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HOUSEHOLD LABOUR SUPPLY IN URBAN AREAS OF A DEVELOPING COUNTRY

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ABSTRACT

We analyze labour supply behaviour and the choice between formal and informal sector work of the two partners in two adults families in urban areas in Bolivia, using cross-section data drawn in 1989. Our model generalizes the neoclassical family labour supply model. Nonmonetary returns of formal sector employment are introduced to capture that the choice between formal and informal work is not exclusively based on wage differentials. The nonlinear system of wage equations for males and females in the formal and informal sector, nonmonetary returns equations, and labour supply equations for both spouses, are estimated simultaneously by smooth simulated maximum likelihood.

Among our findings are substantial negative cross wage elasticities of labour supply. This suggests that families adjust labour supply to opportunities on the labour market: A low wage of the partner is compensated by working more hours. We find that lowering formal sector wages would not lead to a fall in participation: The fall of formal sector employment would be more than offset by a rise in informal sector participation.

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1. Introduction

We analyze labour supply behaviour of the two partners in two adults families in urban areas in Bolivia, using cross-section data drawn in 1989. We distinguish four types of labour supplied by the family: Husband's and wife's hours of work in the formal sector and in the informal sector. We present a static structural model, focusing on the relation between these four types of labour supply, their sensitivity to all four wages, and other family income.

One objective of this study is to see to what extent it is possible for a household in a developing country, to smooth consumption by reallocating labour supply of the family. In a developing country, household income is often generated by more than one member of the household. Poorer families may need more than one income to reach a level of subsistence. The labour supply decisions of the individual family members are likely to be correlated. For instance, if earnings of one family member fall, other family members may increase their labour supply to compensate for the loss in family income. The combined effect on household consumption is likely to be less than the initial shock.

The point of departure is a neoclassical family labour supply model. The family is assumed to take a joint decision regarding household consumption and labour supply of its members. Its objective is to maximize utility, determined by household consumption and leisure of all family members, under a household budget restriction. This approach is used in many studies. For example, Hausman and Ruud (1984) extend the linear labour supply model to the two adults family case and apply it to US data. Kapteyn et al. (1990) apply this model to Dutch data. Ransom (1987) uses a quadratic utility function to analyze labour supply of two adults households. Newman and Gertler (1991) estimate labour supply of rural households of varying size in Peru.

We focus on urban labour markets in a developing country. In this context, it is common practice to distinguish between a "formal" and an "informal" sector. This opens another way in which households can adjust income: If wages fall in one sector, some individuals may find it advantageous to switch to the other. During a period of economic malaise with a direct negative effect on formal sector wages, the informal sector is often seen to expand. This is referred to as the buffer function of the informal sector (Todaro, 1989). We incorporate it in our model.

Previous empirical studies that analyze labour supply in urban areas of a developing country include Magnac (1991), who extends the basic Roy (1951) model to analyze earnings in the formal and informal sector in Columbia, and Gindling (1991), who studied wage determination in the labour market of San José, Costa Rica. Thomas (1992) provides a recent survey on both theoretical and empirical studies concerning the informal sector. Our model combines the main features of Ransom (1987) with those of Magnac (1991).

We will use household survey data from urban areas in Bolivia, drawn in 1989. Our structural approach implies that a new household utility function would have to be specified for each type of household.[1] We therefore limit ourselves to households with one prime age male and one prime age female, which we refer to as two adults households. Some information on the position of these households among all households in the sample, will be presented in section 2.

The organization of the paper is as follows: In section 2 we introduce the dataset and provide descriptive statistics. In section 3 the model is introduced. Section 4 contains information on the estimation strategy and the estimation results are in section 5. Section 6 concludes.

2. Data

The research is based on data of the second round of the 1989 Bolivian household survey (Encuesta Integrada de Hogares). The survey uses a random sample of the urban population and is administered yearly by the Bolivian National Bureau of Statistics (Instituto Nacional de Estadística). The 1989 survey covers 7264 households in 8 urban centers. 3712 households contained one prime age male and one prime age female, with both of them potential workers (between 19 and 65 years old, in good health and not attending full-time education). The definition of formal and informal sector is, following Magnac (1991), based on the worker's status question. Wage workers and independent professionals, such as lawyers and doctors, are classified as formal, other self-employed workers are classified as informal. Others, such as family workers or employers are not classified.[2] 476 households were excluded because one of the partners could not be classified, 281 because one of the partners had more than one job. Finally, 153 households were excluded due to missing information on one the necessary variables (wages (123 cases), education level, hours worked).[3]

The sample used for estimation thus contains 2802 families. Table 1 contains some descriptive statistics. 91 percent of all males is working, against 40 percent of all females. The majority of males work in the formal sector. The opposite holds for females. Most individuals participating in the informal sector have little education; the higher educated are overrepresented in the formal sector.

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[1] Even a reduced form approach, as presented in Newman and Gertler (1991), implicitly makes arbitrary assumptions on the relations between utility functions of families of different composition.

[2] See Pradhan and Van Soest (1992) for details on the classification and for sample statistics on an individual level.

[3] For the sample of 3712 households consisting of one prime age female and one prime age male, average per capita household consumption is 142.8. For the selected sample, it is 136.0. This suggests that the data cleaning does not lead to serious sample selectivity problems. Compared to the average in the total survey, per capita income of two adults households is about 8 percent lower.

