PRELIMINARY DRAFT: PLEASE DO NOT QUOTE OR CITE

Calorie Deprivation and Poverty Nutrition Trap in Rural India[1]

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ABSTRACT

This paper tests for the existence of a Poverty Nutrition Trap (PNT) in the case of the nutrient most likely to have productivity impacts, i.e., calories, for three categories of wages – sowing, harvesting, and other – and for male and female workers separately. We use household level national data for rural India for the period January to June 1994. We use robust sample selection procedures due to Tobit methods and due to Heckman to arrive at consistent estimates. It is discovered that the PNT exists for women workers engaged in harvesting and sowing in the case of the Heckman methodology. In the case of the Tobit analysis a PNT exists in the case of female harvest, male other, and female other categories of wages.

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The effect of nutritional intake on labour productivity and wage rates has been an important area for research for economists and nutritionists for some time. This found initial expression in the form of the efficiency wage hypothesis developed by Leibenstein (1957) and Mazumdar (1959) and formalized and extended by Mirrlees (1975), Dasgupta and Ray (1986, 1987), and Dasgupta (1993), among others. Early surveys include Bliss and Stern (1978a, 1978b) and Binswanger and Rosenzweig (1984). The efficiency wage hypothesis postulated that in developing countries, particularly at low levels of nutrition, workers are physically incapable of doing hard manual labour. Hence their productivity is low which then implies that they get low wages, have low purchasing power and, therefore, low levels of nutrition, completing a vicious cycle of deprivation. These workers are unable to save very much so their assets –both physical and human – are minimal. This reduces their chances of escaping the poverty-nutrition trap (henceforth PNT).[2] Barrett and Swallow (2006) present a theoretical argument in support of the PNT emerging as the result of the existence of multiple dynamic equilibria.[3]

There is a substantial literature on empirically testing for the existence of PNT.[4] Strauss (1986) models the effect of nutrition on farm productivity. He tests and quantifies the effects of nutritional status as measured by annual calorie intake on annual farm production and, hence, labour productivity using farm household level data from Sierra Leone. He finds significant and sizable effect of calorie intake on farm output, even after accounting for endogeneity. These effects are stronger at lower levels of calorie intake with this being determined through the presence of non-linear terms. Thomas and Strauss (1997) investigate the impact of four indicators of health (height, body mass index, per capita calorie intake and per capita protein intake) on wages of urban workers in urban Brazil. They discover that even after accounting for endogeneity issues and controlling for education and other dimensions of health, these four indicators have significant positive effects on wages. The effect of the nutritional variables - per capita calorie intake and per capita protein intake – was higher at low levels of nutrition, again determined through non-linear terms. In contrast Deolalikar (1988) finds in a (panel fixed effects) joint regression of the wage equation and farm production in rural South India that calorie intake does not affect either but a measure of weight-for-height does. He concludes that calorie intake does not affect wages or productivity indicating that the human body can adapt to short-run shortfalls in calorie intake. However, the fact that weight-for-height affects wages and productivity indicates that chronic undernutrition is an important determinant of productivity and wages. Barrett et al. (2006) provide empirical support for the dynamic multiple equilibrium analysis of PNT (along the lines of Barrett and Swallow 2006) in the case of Kenya and Madagascar.

The contribution of the present paper is as follows. We test for the existence of a PNT in the case of the nutrient most likely to have productivity impacts, i.e., calories,[5] for each category of wages – sowing, harvesting, and other – and for male and female workers separately. We use robust sample selection procedures to arrive at consistent estimates. It is discovered that the PNT exists in a number of cases.

The plan of this paper is as follows. We first motivate the analysis of PNT and then discuss the data and present the estimation methodology. Finally we discuss the results of the estimation and offer some concluding remarks.

Nutrition Poverty Traps

In Figure 1, a stylised version of the relationship between work capacity and nutrition is given.[6] The vertical axis represents a measure of work capacity and the horizontal axis income. Note first that work capacity is a measure of the tasks that an individual can perform during a period, say, the number of bushels of wheat that he can harvest during a day. Income is used synonymously with nutrition in the sense that all income is converted into nutrition. Nothing of importance changes if 70 or 80 per cent of income share is spent on nutrition.

