher wages, especially for the case of a $25 a week subsidy. At the wage of $3 per hour that would elicit a maximum aggregate labor supply the reduction is 40.3 percent for a $25 a week subsidy and 64.2 percent for a $50 a week subsidy. The reductions are 19.0 percent and 62.9 percent respectively in the case of a wage of $4 per hour, which is closer to the current average wage.

Wage per hour	Percentage Reduction	
	$25 per week subsidy	$50 per week subsidy
$2	75.2%	100.0%
3	40.3	64.2
4	13.0	62.9
5	29.0	58.2
6	0.8	37.4
7	0.7	11.4
8	8.7	31.8
9	1.8	38.7

Table 2: Percentage Reduction in Aggregate Labor Supply in the Subsidized, as Compared to the Unsubsidized Situation.

7. Conclusions

This study has experimentally measured supply curves of labor on the basis of estimated indifference curves for income-leisure choice given alternative assumptions as to lump-sum welfare subsidies. One conclusion is therefore the feasibility of such an experimental approach in studying labor supply. A second conclusion is that indifference curves and labor supply curves differ considerably as between individuals, but, in general, indifference curves exhibit the usually assumed convexity and labor supply curves are backward bending. Third, the individual supply curves can be summed to obtain an aggregate supply curve which is of the backward bending type. This aggregate supply curve and the other aggregate supply curves for alternative subsidy levels can be used to determine the reduction in labor supply stemming from welfare subsidies and thus can be used to analyze the impacts of welfare reform proposals.

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Wold, H. and L. Jureen, Demand Analysis, New York: John Wiley & Sons, Inc., 1953.