Table 1. Descriptive statistics
(formal and informal sector definition based on worker's status, means and sample fractions; standard deviation in parentheses)

	male formal	inform	not working	female formal	inform	not working
highest level of education attended:						
basic	0.22	0.36	0.32	0.10	0.44	0.35
inter	0.15	0.21	0.13	0.09	0.16	0.16
medio	0.30	0.28	0.30	0.20	0.20	0.28
middle technical	0.04	0.02	0.03	0.08	0.03	0.04
higher tech	0.02	0.02	0.03	0.04	0.01	0.01
normal	0.06	0.02	0.01	0.31	0.01	0.02
university	0.16	0.06	0.15	0.15	0.02	0.04
other	0.05	0.03	0.04	0.04	0.12	0.10
married	0.96	0.98	0.92	0.96	0.94	0.97
ethnic	0.33	0.42	0.36	0.22	0.48	0.34
age	35.66	37.63	39.58	34.33	35.55	33.06
wage	2.21	2.16		1.90	1.72	
	(3.16)	(2.55)		(1.54)	(2.29)	
hours	52.1	53.6		37.4	45.7	
	(17.1)	(17.8)		(16.2)	(25.7)	
othinc	7.46	4.82	35.66	9.01	5.97	10.94
observations	1755	782	265	423	710	1669

Explanation:
Dummy variables "basic" through "university" denote subsequent levels of education. Vocational training is referred to as "technical". "Normal" includes teachers training for primary education. "Other" includes all other types of education.
"married": 1 if married, 0 otherwise.
"ethnic": 1 if the respondent regularly speaks another language than spanish, 0 otherwise.
"othinc": household income (Bs per week) excluding earnings.
"hours": working hours per week.
"wage": hourly wage rate (in Bs).[4]

Ethnic minorities[5] are found more frequently in the informal sector. Average other, nonlabour, income is highest for those who do not participate. Average hourly earnings in the formal sector are slightly higher than in the informal sector. Average hours worked are higher in the informal sector. The hourly earnings distribution of working males and females in the sample is very similar to that in

[4]in Bolivianos; At the time of the survey 1 Boliviano was worth approximately 0.37 U.S. dollar. Income taxes do not play an important role. The bulk of government revenues is collected trough a consumption tax.

[5] Ethnic minorities are identified through the language question. If the respondent commonly speaks another language than spanish he or she is considered to belong to an ethnic minority.

the original sample of 7264 families.
Table 2 contains some *prima facie* evidence of intrahousehold effects of labour supply. We have calculated the average female participation rate and the average log wage of working females by wage quintile of the male. The female participation rate is highest in the lower and upper male wage brackets. Yet, female wages increase with the male's wage. The high participation rate in the lower quintile could be explained by the low income earned by the male: One income is not enough to support the family. For the high male wage bracket, the own wage effect of the female seems to dominate: The high wage she can earn induces her to work.

Table 2. Female labour supply by male wage quintile (participation rate in percentages, log female's wage conditional upon working, standard errors in parentheses)

wage quintile male	participation rate female	log wage female
not working	49.4	0.13
	(3.5)	(0.07)
1 (poor)	44.3	-0.34
	(2.2)	(0.06)
2	36.9	-0.02
	(2.1)	(0.06)
3	39.1	0.26
	(2.2)	(0.06)
4	36.7	0.32
	(2.1)	(0.06)
5 (rich)	40.6	0.78
	(2.2)	(0.06)

3. The model

Since the few individuals with two jobs are removed from the sample, nobody in the sample works both in the formal and in the informal sector. We assume that an individual can earn a fixed hourly wage in each sector, where the wages in the two sectors can be different. The simplest assumption then is to assume that the individual simply chooses the sector with highest hourly earnings. This however is not necessarily consistent with the data (Magnac, 1991). Unobserved nonmonetary returns are introduced to explain why people may choose the sector yielding the lower (monetary) earnings.

As a consequence, three sections of the model can be distinguished. The labour supply section models the joint labour supply decision of the two spouses. Labour supply functions are derived on the basis of wage rates, nonlabour income, and individual taste shifters. The wage rate of each spouse is the maximum of the wage rates he or she can earn in the formal and the informal sector, including nonmonetary returns. The second section of the model describes the wage offers in both sectors for both sexes, excluding the unobserved nonmonetary returns. The third part of the model consists of the nonmonetary returns equations.

Labour supply

The labour supply section of the model is identical to that of Ransom (1987). A household is characterized by a quadratic direct utility function which has household consumption and leisure of both partners as arguments. The family maximizes utility subject to a household budget constraint and nonnegativity conditions on hours worked:

$$\begin{aligned} \max \quad & U(Z) = \alpha Z - \frac{1}{2} Z'\beta Z \\ s.t. \quad & w_m^* h_m + w_f^* h_f + Y = C \\ & h_m \geq 0 \\ & h_f \geq 0 \end{aligned} \tag{1}$$

with

$Z=[T-h_m, T-h_f, C]'$

T: time endowment

h_m, h_f: hours worked by male and female

C: family consumption

Y: nonlabour income

w_m^*, w_f^*: hourly wage of male and female

$\alpha \in \mathbb{R}^3$; $\beta \in \mathbb{R}^{3x3}$.

In our case, wage rates are the maximum of formal and informal sector wages, including nonmonetary returns (see below). We assume that the budget constraint is binding, i.e. that utility increases with C. If neither of the two nonnegativity conditions on hours are binding, first order conditions can be written as

$$\alpha_1^* + \alpha_3^* w_m^* - \beta_{11} h_m - \beta_{33} w_m^* (w_m^* h_m + w_f^* h_f + Y) - \beta_{12} h_f + \beta_{13} (2 w_m^* h_m + w_f^* h_f + Y) + \beta_{23} w_m^* h_f = 0 \tag{2}$$

$$\alpha_2^* + \alpha_3^* w_f^* - \beta_{22} h_f - \beta_{33} w_f^* (w_m^* h_m + w_f^* h_f + Y) - \beta_{12} h_m + \beta_{23} (2 w_f^* h_f + w_m^* h_m + Y) + \beta_{13} w_f^* h_m = 0 \tag{3}$$

The α^*s are a function of α, β and the time endowment. See Ransom (1987) for details. The quadratic specification implies that it is not necessary to specify the time endowment. Following Ransom, we allow α_1^* and α_2^* to be a function of observed taste shifters Q_{ki} and unobserved taste shifters ϵ_{ki} (k=1,2), where the subscript i denotes the household:

If one of nonnegativity constraints becomes binding and one of the partners does

$$\alpha^*_{ki} = Q_{ki}\Gamma_k + \epsilon_{ki} \qquad k=1,2 \quad \epsilon_i = \begin{pmatrix}\epsilon_{1i}\\ \epsilon_{2i}\end{pmatrix} \quad \epsilon_i \sim N(0,\Sigma) \tag{4}$$

not work, one of the first order conditions changes into an inequality condition. This results in a simultaneous model of two tobit equations. Due to the quadratic utility function, the underlying latent model is linear. See Ransom (1987) for details.