The shape of the capacity curve requires an explanation. It is assumed here that much of the nutrition goes into maintaining the body's resting metabolism. This refers to the energy required to maintain body temperature, sustain heart and respiratory action, and to support the ionic gradients across cell membranes. For the "reference man" of the Food and Agriculture organisation (FAO)- a European male weighing 65 kg-the requirement is 1700 calories per day. Of course the requirement varies with the individual and the environment in which he lives. In the case of India Gopalan et al. (1971) indicate that for men doing sedentary, moderate and heavy work the calorie requirements per day are, respectively 2400, 2800 and 3900. A higher body mass raises resting metabolism. Another significant component is energy required to carry out physical labour. The FAO's estimate, applied to their reference man, prescribed lower calorific requirements. It is of course arguable that for the poor in developing countries this may be an underestimate. Once resting metabolism is taken care of, however, there is a marked increase in work capacity, as the bulk of the energy input goes into work. This phase is followed by a phase of diminishing returns, as the body's frame restricts conversion of nutrition into work capacity.

Figure 1 here

Assume that working in a labour market generates income, and that piece rates are paid. A piece rate, then, appears as a relationship between the number of tasks performed and the total income of a person. Using these assumptions, a supply curve of labour could be constructed that shows different quantities of labour supplied at different piece rates. Aggregation across individuals yields an aggregate supply curve, as shown in Figure 2.

Figure 2 here

At a piece rate of v_3 there is a gap in labour supply and a discontinuous jump. Introducing a downward sloping demand curve, an interesting case is that in which the demand curve passes through the dotted supply curve. If the piece rate is larger than v^*, there is excess supply, which lowers this rate. On the other hand, if the piece rate is lower than v^*, there is excess demand, so that wages rise. Note, however, that a piece rate of v^* is an equilibrium wage, provided we allow for unemployment.

Figure 3 here

Having some people work and restricting labour market access to others could fill the gap in labour supply. Those rationed out will be relatively undernourished. This completes the vicious cycle of poverty. Lack of labour market opportunities results in low wages and consequently low work capacity; a low work capacity feeds back by lowering access to labour markets. It is easy to show that higher non-labour assets (e.g. land) lead to higher wage incomes. Thus the poor without assets are doubly disadvantaged: not only do they not enjoy non-labour income but also have restricted access to labour market opportunities.

Note that nutritional status depends on both current consumption of nutrients (e.g. calories) and the history of that consumption. In the analysis that follows, we focus on the effects of differences in calorie intake.[7]

The essence of an empirical test for the PNT Hypothesis[8] is the specification of a wage equation conditional on energy intake and control variables as:

$$w_h = f(calorie_h, p_1, p_2, p_3, p_4, X)$$

where w_h and 'calorie' represents the wage and calorie intake of the h^{th} individual. p_i is the probability of being occupied in the ith occupation with i =1 indicating employment in agriculture, i=2 employment in non-agriculture, i=3 self employment and i = 4 other employment. This set of variables controls for labour market participation. 'X' represents control variables such as prices of various food products, income of the household from the non-agricultural sector, some household characteristics as well as some regional dummies. The probabilities are taken as the control variables to incorporate the impact of labour market participation on wage rate. It is thus argued that the wage rate of the worker depends on his nutrition proxied by his energy intake, which in turn depends on his wages. Hence the wage rate and nutritional intake are both endogenous in this model.

Data and Methodology

The data used in this paper comes from the National Council for Applied Economic Research (NCAER). This data were collected through a multi-purpose household survey spread over six months, from January to June 1994. The data were collected using varied reference periods based on some conventional rules. The wage data used are that for harvesting, sowing and other occupations for male and female workers separately.

Any empirical strategy to estimate the PNT must deal with the mutual endogeneity of wage and nutrition. In the literature two standard approaches to doing this have been followed. The first predicts the probabilities of labour market participation from a Maximum Likelihood Multinomial Logistic Regression (multi-logit) model (discussed next) and then uses these in as determinants of the wage in an appropriately specified Tobit model of the PNT. The second method uses the well-known Heckman self selection procedure.

