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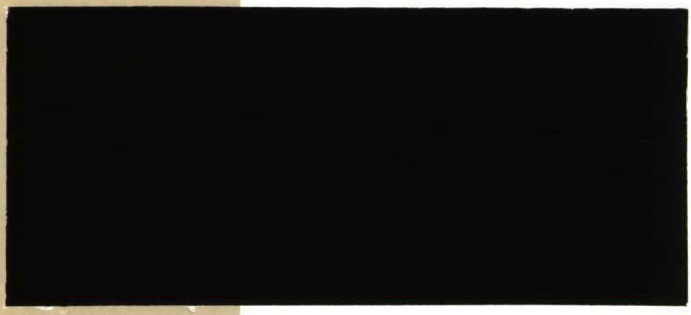

TILBURG UNIVERSITY

Center
for
Economic Research

No. 9366

SECTOR PARTICIPATION IN LABOUR SUPPLY MODELS: PREFERENCES OR RATIONING?

by Menno Pradhan

October 1993

ISSN 0924-7815

July 1993

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This paper benefitted from suggestions by Hans Bloemen, Joop Hartog, Thierry Magnac, Arthur van Soest and seminar participants at the 1993 ESPE conference in Budapest. Financial support by the Netherlands Organization for Scientific Research (NWO) is gratefully acknowledged. The author thanks the World Bank and the Instituto Nacional de Estadistica in Bolivia for providing the data for this research.

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Abstract

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In this paper we propose a model that allows to test for labour market segmentation between the formal and informal sector in a developing country on the basis of cross-section data. Tests of labour market segmentation are usually based on a comparison of observed wages in two sectors. Wage differences for identical workers in different sectors can be attributed to differences in preferences attached to participation in a sector and to restrictions in mobility between sectors. While the latter can be regarded as an indicator of "true" labour market segmentation, compensating wage differentials resulting from preferences would remain existent, even in the absence of rationing. So far, the applied tests have not been able to distinguish between these two effects. The proposed model overcomes this weakness by incorporating information on search, including on the job search, and discouragement to identify rationed individuals. The proposed model exploits the specific features of urban labour markets in developing countries, in particular the existence of a competitive informal sector. The model is estimated on data from the 1989 Bolivian household survey by means of smooth simulated maximum likelihood. The estimates show that the degree of labour market segmentation differs strongly over educational groups.

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1.Introduction

The dual labour market approach is often used to analyze urban labour markets in developing countries (see for examples: Todaro (1989, p. 268), Fields (1989)). In this approach the labour market consists of two sectors: First, a regulated, "formal" sector comprising the public sector and large firms subject to legal regulations. Jobs in this sector typically involve a contract and follow more institutionalized, rigid, wage setting procedures. Second, an unregulated, "informal" sector consisting of small firms with low capital investments, usually operating in the service sector or engaged in small scale production. In the dual labour market approach, labour mobility between the two sectors is restricted. Formal sector jobs are rationed as a result of minimum wage legislation and/or union settlements governing employment conditions. The informal sector is a free entry sector.

Empirical studies of the dual labour market approach have focused on testing for labour market segmentation. In general the methodology is as follows: Wages (or hourly earnings) of workers with a similar background are compared for both sectors. It is assumed that in selecting the preferred sector the potential workers consider the wage offers only. In the absence of rationing every individual would enter the sector offering the highest wage and, in equilibrium, wage offers would equalize. In the presence of rationing, however, some workers desiring a formal sector job (because the wage offer is higher) may not be able to obtain one and end up working in the informal sector. Thus, labour market segmentation implies that there are identical workers with different earnings in the two sectors. This can be empirically tested. Of course, as Heckman and Hotz (1986) point out, the estimated wage equations have to be corrected for the endogeneity of the selection into sectors. Empirical studies for developing countries include Gindling (1991) for Costa Rica and Magnac (1992) for Colombia. For developed countries a similar methodology has been developed by Dickens and Lang (1985). See also Hartog and Oosterbeek (1989) for a comparison between public private sector wages and Dickens and Lang (1992) for a survey of segmentation theory and evidence.

A shortcoming of the applied tests for labour market segmentation is that they have not been able to make a distinction between wage differentials resulting from individual preferences concerning non-wage job characteristics and those resulting from restrictions in mobility between sectors. While the latter can be regarded as an indicator of "true" labour market segmentation, compensating wage differentials resulting from preferences would remain existent, even in the absence of rationing. Compensating wage differentials follow from non-monetary returns to the job such as health insurance, utility associated with the workplace or job security. Also pure preferences, for example following from the social status attached to participation in a particular sector, could cause a wage differential between sectors. Gindling (1991) circumvented this problem by comparing wages

within narrowly defined occupational groups, assuming that within these groups the non-monetary returns are equal across sectors.

In this paper we will propose a model that allows to test for labour market segmentation between the formal and informal sector in a developing country on the basis of cross-sectional data. The proposed test overcomes the shortcomings that were discussed in the previous paragraph. The model exploits the specific features of urban labour markets in developing countries, in particular the existence of a competitive informal sector. The model incorporates information on search, including on the job search, to identify rationed individuals. The organization of the paper is as follows: In section 2 we discuss the underlying assumptions of the model. Especially the treatment of information on search and discouragement is a novelty of the model. On the basis of these assumptions we derive in section 3 a formal model of labour supply that deals simultaneously with wages, sector preferences and rationing. Section 4 describes the data and looks for empirical evidence of rationing by means of descriptive statistics. In section 5 the estimation strategy for the formal model is discussed. In section 6 the estimated coefficients are presented, a test for labour market segmentation is derived and some simulations are presented that could be interesting from a policy point of view. Section 7, finally, concludes.

2. Rationing, search and discouraged workers

A labour supply model in which individuals face no entry barriers for any of the sectors typically comprises two sections: a sector selection section and a wage determination section. In the sector selection section, the sector in which the individual decides to participate is explained. In a Heckman (1974) type model the choice would be between working and not working, but in principle more than two sectors can be allowed for. Sector choice is explained by the wage offers in each sector (for non-participation the value of home production) and individual preferences associated with participation in a sector. In the wage determination section wage offers in each sector are related to individual characteristics and local labour market conditions. The wage equations have to be estimated jointly with the sector selection section because of non-random selection into sectors. For the Bolivian setting, the country of focus in this paper, models of this kind were analyzed in Pradhan and van Soest (1992). In this paper the sector selection section will be replaced by a sector preference section and a rationing section.

We want to develop a labour supply model that explicitly considers rationing and that can be estimated on cross-sectional household survey data stemming from urban areas in a developing country. To this end, some assumptions considering the sectors and the treatment of rationing have to be made. These are:
-The informal sector is a competitive, free entry sector.
-Rationing is indicated by search or discouragement.