Wages

The log of the hourly wage in both sectors is modeled as a linear function of exogenous variables and an error term:

$$\ln (w_{kj}) = X_k \tau_{kj} + \eta_{kj} \qquad \eta_{kj} \sim N(0,\sigma^2_{kj}) \qquad \begin{matrix} j=1,2 & \textit{for formal and informal} \\ k=1,2 & \textit{for male and female}\end{matrix} \tag{5}$$

For ease of notation we have dropped the index i as we shall continue to do in the rest of the paper. We use separate wage equations to describe earnings in both sectors for both sexes. The error terms are assumed to be independent of each other and of the random preference terms in the labour supply section of the model.

Nonmonetary returns

Under the assumption of homogeneous preferences and free movement between sectors all individuals participate in the sector in which the wage offer is the highest. This is the assumption in the classical Roy (1951) model. However, individuals not necessarily participate in the sector with the highest wage offer. Two effects can be distinguished. On the one hand, demand factors may limit movement between sectors. In particular, the view that entrance into the formal sector is restricted is wide spread (see Fields 1975). On the other hand, preferences for sectors may differ across individuals. For example, apart from wages, larger freedom in the informal sector or larger job security in the formal sector may be considered. We capture such effects under nonmonetary returns (NMR) to the job. This is the monetary equivalent of all nonwage factors that influence sector participation. Magnac (1991) assumes homogeneous preferences for sectors and interprets nonmonetary returns as rationing.

We model nonmonetary returns as a fraction of the monetary wage. Only the difference in nonmonetary returns between sectors is identified because we do not observe reservation wages. We normalize informal nonmonetary returns to zero. The log of the (formal sector) nonmonetary returns NMR_k (k=1 (male), 2 (female) are written as a function of individual characteristics, local labour market conditions and an error term:

We assume that each individual chooses the sector with highest wage offer,

$$\ln\,(NMR_k+1)=V_k\gamma_k+\mu_k \qquad \mu_k\sim N(0,\sigma_k^2) \tag{6}$$

including nonmonetary returns. For the formal sector the wage is $w^*_{Ik}=(NMR_k+1)w_{Ik}$. For the informal sector, the wage offer itself enters because non-monetary returns equal zero. With probability one, the wage offers will be different, so that the individual chooses one sector only.

The complete model thus consists of eight equations: two wage equations for each sex, one nonmonetary returns equation for each sex, and two labour supply equations. Note that the labour supply section of the model is modelled in terms of hourly wages, while in the second section of the model wages and nonmonetary returns are modelled in logs, so that the model as a whole is nonlinear.

The model is an improvement on the Ransom (1987) model in that the wage equations are incorporated and estimated jointly with the labour supply equations. Ransom predicted wage offers for nonparticipants using a separate model, thus ignoring wage rate prediction errors. Furthermore, we distinguish between two sectors. The model also generalizes the one presented in Magnac (1991): We follow a more structural approach, and consider not only participation but also hours worked. Moreover, while Magnac considers individuals, we work on the household level and analyze intra household interactions.

4. Estimation

Due to its nonlinear nature, the model cannot be estimated by maximum likelihood. Exact likelihood contributions would be too hard to compute at each step of the maximization process. Instead, we maximize an approximation of the likelihood, based upon simulations of some of the errors in the wage and nonmonetary returns equations. This method is an example of smooth simulated maximum likelihood (cf. Boersch-Supan and Hajivassiliou (1993), for example). We only describe the main idea here. Details can be found in the appendix.

If, for a given family, both partners are working and w^*_m and w^*_f are known, the likelihood contribution of the labour supply part of the model (conditional on wages) is identical to that in Ransom (1987). We denote it by $L_I(h_m,h_f;\, w^*_m,w^*_f)$. To keep notation simple, we suppress the other arguments it depends on (taste shifters, other family income). The complete likelihood contribution is then given by

$$\mathbf{L(h_m,h_f,s_m,s_f,w^*_m,w^*_f) = L_I(h_m,h_f;\, w^*_m,w^*_f)\, L_{II}(s_m,w^*_m)\, L_{III}(s_f,w^*_f)} \tag{7}$$

Here L_{II} and L_{III} are the likelihood contributions of the wage and nonmonetary returns equations for male and female,respectively. s_m and s_f are the observed sectors of male and female. Because of the linearity of this part of the model and independence assumptions of the errors, L_{II} and L_{III} can easily be computed. It factors out into a contribution of the male and a contribution of the female, both similar to Magnac's (1991) likelihood. In this case therefore, the likelihood contribution can be written down exactly.

This is only relevant however, if both partners work in the informal sector. If either of them does not participate or works in the formal sector, his or her relevant wage is not observed. In case of nonparticipation, this is the familiar problem in estimating structural labour supply models with unobserved wage rates (cf. MaCurdy et al (1990), for example). In case of formal sector work, we observe the monetary wage, but we must include nonmonetary returns which are always unobserved. Let us assume that male and female both work in the formal sector. The likelihood contribution can now be written as

$$L(h_m,h_f,s_m,s_f,w_m,w_f) = E\{L_I(h_m,h_f;w_m^*,w_f^*)L_{II}(s_m,w_m^*)L_{III}(s_f,w_f^*)\} \qquad (8)$$

where the expectation is taken with respect to the unobserved errors in the nonmonetary returns equations, linking the observed w_m and w_f to the unobserved w_m^* and w_f^*. See appendix for details. This expectation cannot be computed analytically, because L_I is a complicated nonlinear function of w_m^* and w_f^*. It is therefore replaced by a simulated mean:

$$L_{II}(h_m,h_f,s_m,s_f,w_m,w_f)=(1/H)\Sigma_{j=1}^{H}\{L_I(h_m,h_f;w_{mj}^*,w_{fj}^*)L_{II}(s_m,w_{mj}^*)L_{III}(s_f,w_{fj}^*)\} \qquad (9)$$

where w_{mj}^* and w_{fj}^* $(j=1,\dots,H)$ result from adding H independent draws of the errors in the NMR equations to the observed formal sector wages.

This procedure is easily generalized to other cases. For those individuals who do not participate, we draw all the errors in the wage and nonmonetary returns equations. The maximum wage offer from the two sectors is substituted in the labour supply part of the model. This type of nonlinearity was also solved trough simulation by Laroque and Salanie (1989) for a disequilibrium model. The sample log likelihood is replaced by an approximate loglikelihood, replacing each likelihood contribution by its simulated approximation. The simulated maximum likelihood (SML) estimator maximizes the approximate sample loglikelihood.