Tobit Methodology

The predicted probabilities of participating in the labour market are calculated from a regression equation that models labour market participation and used subsequently in sample selection methods discussed next. In the Tobit analysis the number of hours worked by an Agricultural labourer (AL) is a censored variable. The data is observed only for the individuals who actually work and not for the individuals who are willing to work but are unable to find employment.[9] The efficiency wage hypothesis argues that, starting from a low base, the higher the nutritional intake of an individual the higher the probability that he/she would be employed, *ceteris paribus.* Given the low nutritional attainment of individuals in the sample it is no surprise that there are many households with unemployed individuals.

Hence there exist many zeroes in a random sample of wages of rural individuals. Our motivation for the analysis is to investigate the linkages of nutrition and wage rate for the whole sample rather than the sample comprising individuals who are employed. The conventional regression methods fail to account for the qualitative difference between limit (zero) observations and non-limit (continuous) observations.

Tobin (1958) suggested an estimation method suitable for the censored data. The regression model is referred as the censored regression model or the Tobit model discussed next.

The dependent variable is denoted by Y*, not Y. This is because the dependent variable is latent, and not observed. In theory, we do not observe wages below zero. Y* can be perceived as the desire to work. There is a threshold which one has to reach before one can start working. What we observe is Y, which is the amount an individual earned while working.

The Tobit model is generally represented in the following way. First, we postulate a latent variable, Y*, which depends on some independent variables and a disturbance term that is normally distributed with a mean of zero. But, we have a censoring at point *C,* which in our case, is zero. Thus we have an observed Y that equals Y* if the value of Y* is greater than 0, but equals 0 if the value of the unobserved Y* is less than or equal to 0. The observed model, therefore, has a dependent variable Y, with some independent variables and coefficients, and an error term. Because of the censoring, however, the lower tail of the distribution of Y_i, and of u_i, is cut off and the probabilities are piled up at the cut-off point. The implication is that the mean of Y_i is different from that of Y_i*, and the mean of u_i (the error term in the model with the observed variable) is different from the mean of u^*_i (the error term in the model with the latent variable; which is zero).

$$Y_i^* = X_i'\beta + u^*_i \qquad (1a)$$

We have censoring at C =0:

$$Y_i = Y_i * if\, Y_i* > C \qquad (1b)$$

$$Y_i = C \;\; if\, Y_i* \leq C \qquad (1c)$$

So the observed model is

$$Y_i = X_i'\beta + u_i \quad if\; Y_i > 0 \;\; and \;\; Y_i = 0, otherwise.$$

The procedure to estimate the above model has to take account of the censoring. We note that the entire sample consists of two different sets of observations. The first set contains the observations for which the value of *Y* is zero. For these observations we know only the values of the *X* variables and the fact that Y* is less than or equal to 0. The second set consists of all observations for which the values of both *X* and *Y** are known and the latter is positive. The likelihood function of the Tobit model consists of each of these two parts.

$$L = \sum_{Y_i > 0} -\frac{1}{2}\left[\log(2\pi\sigma^2)\right] - \frac{1}{2}\sum_{i=1}^{n}\left(\frac{(Y_i - \beta' X_i)^2}{\sigma}\right) + \sum_{Y_i = 0}\log\left[1 - \Phi\left(\frac{\beta' X_i}{\sigma}\right)\right] \qquad (2)$$

where the first two terms constitute the first part of the likelihood function and the third is the second part.

The Tobit model has some notable limitations (Greene 2003, Smith and Brame 2003). The first limitation is that in the Tobit model the same set of variables and coefficients determine both the probability that an observation will be censored and the value of the dependent variable. Second, the Tobit analysis is not based on a full theoretical explanation of why the observations that are censored are censored. These limitations can be remedied by replacing the Tobit model with a sample selection model.

Sample selection models address these shortcomings by modifying the likelihood function. First, a different set of variables and coefficients determine the probability of censoring and the value of the dependent variable given that it is observed. These variables may overlap, to a point, or may be completely different. Second, sample selection models allow for greater theoretical development because the observations are said to be censored by some other variable, which we call *Z*. This allows us to take account of the censoring process, as we will see, because selection and outcome are not independent. A popular empirical strategy to pursue this is the Heckman procedure which we now discuss.