The first assumption is rather standard. It is often used as a way to define the informal sector. It is also mentioned in a recent review of the informal sector studies by the OECD (Lubell 1990). Firms operating in the informal sector are small and require low capital investments. Anyone wishing to work in the informal sector can do so immediately. As a consequence, all rationing takes place for formal sector jobs only.

The second assumption requires more discussion. If an individual searches, this indicates that he (or she) is not content with his (or her) present situation. If the individual were not rationed he (or she) would change to the preferred situation. Search indicates that the person is not able to do so immediately and is rationed. There may, however, be individuals who are rationed but do not search. They may have searched in the past but were unsuccessful in their quest. In our analysis we treat these discouraged persons (those who report not to be searching for work because no work is available) identical to the searchers. Finally, it is also possible that an individual searches but is not rationed. In that case the individual just wants to determine his or her market value by looking what is available. The model does not allow for this: The individual is assumed to have perfect information on potential earnings in all sectors.

One way to interpret discouragement is the presence of search costs: Some people will not search because the costs of search exceed the expected gains. These people are therefore rationed in the sense that their long run preferred status is different from the actual state, but they do not search. By treating them as rationed, search costs do not play a role. The model does thus not explain the search-no search decision, but only the preferred state, ignoring search costs. In principle, the distinction between discouraged and searching individuals could be useful to identify search costs but, given the nature of the cross section data, without information on how long it takes to find a job, this approach does not seem to be feasible. In the sequel, the term searchers will be used for both searching and discouraged individuals.

Under the assumptions stated above rationing takes place for formal sector jobs only and individuals rationed for formal sector jobs are identified by their search activity or because they are discouraged. The sector in which an individual is observed is influenced by wage offers, preferences and rationing. As yet, the model does not allow for individuals to search while they are working in the formal sector. Since they are working in the formal sector they cannot be rationed for this sector at the same time. Such observations, however, do appear in the dataset. To allow for this situation we introduce two types of formal sector jobs: "good" and "bad" jobs. Good jobs have the advantage over "bad" jobs in that they offer a higher wage. In other respects, such as the non-monetary returns, the two type of

jobs are assumed to be the same[1]. Thus, any individual will always prefer a "good" formal sector job to a "bad" one. Those who work in the formal sector and search are assumed to have a "bad" formal sector job and to be looking for a "good" one. Those who do not search have a "good" formal sector job. Search or discouragement thus identifies the difference between "good" and "bad" in the data. In this setting we assume that rationing takes place for "good" formal sector jobs only. The nature of the (cross section) data does not allow for a continuum of bad-good job offers.

The model described above allows us to specify for each individual the preferred sector, the actual sector and whether the individual is rationed or not. Systematically all the possible cases are given in table 1. Entry into the "good" formal sector is rationed, all other sectors are assumed to operate competitively. Non-workers, by definition, include both voluntary and involuntary unemployed. For formal and informal sector workers we define search as looking for another job replacing the current one. As hours of work are not considered, those individuals who report to be looking for additional work are categorized as non-searchers. For non-participants and workers in the informal sector that do not search we know that their actual status is the preferred one. For them we do not know whether they are rationed for "good" formal sector jobs. They can directly enter into the preferred sector and rationing for the formal sector is irrelevant to their actual status.

Table 1. Relationship between observed, preferred sector and rationing

Observed Sector	searching	Preferred Sector	Actual Sector	Rationed
formal sector	yes	(good) formal	bad formal	yes
	no	(good) formal	good formal	no
informal sector	yes	(good) formal	informal	yes
	no	informal	informal	?
non-participation	yes	(good) formal	non-participation	yes
	no	non-participation	non-participation	?

Identification of the effects of preferences versus rationing is achieved through incorporation of search information in the model. The coefficients in the rationing section are identified on the basis of the search information of formal sector workers. The sector participation decision of non-searchers in combination with their observed wages identify the coefficients in the preference section of the

[1]In principle, the model can be adjusted to allow for the utility of "good" and "bad" formal jobs to differ with taste shifters as well. However, since both "good" and "bad" jobs are similar in the sense that they are both salaried work we do not allow for this in the estimation. Only the difference in non-monetary returns between the formal and informal sector is analyzed.

model. Only the difference in preferences attached to participation in the informal versus non-participation and participation in the formal versus non-participation can be identified. The difference in the wage offer function between good and bad formal sector jobs is identified on the basis of the observed wages of searchers and non-searchers in the formal sector and on the assumption that informal sector searchers prefer a good formal sector job to their current one while this is not the case for a bad formal sector job.

3. The Model

In the model three possible labour markets statuses are distinguished. These are: (1) work in the formal sector (good and bad jobs), (2) work in the informal sector and, (3) non-participation. The latter includes home production. The only difference between "good" and "bad" formal sector jobs is that a bad formal sector job offers a lower wage. In other respects, such as the non-monetary returns to the job, the two types of jobs are identical. Bad formal sector jobs can be regarded as underpaid. Any individual will prefer a "good" formal sector job to a "bad" formal sector job.

Wage offers. Wage offers in the formal and informal sector are a function of individual specific variables and regional specific variables describing the local labour market conditions. In the formal sector two wage offers exist, a "good" and a "bad" one. They differ in that the wage offer for the "good" one is higher than for the "bad" one. We start by formulating the "good" formal sector wage. In the informal sector (j=2) no distinction between good and bad exists. The potential hourly wage in sector j is modelled as

$$w_{ij}^{g} = X_i\beta_j + \eta_{ij} \qquad j=1,2 \tag{1}$$

with

X_i = a vector of explanatory variables influencing returns
η_{ij} = an error term

Bad formal sector jobs offer a lower wage than good formal sector jobs. This is imposed in the estimation by including an exponential term on the difference in the wage offer between "good" and "bad" formal sector jobs. The difference in the wage offer is made dependent on individual characteristics and local labour market conditions. The potential hourly wage for a "bad" formal sector job equals

$$w_{il}^{b} = w_{il}^{g} - \exp(X_i\tau) \tag{2}$$

with

w_{il}^{g} = wage offer of a "good" formal sector job
w_{il}^{b} = wage offer of a "bad" formal sector job

Preferences. Preferences are modelled using a latent variable structure. Each individual prefers the sector yielding the highest utility. The utility of participation in sector j is related to the wage offer and non-monetary returns in that sector. Non-monetary returns relate to any utility that the individual may attach to participation in a sector besides the wage offer. For example, a head of the household responsible for a large family may prefer to work in the formal sector because it offers additional job security.