The estimator is consistent if both the number of observations N and the number of draws per observation H go to infinity. Moreover, if draws for different observations are independent, the estimator is asymptotically efficient if $\sqrt{N}/H$ goes to zero (Gourieroux and Monfort 1993). Because the errors in the labour supply part of the model are retained and not simulated, the approximate likelihood is a continuous and differentiable function of the parameters. This makes maximization feasible and, according to previous studies on similar models (Boersch-Supan and Hajivassiliou, 1993, for example), should lead to acceptable results for small values of H already. We use H=30[6].

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[6] Pradhan (1993) finds for a similar model that further increasing the number of draws hardly changes the results.

5. Estimation Results

We first present the estimates of the labour supply model, equations (1) through (4). The estimates of Γ_1 and Γ_2, determining α_1^* and α_2^*, are in table 3. A higher value of α^* is associated with a higher propensity to work, since α^* is a negative function of α. Exogenous variables included in Q_k (k=1,2) refer to family composition and age. The number of children in the household (YOUNG) significantly increases the propensity to work for males and has the opposite effect for females. The number of older persons in the household (OLD) is insignificant. A quadratic age pattern is significant for both males and females.[7] The propensity to work is highest at age 33 for males and at age 42 for females. There is a significant negative correlation between the two random preference terms indicating, *ceteris paribus*, a tendency towards specialization.

Table 3. Estimates for taste shifters in labour supply model (standard errors in parentheses)

	α_1^*	α_2^*		
cnst	1.546	-8.652		
	(0.733)	(1.830)		
young	0.125	-0.154		
	(0.037)	(0.052)		
old	-0.067	0.196		
	(0.306)	(0.318)		
age	1.419	3.843		
	(0.390)	(0.935)		
age squared/100	-2.173	-4.592		
	(0.471)	(1.145)		
σ^2	9.117	7.068	σ_{12} (Σ_{12})	-1.944
	(0.416)	(2.077)		(0.802)

The estimates for the matrix β are presented in table 4. To normalize the scale of the utility function, we have set β_{11} equal to one, following Ransom (1987). All estimated coefficients are significant. The marginal utility of leisure increases with additional leisure of the partner. Moreover, marginal utility of both partners increases with family consumption.

In writing down the first order conditions (2)-(3), we do not take account of the possibility that an interior point of the budget set is chosen. It is thus assumed that the utility function increases with family consumption. According to our results, this is the case for 2757 out of 2802 observations. The 45 remaining observations are discarded in the simulations below. If utility increases with family consumption, the solution of the Lagrange equations (equalities and inequalities) corresponds to the utility maximum if the utility function is quasiconcave. Positive definiteness of β is a sufficient but not a necessary condition. Since our estimate of

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[7] α_1^* and α_2^* depend on the male's and female's age, respectively.

β is not positive definite, we checked concavity conditions for all observations. It appears that they are satisfied without exception.[8]

Table 4. Estimates for β matrix (standard errors in parentheses)

	male leisure	female leisure	consumption (/10)
male leisure	1		
female leisure	-0.262	0.414	
	(0.054)	(0.088)	
consumption(/10)	-0.340	-0.326	0.0178
	(0.057)	(0.055)	(0.0029)

Figures 1 and 2 illustrate the shape of the labour supply curves. Figure 1 shows unconditional supply curves, i.e. predicted numbers of hours worked (divided by 10) for males and females as a function of both partners' wages (including nonmonetary returns).[9] α_1^* and α_2^* are set equal to their sample means (α_1^*=4.1, α_2^*=-1.7), random preferences are set equal to zero. Male labour supply is forward bending in most of the range of male wages, and backward bending for very high wage rates, where the income effect dominates the substitution effect. If w_f^* is low, the female does not work, and male hours depend on w_m^* only. If the female works, male hours are negatively affected by the female's wage. The female's hours of work increase with her own wage and decrease with the husband's wage.

Figure 2 shows the probability of participation for both males and females as a function of their own wage and the number of hours worked by the partner (divided by 10). The wage of the partner and all family characteristics are kept at the mean predicted value. Random preferences are taken into account. For females, the own wage effect on the probability of working is positive. The effect is stronger if the male works fewer hours. The effect of the husband's wage on the wife's hours is small, and its sign depends on the female's wage. Only for high wages of the female, this effect is substantially negative. For the family the graph refers to, the probability that the male works is always higher than 0.95. There is a slight positive own wage effect and a negligible effect of the female's hours on this probability.

The estimates of the wage equations and the non-monetary return equation for both sexes are presented in table A1 in the appendix. In the wage equations we have included individual characteristics such as age, education level and ethnicity, and variables describing local labour market conditions such as the local unemployment rate and a measure for the size of the economically active

[8] This also implies that the model is coherent, in the sense that endogenous variables are uniquely determined (cf. Van Soest et al., 1993).

[9] Estimated sample averages of wages including nonmonetary returns are 6.6 for males and 3.0 for females.

population, as a proxy for the size of the local labour market. The specification is similar to that in Pradhan and Van Soest (1992), and so are the results. For example, returns to education are larger in the formal sector than in the informal sector. This may indicate that the formal sector requires skills obtained trough the formal education system or that education is used as a screening device in the formal sector. A larger local labour market generally leads to a higher wage. The effect is significant for males in the formal sector and for females in the informal sector. The significantly negative effect of the local unemployment rate is largest in the informal sector. This can be explained by the fact that the informal sector is more competitive than the formal sector. In the formal sector, ethnic minorities are paid significantly less than others.