The Heckman Procedure

The problem of sample selection arises when the data in the survey is incidentally truncated or non-randomly selected. Our model determining wage nutrition relationship contains following main regression equation:

$$Y_i = \beta' X_i + \varepsilon_i \qquad (3)$$

where Y_i is the wage rate and X_i is a vector comprising the nutrition and other household characteristics. The model may imply a wage rate for all the individuals but we observe it only for those who are actually employed. Hence the model is truncated as the sample is selected on the basis of wages (in the agricultural sector).

Formally, the wages are observed only if:

$$Z_i* = \gamma' W_i + u_i \qquad (4)$$

where W_i are independent variables that contribute to the employment probability of an individual. W_i may or may not overlap with the X_i. In our case it does.

Equation (4) is called the selection equation. The sample rule thus becomes that Y_i* (the wage rate) is observed only when Z_i*> 0 (or the person under consideration is employed in agricultural sector). We now discuss the estimation issues related to the observations in our sample (based on the above rule).

A simple OLS regression of the observed data produces inconsistent estimates of β essentially because of omitted variables. Moreover, the disturbance term is heteroscedastic so that the estimates will be inefficient.

Marginal Effects

The marginal effect of the regressors on Y_i has two components: direct effect on mean of Y_i, which is β, and the indirect effect through the regressor which is present in X_i. The problem of sample selection can lead the marginal effects to be overstated for the observed category (for which Z_i* > 0) and understated for the other category. For example, suppose that nutrition affects both the probability of working in agricultural sector and wage rate in either sectors (agricultural sector or non-agricultural sector). If we assume that the wages of the agricultural labourers (AL) is higher than that of otherwise identical non agricultural labourers (NAL), the marginal effects of nutrition has two parts: one due to its influence in increasing the probability of the individuals entering agricultural sector and the other due to its influence on wage rate within the group. Hence the coefficient on nutrition in the regression overstates the marginal effect of the nutrition of AL and understates it for the NAL. In the opposite case it would understate the marginal effect.

Heckman suggested a two step procedure for estimating the above model. The model is first reformulated to a probit form. It should be noted that although the variable Z_i* is not observed, one can infer its sign (for example whether an individual works in agricultural sector or not) but not the magnitude. Thus the model can be reformulated as follows:

Selection Mechanism and Regression Model:

$Z_i{}^* = \gamma' W_i + u_i \; if \; Z_i{}^* > 0 \; and \, 0 \, otherwise.$ Whence we can write the regression model as:

$Y_i = \beta' X_i + \varepsilon_i \; observed \, only \, if \; Z_i = 1, (u_i, \varepsilon_i) \sim bi\,\mathrm{var}\,iate\,normal[0,0,1,\sigma_\varepsilon, \rho]$

The parameters of the sample selection model can be estimated using Heckman's two step estimation procedure discussed next.

Heckman's two step procedure

Heckman's two step estimation procedure (Heckman 1976, 1979) involves the following steps:

• Step 1: Estimate the probit equation by maximum likelihood to obtain estimates of γ. For each model in selected sample compute the inverse Mills ratio

$$\hat{\lambda}_i = \frac{\phi(\hat{\gamma} w_i)}{\Phi(\hat{\gamma} w_i)} \text{ and } \hat{\delta}_i = \hat{\lambda}_i (\hat{\lambda}_i + \hat{\gamma} w_i)$$

where $\phi \; and \; \Phi$ are, respectively, the probability density function and the cumulative density function of a standard normal distribution.

• Step 2: Estimate β and $\beta_\lambda = \rho\sigma_\varepsilon$

by least squares regression of Y_i on X_i and $\hat{\lambda}$.

This methodology allows consistent estimates of the individual parameters. In this paper we present Heckman estimates for the wages for which we have a PNT.

Results

We discover the existence of a Poverty Nutrition trap in two cases – female harvesting and female sowing using the Heckman methodology. With the Tobit methodology we found the PNT to hold in the case of Female Harvest, Male other, and Female other categories of wages.

Results for the existence of PNT for the Heckman model[10] are shown in Table 1.

Table 1 here.

In Table 2 we report on the nutritional requirement to break out of the PNT. From the regression equation we compute the nutritional requirement to break the PNT. Thus if we use the Heckman method for female harvest wage we discover that the minimum daily calorie requirement is 3264.08. From the data the minimum annual per capita expenditure that can attain this is Rs. 3011. This is much higher than the per capita poverty line for that year which was Rs 2484 per year. As a percentage of the poverty line this gap[11] is over 21 percent.[12]

Table 2 here.