The utility of individual i associated with sector j equals

$$U_{ij}^{g/b} = Z_i\delta_j + w_{ij}^{g/b} + \epsilon_{ij} \qquad (3)$$

with

i = subscript denoting the individual
j = subscript denoting the sector with
= 1 : formal sector ("good" and "bad" jobs)
= 2 : informal sector
= 3 : non-participation
U_{ij} = utility of individual i in sector j
Z_i = a vector of explanatory variables influencing preferences for sectors
$w_{ij}^{g/b}$ = a (good or bad) wage offer to individual i in sector j
ϵ_{ij} = an error term

Z_i contains individual and household specific variables. Characteristics of the observed job are not included as they are not constant across sectors. The potential hourly earnings in the informal sector are unique for each individual (no distinction between "good" or "bad"). Earnings stemming from both sectors are equally valued in the utility function. The coefficient on the wage is set to one. As a result the $Z\delta$ terms can be interpreted as the non-monetary returns of participation measured in monetary terms. Normalization requires one of the utilities to be set to zero. We choose U_{i3}, the utility of non-participation. This implies that we do not have to be concerned about the unobserved w_{i3}, the value of home production.

Rationing.

Rationing for "good" formal sector jobs is assumed to be a discrete zero/one variable and to depend on individual and labour market characteristics influencing the demand for formal sector labour. We model the probability that an individual is rationed by

$$R_i^* = R_i\alpha + \epsilon_{ri}^* \qquad \textit{with} \quad \begin{matrix} R_i^* > 0 \textit{ if rationed,} \\ < 0 \textit{ if not rationed} \end{matrix} \tag{4}$$

with

R_i^* = a latent variable indicating whether individual i is rationed
R_i = Explanatory variables influencing rationing
ϵ_{ri}^* = an error term, representing "luck" in entering into the good formal sector

Error structure

$\epsilon_1, \epsilon_2, \eta_1, \eta_2$ and ϵ_r^* are assumed to be i.i.d. and multivariate normal with mean zero and covariance matrix Σ.

$$\epsilon = \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \eta_1 \\ \eta_2 \\ \epsilon_r^* \end{pmatrix} \sim N(0, \begin{pmatrix} \sigma_1^2 & 0 & 0 & 0 & 0 \\ & \sigma_2^2 & 0 & 0 & 0 \\ & & \sigma_f^2 & & \sigma_{fr} \\ & & & \sigma_i^2 & \sigma_{ir} \\ & & & & 1 \end{pmatrix}) \tag{5}$$

Correlation between the preference section and the wage determination section of the model enters through the inclusion of wages into the utility equation. The correlation between wages and rationing is included directly in the covariance matrix. The correlation between the errors of the wage equation in the formal and informal sector is not identified because we observe an individual working in at most one sector. The variances in the preference section equations (σ_1 and σ_2) can be identified because we normalize the coefficient of the wage in the indirect utility function to one. The wage offers can be included in the RHS of the preference equations because of exclusion restrictions in Z and X. Rationing is modelled in a probit type specification and therefore the variance of ϵ_r^* is normalized. The errors in the rationing equation and the preference section equations are assumed independent. However, some correlation is introduced indirectly as omitted variables appearing in the wage offer equations are allowed to influence both the probability of rationing as well as the indirect utility of participation in sectors.

4. Data

The research will be based on data of the second round of the Bolivian household

survey (Enquesta Intergrada de Hogares), drawn in 1989. The survey uses a random sample of the urban population and is administered yearly by the Bolivian National Bureau of Statistics (Instituto Nacional de Estadistica) with technical assistance of the World Bank. The survey is a repeated cross-section. The 1989 survey covers 7264 households in 8 urban centers. Household survey data, in contrast to firm level data, are particularly appropriate for measuring activity in the informal sector since they are drawn from the entire urban population. Firm level data often do not include non-listed firms (micro-enterprises), of which the bulk of the informal sector consists. The survey collects a measure for household consumption and, for every family member separately, detailed information on labour supply, earnings, education, health, fertility and migration. The labour section of the survey is extensive. It provides information on occupation, earnings, hours worked and search behaviour.

Following Magnac (1991), our definition of formality is based on the information on the worker's status and household business related, assets. Wage workers and independent professionals are classified as formal. Self-employed workers are classified as formal sector workers if their household business assets are greater than 15.000 bolivianos (+/- u$ 5500). Business assets include property of land, car for business use and telephone. The other self-employed (about 95 percent) are categorized as informal sector workers. Others, that is employers, home and family workers, are left unclassified and are not included in the analysis. For them it is not possible to obtain a proper measure of their earnings. See Pradhan and van Soest (1992) for details on the implications of the choice of definition for the informal sector.

The research focuses on labour supply behaviour of individuals between 19 and 65 years of age. Table 2 provides summary statistics for the individuals that were included in the estimation. Individuals who cannot be considered potential workers because of health or education reasons are excluded from the analysis. The decision to go to school is thus assumed to be taken prior and independent from the labour supply decision. A description of all variables that are used in this paper is included in appendix I. In general, we find that formal sector workers have a higher education than informal sector workers. Ethnic minorities are overrepresented in the informal sector. Ethnic groups are identified in the data trough the language they report to speak: If they regularly speak another language than Spanish they are classified as an ethnic minority. On average, hourly earnings are higher in the formal sector than in the informal sector. Average savings are higher in the informal sector (significant for females, not for males) which corresponds to the precautionary savings motive predicting that savings will be the highest in the sector in which earnings are most volatile.

Table 2. Descriptive statistics
(means and sample fractions; standard deviations in parentheses)

	male			female		
	formal	inform	not working	formal	inform	not-working
highest level of education attained:						
basic/none	0.21	0.35	0.24	0.11	0.40	0.29
inter	0.14	0.19	0.13	0.08	0.15	0.15
medio	0.29	0.30	0.33	0.22	0.20	0.29
midtech	0.04	0.03	0.04	0.09	0.03	0.05
hightech	0.03	0.02	0.03	0.04	0.01	0.01
normal	0.06	0.01	0.02	0.26	0.02	0.03
university	0.19	0.07	0.16	0.17	0.03	0.05
other	0.04	0.03	0.05	0.03	0.16	0.13
married	0.79	0.84	0.59	0.56	0.71	0.80
ethnic	0.30	0.39	0.33	0.20	0.46	0.34
age	36.1	39.5	38.7	34.0	39.3	36.8
active searching (%)	6.3	6.6	52.9	2.0	3.5	8.8
discouraged (%)	13.4	22.7	10.9	11.9	14.7	2.4
hourly earnings[2]	2.50	2.38		2.03	1.94	
(primary activity[3])	(4.7)	(4.0)		(2.6)	(4.4)	
net dissavings[4]	8.83	-35.1	322.8	100.24	-48.6	141.5
	(1015)	(890)	(634)	(1228)	(854)	(1065)
number of observations	3705	1763	881	1494	1917	3882