In the nonmonetary return equations for formal sector employment, we have included the variables of the wage equations and two taste shifters: the numbers of young and old persons in the family. Nonmonetary returns may result from demand side constraints (rationing) or from individual preferences concerning sector participation. For both male and females we find that "normal" education (primary school teachers) has positive nonmonetary returns. People with this type of training attach a higher status to teaching in a primary school, which is exclusively formal, to informal sector work. If one assumes that preferences do not depend on ethnicity, the negative coefficient on "ethnic" can be interpreted as an indicator of relatively high job search costs for ethnic minorities for formal sector jobs or, discrimination. The number of young children increases preference for informal sector jobs. Perhaps this is because of higher flexibility of when and how much to work in the informal sector. Maybe also, additional income can be generated in the informal sector by child labour. The hypothesis of weakly competitive markets (all parameters in nonmonetary returns equation equal zero) as defined by Magnac (1991), is clearly rejected for both males and females.[10]

Simulations

To see how well the model predicts the distribution of hours worked and sector participation, we present figure 3 and table 5. For all observations in the sample we have simulated wages, nonmonetary returns, and the number of hours worked, taking one draw from the distribution of the error terms. In the top and bottom panel of figure 3, the predicted and actual sample distribution of hours worked are shown, respectively. Note that the scale of the vertical axis varies per graph. Actual hours distributions for males are peaked at 40 and 48 hours per week. These peaks are not fully reproduced by the predictions. This would require a model incorporating restrictions on hours worked, as in Dickens and Lundberg (1993). For females, the distribution of both actual and predicted hours worked is more dispersed.

In table 5 we present a cross tabulation of the sector in which husband and

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[10] Wald tests statistics are 230 and 580, exceeding critical values of χ^2_{15}, for any sensible significance level.

wife participate.[11] We compare actual and predicted numbers. The model underpredicts the number of nonparticipants. This is particularly serious for males. Possible explanations may be fixed costs of working or a lack of available part-time jobs. The ratios of formal and informal sector participation rates are predicted with reasonable accuracy.

Table 5. cross tabulation of sector participation for male and female (actual and predicted, percentages)

female⇒	formal		informal		not-working		total	
male⇓	actual	pred	actual	pred	actual	pred	actual	pred
formal	11.1	10.0	12.0	17.0	39.7	39.9	62.8	66.9
informal	2.7	4.8	9.0	9.5	16.0	15.3	27.6	29.7
not working	1.4	1.3	3.4	0.8	4.9	1.4	9.6	3.5
total	15.1	16.1	24.4	27.3	60.5	56.7	100	100

In Table 6 we present the results of some simulation exercises. The objective of the first two simulations is to examine the importance of intra-household effects. We first simulate the labour supply response of a 10 percent drop of wage rates for all males. This has hardly any effect on the average number of hours the male works. Participation of males slightly decreases. Labour supply of the females however, shows a stronger response: Her average number of hours worked increases by 3.0 percent, corresponding to a cross labour supply elasticity of -0.3.

A closer look at the own labour supply response for males reveals that the low elasticity is not uniform over the sample. Males with a positive labour supply response are those who initially had a high wage. For most males with a low wage, the labour supply response to a wage decrease is negative. This corresponds with the inverted U shape of the labour supply curve shown in figure 2.

The second simulation concerns a 10% decrease of wage rates of females. This has only a very small effect on hours worked by males and females. Male hours increase and female hours decrease, but both effects are less than one percent. To get some insight in aggregate income elasticities, we also performed a simulation in which nonlabour income increased by 10 percent for all households. For 15 percent of the households this does not have any effect, since their non-labour income was zero to start with. The effects were quite small. For both males and females, hours worked decrease slightly. Income elasticities are 0.005 for males and 0.012 for females.

A main objective of this paper is to see how well a family can counter an exogenous shock in income by adjusting hours worked and by switching between sectors. Therefore, we simulated a fall in all formal sector wages by 10 percent.

[11] Tables 5 through 7 are based on the 2757 observations for which utility increases with family consumption.

See tables 6 and 7. There is a strong direct effect on the income of the majority of males employed in the formal sector. 2.3 percent of males switch from the formal to the informal sector, while the participation rate for males remains the same. Labour force participation of females increases by 0.4 percent. This is a result of two opposite effects: An increase due to reduced partner's earnings (cf. previous simulation), and a decrease due to the fall of the own (formal sector) wage. The average number of hours worked increase for both males and females. Labour supply of males increases because formal sector workers are generally in the higher income brackets. The size of the informal sector increases by 5.9 percent. This prediction should be viewed as an upper limit, since a fall in formal sector wage offers will often be accompanied by a fall in informal sector wages.

Table 6. Simulations (sample averages and changes of sample averages, standard errors in parentheses[12], wage and income excluding nonmonetary returns)

	actual	predicted	wage male -10%	wage female -10%	formal wage -10%
		mean	Δ	Δ	Δ
wage offer male		2.05	-0.205	0	-0.135
		(0.04)	(0.004)		(0.005)
wage offer female		1.48	0	-0.148	-0.051
		(0.04)		(0.004)	(0.004)
hours male	47.10	46.93	-0.034	0.156	0.120
		(0.55)	(0.040)	(0.015)	(0.031)
perc working	90.40	96.44	-0.208	0.144	-0.009
		(0.30)	(0.081)	(0.072)	(0.076)
hours female	16.10	16.86	0.458	-0.129	0.306
		(0.77)	(0.043)	(0.032)	(0.035)
perc working	59.50	43.33	0.902	-0.838	0.419
		(1.03)	(0.191)	(0.177)	(0.171)
household income	126.30	130.95	-8.581	-2.688	-6.285
		(2.23)	(0.227)	(0.152)	(0.278)

[12] Based on 300 draws from estimated asymptotic distribution of estimator of β.

Table 7. Simulated Sector participation rates after 10 percent drop formal sector wage (percentages, standard errors in parentheses)

	male		female	
	before	after	before	after
	mean	Δ	mean	Δ
formal	66.8	-2.23	16.0	-0.74
	(0.95)	(0.25)	(0.80)	(0.18)
informal	29.6	2.22	27.3	1.15
	(0.93)	(0.25)	(1.07)	(0.19)
not working	3.6	0.01	56.7	-0.42
	(0.29)	(0.08)	(1.03)	(0.17)

6. Conclusions

We have analyzed labour supply behaviour and the choice between formal and informal sector work of the two spouses in two adults families in urban areas of Bolivia. For this purpose, we have developed a static neoclassical model, combining the family labour supply model of Ransom (1987) with the model explaining sector choice and earnings of Magnac (1991). Our main empirical conclusion is that intra-household effects are substantial: low earnings of the husband are compensated by more working hours of the wife. Second, we find that a wage shock in the formal sector induces people to move to the informal sector, while the effect on nonparticipation is much smaller. Third, we find that nonmonetary returns in the formal sector are usually positive. This implies that, on average, if formal and informal sector wage are equal, people prefer a formal sector job. It can be explained by differences in job characteristics. This finding is different from that of Magnac (1991), who finds that nonmonetary returns are insignificant.

Although our model captures some features of the data quite well, a simulation makes clear that it is not fully capable to reproduce the data. In particular, nonparticipation of males and, to a lesser extent, of females is underpredicted. Allowing for fixed costs of working or taking account of constraints on hours worked, might help to overcome this problem. The quadratic specification of the utility function, together with the estimation method of smooth simulated maximum likelihood, make these extensions feasible areas of future research.

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Explanation table A1 on next page:

Education level is incorporated as follows: First, dummies are used to indicate the highest level of courses attended. Second, for those who did not complete the course, we used the deviation between the level attained and the level if completed, expressed in years ("miss years"). This deviation is zero if the course is finished and negative otherwise.

Cf. table 1 for the other variables.

Table A1. estimated coefficients for wage equations and non-monetary return equations (standard errors in parentheses)

	male			female		
	formal	informal	nmr	formal	informal	nmr
cnst	-1.334	0.649	2.399	-2.069	-0.820	-2.055
	(0.281)	(0.384)	(0.372)	(0.649)	(0.514)	(0.944)
age	0.710	0.101	-0.124	0.808	0.429	1.109
	(0.137)	(0.168)	(0.206)	(0.318)	(0.239)	(0.502)
age squared	-0.771	-0.083	-0.259	-0.967	-0.483	-1.441
	(0.177)	(0.202)	(0.269)	(0.410)	(0.299)	(0.647)
inter	0.167	-0.059	-0.241	0.553	0.177	0.365
	(0.060)	(0.076)	(0.089)	(0.129)	(0.103)	(0.202)
medio	0.351	0.168	0.182	0.812	0.210	0.395
	(0.051)	(0.070)	(0.072)	(0.119)	(0.091)	(0.192)
midtech	0.664	0.206	-0.049	1.120	0.172	1.000
	(0.110)	(0.172)	(0.196)	(0.142)	(0.204)	(0.217)
hightech	0.784	0.311	-0.046	1.165	0.688	1.448
	(0.126)	(0.223)	(0.209)	(0.225)	(0.264)	(0.264)
normal	0.581	-0.375	0.273	1.280	-0.068	2.311
	(0.105)	(0.175)	(0.131)	(0.126)	(0.254)	(0.182)
university	1.181	0.099	-0.159	1.767	0.326	1.130
	(0.062)	(0.102)	(0.094)	(0.134)	(0.177)	(0.208)
other	0.583	-0.190	0.347	0.016	-0.253	-0.377
	(0.091)	(0.170)	(0.098)	(0.169)	(0.124)	(0.283)
miss years	0.068	0.027	-0.001	0.123	0.013	0.121
	(0.015)	(0.022)	(0.021)	(0.031)	(0.027)	(0.049)
econ act	0.144	0.041	-0.226	0.089	0.199	-0.010
	(0.029)	(0.044)	(0.044)	(0.055)	(0.054)	(0.075)
unempl	-0.630	-1.211	-0.351	-0.568	-0.918	-0.507
	(0.121)	(0.173)	(0.162)	(0.226)	(0.219)	(0.308)
ethnic	-0.160	-0.031	-0.220	-0.210	0.041	-0.291
	(0.044)	(0.060)	(0.060)	(0.091)	(0.078)	(0.134)
young			-0.059			-0.088
			(0.017)			(0.037)
old			-0.083			-0.142
			(0.080)			(0.136)
σ	0.751	0.798	1.086	0.684	0.904	1.113
	(0.010)	(0.020)	(0.025)	(0.025)	(0.023)	(0.054)

Appendix: Simulated Likelihood Contributions

The likelihood contributions consist of three parts, L_I, L_{II}, and L_{III}, as introduced in (7). L_I is the contribution of the labour supply section of the model, for given wages w_m^* and w_f^* of males and females. The expression for L_I is given in Ransom (1987). L_{II} and L_{III} reflect the likelihood contributions of wage equations and nonmonetary returns, for males and females, respectively. Because males and females are treated identically in the model, L_{II} and L_{III} are similar. We first consider the male and look at L_{II}.

If the male works in the formal sector, w_m is observed, but w_m^* is not, because of the nonmonetary returns. If μ_1, the error in the NMR equation, were known, the likelihood contribution of this section of the model would be given by

$$L_{II}(\mu_1) = \int_{-\infty}^{\ln(w_{11})+V_1\gamma_1+\mu_1-X_1\tau_{12}} f(\eta_{12})d\eta_{12}\, f(\eta_{11}) \tag{A1}$$

where f denotes the (normal) p.d.f. of η_{12} and η_{11} resp. $L_{II}(\mu_1)$ is thus easy to compute.

If the male works in the informal sector, we observe w_m^*. Nonmonetary returns in the informal sector are zero. The likelihood contribution equals

$$L_{II} = \int_{-\infty}^{\ln(w_{12})-X_1\tau_{11}-V_1\gamma_1} f(\mu_1+\eta_{11})\, d(\mu_1+\eta_{11})\, f(\eta_{12}) \tag{A2}$$

If the male does not participate, we don't know whether the informal or the formal sector wage is relevant, and we must condition on η_{11}, η_{12} and μ_1. L_{II} equals 1 and vanishes. The wage that enters into L_I equals

$$w_m^*(\eta_{11},\eta_{12},\mu_1)=\exp(\max(X_1\tau_{11}+\eta_{11}+V_1\gamma_1+\mu_1, X_1\tau_{12}+\eta_{12})). \tag{A3}$$