With respect to search activity the pattern is very different for males and females. For males, most of the search takes place in the non-workers group. 53 percent of males who do not work are involuntary unemployed. For females, the amount of search is much lower for non-participants. Staying at home is in most of the cases the preferred status. For both males and females, on the job search activity is higher in the informal sector than in the formal. This suggests that the informal sector may function as a buffer, for those who seek a good job in the formal sector. Getting out of this buffer sector is not that easy, however. The percentage of discouraged searchers is the highest in the informal sector. This high rate of discouragement could be caused by high costs of on the job search in the informal

[2]in Bolivianos; At the time of the survey 1 Boliviano was worth approximately 0.37 U.S. dollar. Taxes and premiums are relatively low in Bolivia. Most of government revenues are collected through consumption based taxes.

[3]The survey does collect information on the secondary activity. However, the information for the second activity is not collected with the same detail as for the first. We do not observe a great number of individuals participating in both sectors. In the dataset 2.5 % percent of the males and 1 % of the females participated both in the formal and informal sector. In this study information on secondary activities is ignored.

[4]household level variable defined as total household consumption minus total household labour income. See Pradhan and van Soest (1992) for details.

sector or by an adverse selection and/or stigma effect. In the estimation active searchers and discouraged workers are treated identically. In our model, formal sector workers are assumed to be searching because they have an underpaid, "bad", job. To get a rough idea whether this is indeed the case we ran a log hourly wage regression for all formal sector workers including a dummy for search activity in the set of explanatory variables. For both males and females, the estimated coefficient came out negative, as expected. For males the estimated coefficient was -0.23 with a t statistic of -7.4 and for females -0.13 with a t-statistic of -2.5[5]. This result is also found for developed countries (See Devine and Kiefer, p238).

5. Estimation method

Estimation of the model is achieved by smooth simulated maximum likelihood (SSML). Evaluation of the likelihood function involves the computation of multiple integrals. Since these integrals are of a dimension higher than two, numerical integration requires an infeasible amount of computer time. Lerman and Manski (1981) proposed a frequency simulator to approximate the probabilities that appear in the likelihood function. Their simulator involves taking multiple draws from the distribution of the error terms. It has the disadvantage that a large number of draws is needed to obtain precise estimates. Moreover, the simulated likelihood function is not a smooth function of the unknown parameters. Standard optimization routines (Newton Raphson e.g.), which require differentiability of the approximated likelihood cannot be used. We follow a method that is similar to that proposed by Stern (1992). The resulting simulated likelihood function is a smooth function of the unknown parameters of the model. The estimates obtained by maximizing the simulated log likelihood function are consistent if the number of draws per observation tends to infinity with the number of observations. Moreover, provided that draws for different individuals are independent, ML and SSML will be asymptotically equivalent as $H/\sqrt{N}\to\infty$, where H is the number of draws and N is the number of observations (cf. Gourieroux and Monfort, 1990)

Define $\theta=(\delta_1,\delta_2,\beta_1,\beta_2,\tau,\alpha)$. The likelihood function can be written as

$$L = \prod_{i=1}^{n} Pr[c_{1j}(y_i,X_i,\theta)<\tilde{u}_i<c_{2j}(y_i,X_i,\theta)\,|\,X_i,\zeta_i]\; f_j(\zeta_i|X_i) \qquad (6)$$

with

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[5]Because of the endogeneity of the search dummy this regression is not valid in the framework as a whole. The results are given for descriptive purposes only. However, the significance of the results does not change if one instruments for search (Heckman 1978) using taste shifters as instruments. The estimated coefficient on the predicted probability of search remains negative. For males the estimated coefficient is -1.16 with a t-statistic of 3.7 and for females -1.21 with a t-statistic of 2.6.

$\tilde{u}_i = A_j \epsilon_i$
$\zeta_i = B_j \epsilon_i$
$y_i, X_i =$ vectors containing dependent and independent variables

The contribution to the likelihood function of one individual can be written as a conditional probability times a density. The calculation of the conditional probability involves the evaluation of multiple integrals. Given θ, y_i and X_i, the value of ζ_i can be calculated. The transformed error terms, ζ and $(\tilde{u} \mid \zeta)$, follow a normal distribution $N(0, B_j \Sigma B_j')$ and $N(\mu, \Omega)$ with $\mu = A_j \Sigma B_j' (B_j \Sigma B_j')^{-1} \zeta$ and $\Omega = A_j \Sigma A_j' - A_j \Sigma B_j' (B_j \Sigma B_j')^{-1} B_j \Sigma A_j'$. The specification of the matrices A_j and B_j and the functions c_{1j} and c_{2j} depend on the regime (j) the individual is in. For example, in the case the individual is working in the informal sector and simultaneously looking for a job, A, B, c_1 and c_2 are defined by

$$A = \begin{bmatrix} -1 & 1 & -1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 \end{bmatrix} \qquad B = [0\ 0\ 0\ 1\ 0] \tag{7}$$

$$c_1 = \begin{bmatrix} Z_i(\delta_1 - \delta_2) + X_i\beta_1 - \exp(X_i\tau) - w_{i2} \\ -\infty \\ -\infty \end{bmatrix} \quad c_2 = \begin{bmatrix} Z_i(\delta_1 - \delta_2) + X_i\beta_1 - w_{i2} \\ Z_i\delta_2 + w_{i2} \\ R_i\alpha \end{bmatrix} \tag{8}$$

In this example, $\zeta_i = \eta_{i2}$ equals

$$\zeta_i = w_{i2} - X_i\beta_2 \tag{9}$$

The SSML estimator obtains an unbiased estimate of the probability in (6) by means of simulation. The idea is to decompose $\tilde{u}$ into two components, each normally distributed. The first is chosen such that it has a relatively simple covariance structure. The other is simulated. Let

$$\tilde{u} = u_1 + u_2 \tag{10}$$

The Probability in (6) can now be written as

$$\begin{aligned} Pr[c_1 < \tilde{u} < c_2 \mid X, \zeta] &= Pr[c_1 - u_2 < u_1 < c_2 - u_2 \mid X, \zeta] \\ &= E_{u_2}\{Pr[c_1 - u_2 < u_1 < c_2 - u_2 \mid X, \zeta, u_2] \mid X, \zeta\} \\ &= \int Pr[c_1 - u_2 < u_1 < c_2 - u_2 \mid X, \zeta, u_2]\, f(u_2 \mid X, \zeta)\, du_2 \end{aligned} \tag{11}$$

where the subscript i is suppressed. This is simulated by

$$\frac{1}{H}\sum_{k=1}^{H} Pr[c_1 - u_{2k} < u_1 < c_2 - u_{2k} \mid X, \zeta, u_{2k}] \tag{12}$$

where the u_{2k} are drawn independently from $f(u_2 \mid X, \zeta)$, the conditional density of u_2, with H replications.