L_{III} is calculated in a similar way. The full likelihood contribution of the family is given by the expectation of the product of L_I, L_{II} and L_{III}, with respect to the error terms that we conditioned on. For example, if the husband works in the formal sector and the wife does not participate, the exact likelihood contribution is given by

$$L(h_m,h_f,s_m,w_m) =$$

$$= \int L_I(h_m,h_f;w_m^*(\mu_1),w_f^*(\eta_{21},\eta_{22},\mu_2))L_{II}(\mu_1)f(\mu_1,\eta_{21},\eta_{22},\mu_2)d\mu_1 d\eta_{21} d\eta_{22} d\mu_2 \tag{A4}$$

where f denotes the (normal) p.d.f of $(\mu_1,\eta_{11},\eta_{22},\mu_2)$. The four dimensional integral in (A4) cannot be computed analytically, because L_I is a complicated nonlinear function of w_m^* and w_f^*. It is therefore replaced by a simulated mean:

$$L_H(h_m,h_f,s_m,w_m)=(1/H)\Sigma_{j=1}^{H}\{L_I(h_m,h_f;w_m^*(\mu_{1j}),w_f^*(\eta_{21j},\eta_{22j},\mu_{2j}))L_{II}(\mu_{1j}) \tag{A5}$$

where $(\mu_{1j},\eta_{21j},\eta_{22j},\mu_{2j})$, $j=1,\ldots,H$, are i.i.d. draws from the distribution of $(\mu_1,\eta_{21},\eta_{22},\mu_2)$. Other cases are treated in a similar way. The integral to be replaced varies from six dimensional ($h_m=h_f=0$) to zero dimensional (male and female work in the informal sector).