In the decomposition of $\tilde{u}$ we exploit the restrictions on the covariance matrix Σ. The decomposition varies with the regime the individual is in. We include in u_2 η_1 and/or η_2 if these are included in $\tilde{u}$. In the example stated above $u_2=[\eta_1,0,0]'$ and $\eta_1 \mid X, \zeta \sim N(0,\sigma_f^2)$. ζ does not enter here because the errors in the two wage equations are assumed independent. The distribution of $(u_1 \mid X, \zeta, u_{2k})$ is normal $N(\mu_k,\Omega)$ with $\mu_k = A\Sigma B'(B\Sigma B')^{-1}(\zeta\ u_{2k})'$ and $\Omega = A\Sigma A' - A\Sigma B'(B\Sigma B')^{-1}B\Sigma A'$. A and B are defined as

$$A = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 \end{bmatrix} \qquad B = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix} \tag{13}$$

In Stern (1992) the error terms u_1 and u_2 are assumed independent and the covariance matrix of u_1 is diagonal. In our method the error terms are dependent and we work with conditional distributions. The covariance structure of u_1 includes one non-zero covariance element. Computation of the probability remains feasible as this involves at most evaluating a bivariate cumulative probability. In the cases where it is unknown whether the individual is rationed, the contribution to the likelihood is calculated without simulation.

6. Estimation Results

The estimated coefficients are obtained choosing the number of draws, H, equal to 30. The draws are different and independent for each observation. We experimented with taking different numbers of draws. A change from 10 to 30 draws made only a small difference in the estimation results. The reported estimates should thus be close to the exact ML estimates. The estimated coefficients are reported in tables A1 to A4 in the appendix. Below we will discuss the results.

The estimated coefficients for the preference section of the model are presented in table A1. The presence of other prime age individuals (PRIME) in the household significantly reduces the utility of working for both males and females. The effect is the strongest for males. The presence of young children (YOUNG) significantly reduces the preference of working for females. For males, formal sector preference increases. The model allows for the effect of being married to be different for

different age groups. In table 3 we report the partial derivatives of the preferred sector probability with respect to MARRIED for different age groups and sexes. For males, for every age group MARRIED has a positive effect on the probability of working. This effect diminishes as the individual gets older. For females the effect is opposite, MARRIED increases the probability that non-participation is the preferred sector. Especially when females approach 30, being married drives them out of formal employment into non-participation.

Table 3. Partial effect of marriage on the probabilities for preferred sectors (percentages, calculated at mean values)

	males			females		
age	20	30	40	20	30	40
formal	3.54	2.28	2.13	-5.54	-24.8	-30.8
informal	2.40	4.92	-0.09	-0.61	-5.76	-3.50
not working	-5.94	-7.20	-2.04	6.15	30.52	34.32

The preference section of the model includes a measure of per capita net dissavings. In a life cycle framework, two stage budgeting implies that the household first decides upon the intertemporal allocation of consumption and, in the second stage, decides on the allocation of consumption between goods and leisure (Cf., e.g., Blundell and Walker, 1986). Net dissavings is obtained by subtracting the total household expenditures from the total household earnings and should, according to the theory, be uncorrelated with the error terms in the preference section of the model. Net savings may, however, very well be endogenous to the labour supply decision as a result of unobserved heterogeneity. We add a reduced form equation for net dissavings to account for this potential endogeneity (see Pradhan and van Soest 1992). The inclusion of non-labour income into the instrumenting equation guarantees identification. The residual from the instrumenting equation (PRED ERROR) is included as an explanatory variable in Z.[6] If net dissavings is exogenous, the coefficient on the predicted error term of the instrumenting equation would be insignificant. For both males and females the effect of net dissaving decreases the probability of working. The hypothesis that net dissavings can be treated as exogenous is rejected for both sexes.

The estimated coefficients on the $Z\delta$ term in the preference equations can be used to get an idea of how the non-monetary returns compare in the formal and informal

[6]The standard errors of the ML estimates should be corrected for the error due to replacing the parameters of the instrumenting equation in the correction term by their estimates. Previous experience in which we used the same instrumenting equation showed that the effect of the correction is quite small (see Pradhan and van Soest 1992). Therefore, for computational convenience, we have not corrected the standard errors here.

sector. For males, at mean values, non-monetary returns are higher in the formal sector than in the informal sector. To make the systematic part of the indirect utility of participation in the two sectors equal, a formal sector wage offer of only 0.46 (std err: 0.04) times that of the informal sector is needed. The additional security and benefits may cause males to value participation in the formal sector higher. For females the opposite holds, there a formal wage offer of 1.18 (std err: 0.11) times that of the informal sector is needed to equalize probabilities.

To obtain insight into the effects of the wages on the sector preference we have drawn figures 1 and 2. The figures show the probability a sector is preferred as a function of the wage offer. The figures are ceteris paribus, calculated at the mean value of the exogenous variables. The wage offer in one sector is varied, the wage offer in the other sector is held constant at the sample mean. For males, the effect of a change in the wage offer is mostly a substitution effect between sectors. Since not-working is seldom the preferred status an increase in the wage offer in one sector reduces the probability that the other sector is the preferred one. For females the effects are different. For them an increase in the wage offer increases the probability of preference for that sector at the cost of not working. At the mean value the log wage offers are for males and females (in parentheses) respectively: 0.62 (-0.38) in the formal sector and -0.14 (-1.06) in the informal sector. The own wage elasticities (relative change of probability of participation over a relative change in the wage offer) are 0.21 (1.35) for the formal sector and 1.19 (1.34) for the informal sector. The cross elasticities are -0.17 (-0.15) for the effect of the informal wage offer on the participation in the formal sector and -1.12 (-0.26) for the reverse.

The estimates for the wage equations are presented in table A2. Ceteris paribus, males reach their highest earnings at 45 years in the formal sector and at 48 years in the informal sector. For females the peaks are at 40 and 46 respectively. The variables "inter" through "missed years" show the effect of education on earnings. "Basic", which is the lowest education level, is the excluded reference category. For males, returns to education are higher in the formal sector than in the informal sector. "Normal" education, which is a training for primary school teachers, only has positive returns in the formal sector. For females, education only has positive returns in the formal sector. In the informal sector only intermediate education has positive return. For some categories, such as "normal" and "university" even a significant negative return is estimated. Returns to education in the formal sector are higher for females than for males. For both males and females, the estimates are conform the segmented labour market hypothesis. We do allow the error terms of the wage equations to be correlated with the rationing equations. Whether such a correlation should be included for the informal sector is not obvious. In this sector it is less likely that there are unobserved factors which are used as rationing devices that influence productivity in the informal sector. For males, this correlation is not significantly different from zero at the 5% level. For females it

is. The correlation between the formal sector wage equation and the rationing equation is positive and significant for both sexes. This indicates that overpaid (as a result of strong collective bargaining, for example) formal sector workers (good and bad) have a higher probability of being rationed.

The local unemployment rate has a significant negative effect on earnings in the informal sector. The effect is the strongest for males. In the formal sector, neither for males nor for females, a significant effect of unemployment can be detected. Belonging to an ethnic group significantly lowers the returns in the formal sector for males. For females, a positive effect of ethnicity is found in the informal sector. A possible explanation is that informal sector activity of females is largely concentrated in the commerce and restaurants sector (82%). In that sector a positive discrimination of ethnicity for females may exist.

Table A3 presents the estimate for τ, the coefficient in the equation (2) that relates the good and bad formal wage offer. For males the difference is the greatest for higher technical education and university level training. For normal education the wage difference is relatively small. For females the effects are smaller. Only the local unemployment rate and the normal and university education variables have a significant effect. This indicates that underpayment is not a primary motive for search for females. Their search activity in the (bad) formal sector may be more correlated with other, non-wage job characteristics. A likelihood ratio test rejected the null hypothesis that the wage differential, τ, does not depend on covariates for both sexes at the 5% level.[7]

Table A4 presents the estimates for the rationing equation for good formal sector jobs. A higher value of the left hand side variable is associated with an increased probability of rationing. The probability of rationing decreases with the level of education. This result holds for both males and females. This suggests that formal education is used as a screening device for formal sector jobs. A higher local unemployment rate increases the rationing level, as expected. Belonging to an ethnic group significantly increases rationing for females, for males the effect is much smaller. We experimented with incorporating information on migration into the rationing equation. For 2 out of 8 regions we have information about how long ago the individual moved to the place he currently lives. In a Harris-Todaro type migration model, migrants work for a while in the informal sector while they queue up for formal sector jobs. Therefore we would expect the probability of rationing to increase if the individual moved in more recently. We could not find

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[7]As noted, it can be tested whether "good" and "bad" formal jobs differ with taste shifters (Z) as well. An LM test rejected the null Hypothesis that good and bad formal jobs only differ in the wage offer as is assumed in the model at the 5% level. Estimating the model, allowing for the effect of taste shifters, causes additional complexities as the likelihood may not be defined for some individuals, since the utility of bad jobs might exceed that of good formal sector jobs.

any significant effect of these variables. Because we only have the migration information for two capital cities we decided not to include the migration variables in the presentation of the results.

Rationing can be viewed as an indicator for labour market segmentation. As is clear from the estimates, the degree of rationing varies strongly over individuals with different observed characteristics. It is therefore not possible to give a simple yes/no answer to whether there is labour market segmentation between the formal and informal sector in Bolivia. In table 4 we have calculated the probability of rationing for some standard individuals. For all individuals the probability of rationing is significantly different from zero which would suggest that the hypothesis of no labour market segmentation is rejected. The conclusions need not be that strong, however. If one believes in a natural rate of (frictional) search, one would test whether the predicted probability is significantly different from the natural search rate. Note that labour market segmentation as defined in this model only refers to the rationing of "good" formal sector jobs.

Table 4. Predicted probability of rationing for standard individuals
(percentages, standard error in parentheses, base: age=30, missed years=0, econ active and unempl at mean value)

		males	females
education	ethnic		
inter	no	33.2	34.1
		(1.98)	(3.88)
hightech	no	27.2	18.03
		(4.12)	(4.23)
university	no	20.0	21.3
		(1.66)	(2.62)
inter	yes	37.4	44.3
		(2.25)	(4.75)

The goodness of fit of the model can be examined by comparing the predicted probabilities of participation with the observed outcomes. The first 4 columns of tables 5 and 6 present the results for males and females. Predicted probabilities were obtained by simulation, taking multiple (50) draws from the estimated error distribution for each individual. The preferred status can be obtained by solely taking into consideration the predicted utilities of participation in a sector, setting the probability of rationing to zero. In general the predicted numbers are relatively close to the observed. For males, the model underestimates the number of individuals for whom the preferred sector is the formal sector at the cost of the number of individuals for whom not working is the preferred status. For females, the number of individuals who prefer not to work is underestimated. Overall the fit is reasonable.

Table 5. Males: Goodness of fit and simulation (number of individuals)

	Observed		Predicted		Unempl +5%	
	Actual	Preferred	Actual	Preferred	Actual	Preferred
Formal good	2973	4783	2782	4625	2088	4921
Formal bad	732		936		1275	
Informal	1763	1247	1780	1264	1462	837
Not working	881	319	850	460	1523	591

Table 6. Females: Goodness of fit and simulation (number of individuals)

	Observed		Predicted		Unempl +5%	
	Actual	Preferred	Actual	Preferred	Actual	Preferred
Formal good	1265	2280	1277	2281	765	2210
Formal bad	229		264		202	
Informal	1917	1568	1859	1674	1532	1324
Not working	3882	3445	3893	3338	4794	3759

The last two columns in table 5 and 6 present the results of a simulation exercise. We have simulated the effect of an exogenous increase in the rate of unemployment by 5 percent on sector participation and preferences. The results should be compared with the predictions from the base case (column 3 and 4). The effect of an increase in unemployment works in several ways. First, it has a negative effect on earnings in both sectors, thereby making non-participation more attractive. Second, the probability of rationing for "good" formal sector jobs increases. The combined effect is rather different for males and females. For males, formal sector preference increases even though the effect of unemployment on formal sector wages is negative. For only 2% of the males the preferred sector changes from working to non-working. Because the probability of rationing increases not all of the workers end up working in the "good" formal sector. All effects considered, "good" formal and informal sector participation decrease and the participation in the other sectors increase. For females, the effect of an increase of unemployment is clearly a move out of employment towards non-participation. Both the "preferred" as well as the "actual" numbers decrease for both sectors. The simulation shows that females labour supply is more sensitive to labour market conditions than that of men.