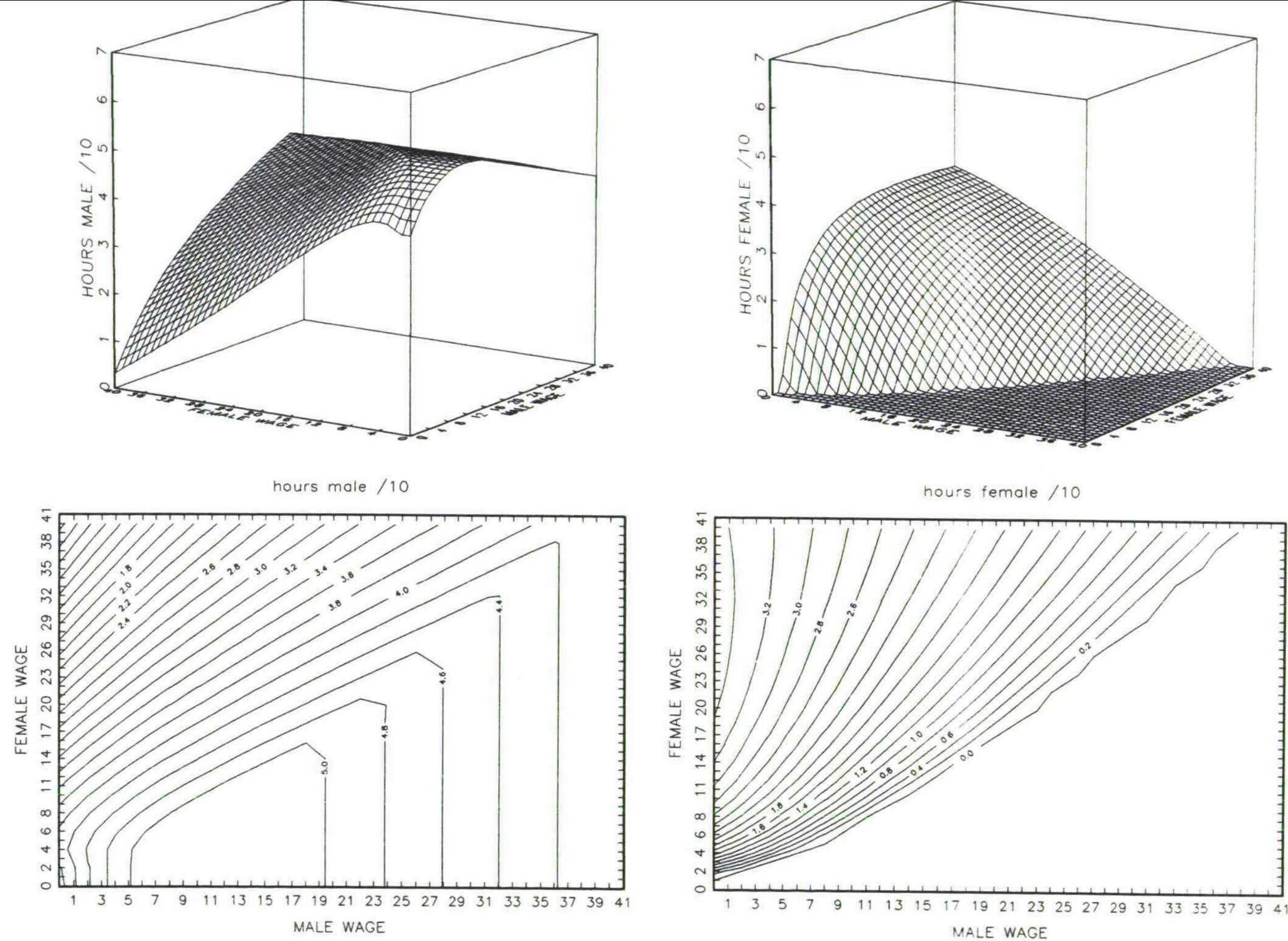

Figure 1. Labour Supply Functions

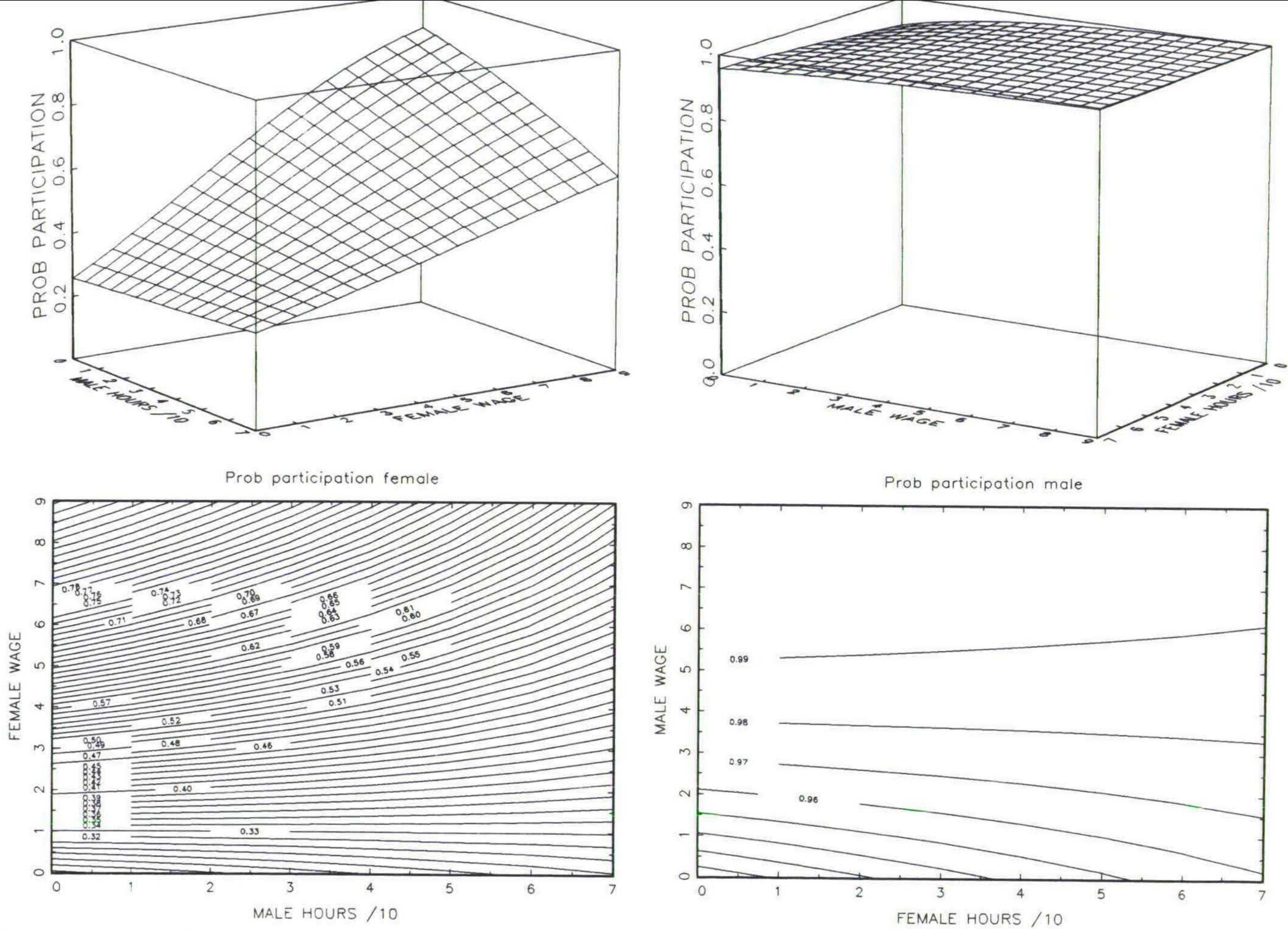

Figure 2. Participation Probabilities.

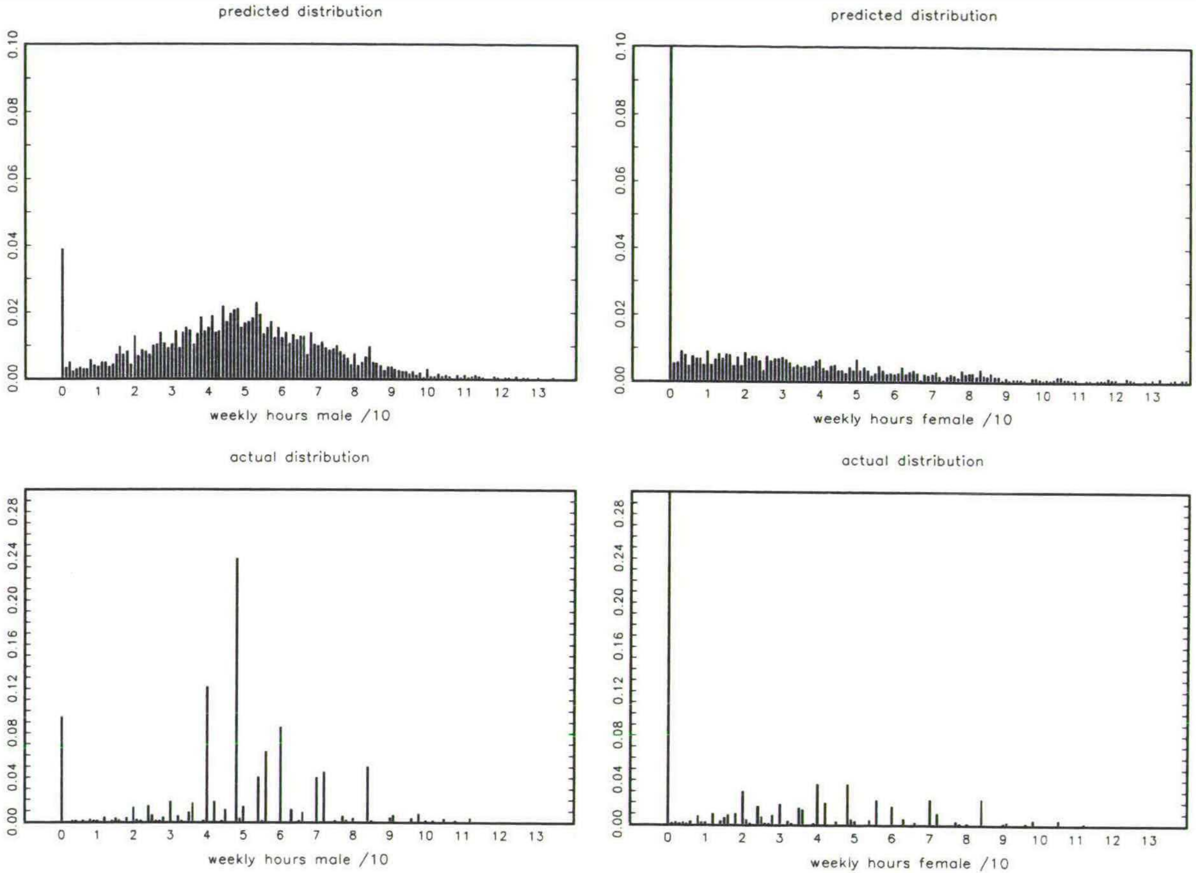

Figure 3. Hours Distributions

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