7. Concluding remarks

Labour supply in urban areas of a developing country has been analyzed using a model that explicitly incorporates rationing for formal sector jobs. Information on search, including on-the-job search, allows us to disentangle the effects of sector

preference and rationing in the model. The informal sector is taken as a free entry sector. The test of labour market segmentation that follows is thus a test for rationing of formal sector jobs, and not a test for wage differences between sectors, as is common in the literature. The model corrects for endogenous selection into sectors and treats earnings in all sectors as endogenous. The model is estimated on cross section data stemming from a Bolivian household survey. In general, estimation results are in line with the segmented labour market hypothesis.

Rationing is treated as a heterogeneous phenomenon in the model. The results show that the probability of rationing decreases with additional education. Conclusions on whether labour market segmentation is present vary with observed characteristics of the individual. Ethnicity has a significant positive effect on the probability of rationing for both males and females. The effect is the largest for females. Regional variation is exploited to estimate demand side effects on earnings and participation. Larger labour markets increase the probability of rationing for males. Unemployment has a positive effect on rationing for both sexes.

Policy simulation exercises can be done to investigate the effect of a change in exogenous variables on earnings and participation in sectors. The structure of the model has the advantage that the effects resulting from changes in preferences, wages and rationing can be analyzed separately. For males, exogenous shocks mostly influence the choice between formal and informal sector participation and not so much the choice of whether to work or not. For females, on the contrary, the move is more in and out of employment. Policy simulation should be treated cautiously as demand side effects are modelled rather parsimoniously.

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Appendix I. List of variables

Individual level variables

married	dummy = 1 if individual is married
ethnic	dummy = 1 if the individual regularly speaks other than spanish
active search	if the individual reported to be searching for work in the last week.
discouraged	if the individual reported not to be looking for work because "there is no work"
hourly earnings	calculated as total earnings divided through the number of hours worked

Education variables

variable dummies	description	number of years of education at completion
Basic	includes no education and basic education	
inter	intermediate education	8
medio		12
midtech	vocational training	13
hightech		15
normal	primary school teacher training	17
university	university both private and public	20
other	non-categories, for males probably largely military training	
missed years	if individual did not complete training: minus number of years before completion	

Household level variables

net pc dissavings	total household consumption minus total household income divided by family size
young	number household members of less than 15 years old
prime	number of household members between 15 and 65
old	number of household members greater than 65 years old

Regional variables

unemployment	share of labour force unemployed per urban center
econ act	number of working or searching individuals in the sample per urban center

Table A1. Sector preference section

	males				females			
	formal vs non-part		informal vs non-part		formal vs non-part		informal vs non-part	
	parameter	std err	parameter	std err	parameter	std err	parameter	std err
cnst	0.961	0.242	-1.601	0.396	-0.421	0.306	-1.499	0.373
age	0.036	0.013	0.096	0.019	0.101	0.016	0.123	0.017
age squared /100	-0.075	0.016	-0.094	0.023	-0.160	0.021	-0.134	0.020
young	0.037	0.014	0.020	0.018	-0.047	0.014	-0.032	0.016
prime	-0.121	0.014	-0.142	0.019	-0.045	0.013	-0.117	0.016
old	0.034	0.063	0.183	0.086	-0.029	0.062	-0.095	0.080
married	-0.028	0.171	0.838	0.225	-1.812	0.143	-0.624	0.185
net pc dissavings /1000	-5.326	0.468	-7.169	0.699	-1.346	0.462	-4.804	0.680
pred error	4.789	0.468	5.764	0.675	1.162	0.478	4.241	0.679
married*age	0.007	0.004	-0.016	0.006	0.021	0.004	0.002	0.004
σ^2	0.617	0.044	1.306	0.201	0.821	0.066	1.255	0.121

Table A2. Wage equations

	males				females			
	formal		informal		formal		informal	
	parameter	std err	parameter	std err	parameter	std err	parameter	std err
cnst	-1.106	0.209	-0.875	0.276	-1.366	0.283	-2.548	0.356
age	0.061	0.010	0.064	0.012	0.037	0.013	0.080	0.015
age squared /100	-0.067	0.012	-0.066	0.014	-0.046	0.017	-0.086	0.018
inter	0.077	0.058	0.068	0.058	0.096	0.066	0.120	0.074
medio	0.219	0.049	0.195	0.050	0.307	0.058	-0.023	0.065
midtech	0.530	0.098	0.212	0.111	0.832	0.088	-0.166	0.113
hightech	0.635	0.134	0.192	0.140	1.078	0.138	-0.032	0.172
normal	0.372	0.098	-0.573	0.116	1.292	0.088	-0.781	0.120
university	0.879	0.058	0.104	0.071	1.467	0.080	-0.177	0.107
other	0.139	0.081	-0.327	0.095	-0.015	0.080	-0.091	0.082
missed years	0.069	0.014	0.006	0.016	0.074	0.016	-0.047	0.019
econ act /10	0.208	0.028	0.094	0.031	0.137	0.032	0.174	0.038
unemployment *10	-0.081	0.110	-1.074	0.121	-0.207	0.125	-0.657	0.147
ethnic	-0.120	0.041	-0.022	0.041	-0.048	0.047	0.184	0.051
σ^2	1.031	0.043	0.790	0.034	0.929	0.056	1.502	0.085
σ_w	0.701	0.040	0.078	0.040	0.472	0.066	0.786	0.092

Table A3. Tau estimate-difference between good and bad formal sector wage

	males		females	
	parameter	std err	parameter	std err
cnst	0.241	0.175	0.163	0.350
age	0.016	0.008	-0.007	0.017
age squared /100	-0.020	0.010	0.004	0.023
inter	0.005	0.047	-0.026	0.103
medio	0.054	0.040	-0.024	0.080
midtech	0.122	0.077	0.119	0.119
hightech	0.251	0.084	-0.051	0.196
normal	-0.348	0.119	-0.368	0.144
university	0.236	0.045	0.156	0.090
other	0.053	0.079	0.142	0.117
missed years	0.022	0.011	-0.012	0.021
econ act /10	0.006	0.022	-0.044	0.041
unemployment *10	0.116	0.091	0.622	0.189
ethnic	-0.059	0.032	0.071	0.063

Table A4. Rationing equations

	males		females	
	parameter	std err	parameter	std err
cnst	-0.072	0.241	0.680	0.377
age	-0.060	0.010	-0.078	0.017
age squared/100	0.068	0.013	0.076	0.023
inter	-0.117	0.061	-0.360	0.107
medio	-0.180	0.052	-0.435	0.091
midtech	-0.213	0.102	-0.752	0.126
hightech	-0.289	0.130	-0.865	0.177
normal	-0.378	0.099	-0.689	0.109
university	-0.523	0.065	-0.748	0.111
other	-0.330	0.101	0.185	0.129
missed years	-0.047	0.015	-0.061	0.024
econ act /10	0.103	0.030	0.001	0.043
unemployment *10	0.933	0.122	1.122	0.177
ethnic	0.114	0.041	0.265	0.065

Figure 1. Effect of wage offer on preferred sector for males

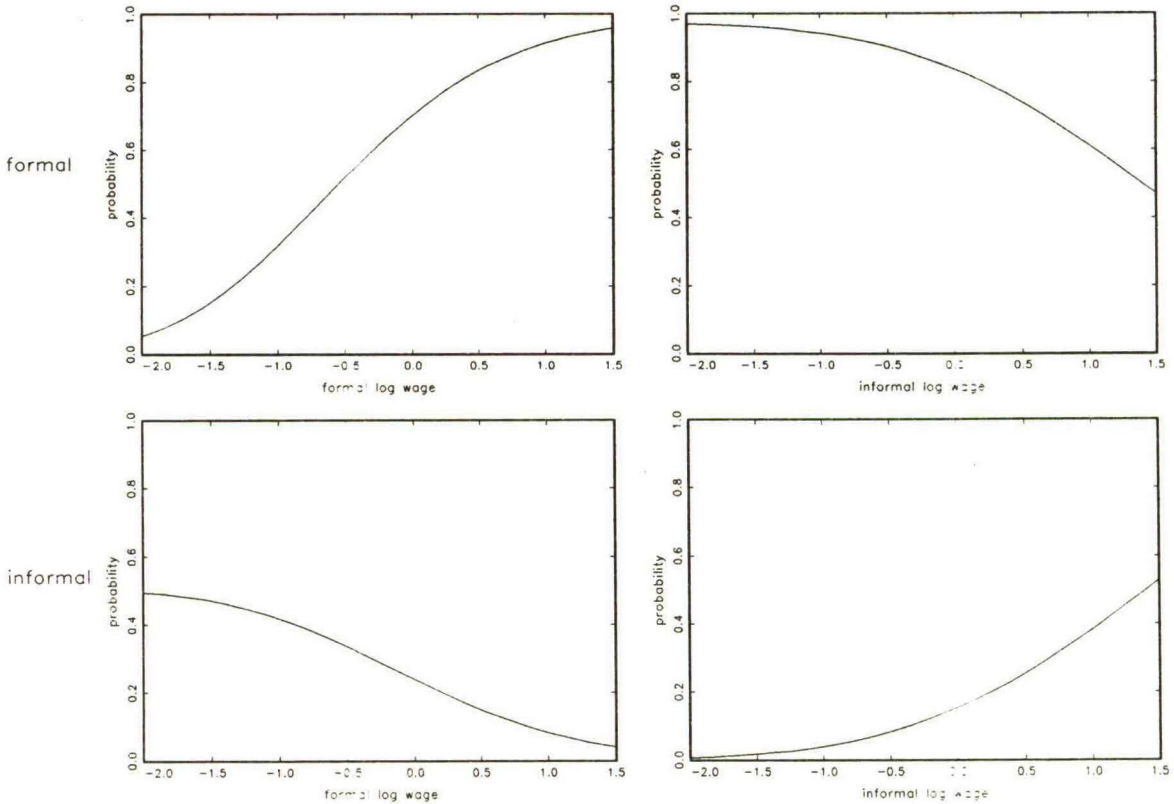
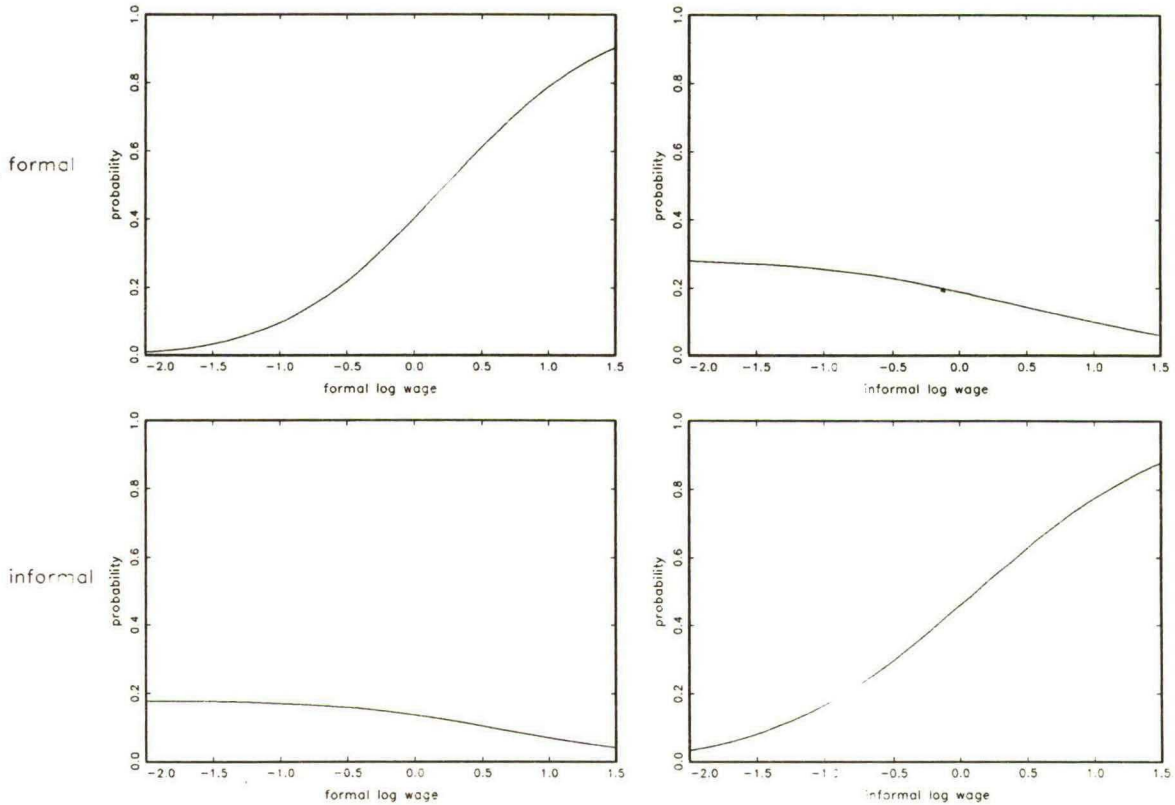


Figure 2. Effect of wage offer on preferred sector for females



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