Conclusions

The possibility that when workers are acutely under-nourished they may not be able to exert sufficient effort so that their wages remain low which then leads to further poor nutritional outcomes has been known in the literature for almost fifty years now. A number of authors have tried to empirically test for this existence of this trap but none has been able to establish unambiguously that this holds for a subset of the working population and not the whole. Further, the extant literature also has not been able to establish the existence of PNT by occupation.

This paper has attempted to quantify and formally test for the presence of PNT in rural India. It outlines a methodology that can identify the impact of energy consumption, protein and micronutrients on wage rates, even in the presence of mutual endogeneity.

This paper has an important policy implication in that it argues that if a minimum wage has to be set in agriculture it must be adequate to ensure that workers are not caught in the poverty-nutrition trap. The PNT is shown to exist for women using both Tobit and Heckman procedures whereas it exists for men only in the case of Tobit regression. These results then suggest a persistent gender bias in calorie undernutrition against women workers in rural India’s labour markets. This is a matter of urgent policy concern.

References

Barrett, C. and B. Swallow (2006) "Fractal Poverty Traps" *World Development*, Vol. 34, no.1, pp. 1-15.

Barrett, C., Marenya, P. ,McPeak, J., Minten, B., Murithi, F., Oluoch-Kosura, W., Place, F., Randrianarisoa, J., Rasambainarivo, J. and J. Wangila (2006) "Welfare Dynamics in Rural Kenya and Madagascar" *Journal of Development Studies,* vol.42, no.2, pp.248-277.

Behrman J. and A. Deolalikar (1987) "Will Developing Country Nutrition Improve with Income? A Case Study of Rural South India" *Journal of Political Economy*, vol.95, no.1, pp.108-138.

Binswanger, J. and M. Rosenzweig (1984) "Contractual Arrangements, Employment and Wages in Rural Labour Markets: A Critical review" in Binswanger, J. and M. Rosenzweig (eds.) *Contractual Arrangements, employment and Wages in Rural Labour Markets in Asia,* New Haven, Conn.: Yale University Press.

Bliss, C. and N. Stern (1978a) "Productivity, Wages and Nutrition: Part I: The Theory" *Journal of Development Economics*, vol.5, no.2, pp. 331-362.

Bliss, C. and N. Stern (1978b) "Productivity, Wages and Nutrition: Part II: Some Observations" *Journal of Development Economics*, vol.5, no.2, pp. 363-398.

Dasgupta, P. and D. Ray (1986) "Inequality as a determinant of Malnutrition and Unemployment: Theory" *Economic Journal*, vol.96, no.4, pp. 1011-1034.

Dasgupta, P. and D. Ray (1987) "Inequality as a determinant of Malnutrition and Unemployment: Policy" *Economic Journal*, vol.97, no. 1, pp. 177-188.

Dasgupta, P. (1993) *An Inquiry into well-being and Destitution*, Oxford: Oxford University Press.

Deolalikar, A. (1988) "Nutrition and Labour Productivity in Agriculture: Estimates for rural South India" *Review of Economics and Statistics*, vol.70, No.3, pp. 406-413.

Greene, W. (2003) *Econometric Analysis*, 5th Edition, Upper Saddle River, NJ: Prentice Hall

Heckman, J. (1976) "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables and a Simple Estimator for Such Models" *Annals of Economic and Social Measurement*, vol. 5, no. 3, pp. 475-492.

Heckman, J. (1979) "Sample Selection Bias as a Specification Error" *Econometrica,* Vol. 47, no.1, pp. 153-161.

Leibenstein, H. (1957) *Economic Backwardness and Economic Growth: Studies In the Theory of Economic Development*, New York: Wiley and Sons.

Lipton, M. (2001) *Successes in Anti-Poverty*, ILO Geneva, Discussion Paper 8.

Lybbert, T., Barrett, C., Desta, S. and D. Coppock (2004) " Stochastic Wealth Dynamics and Risk Management among a Poor Population" *Economic Journal,* vol.114, no.3, pp. 750-777.

Mazumdar, D. (1959) "The Marginal Productivity Theory of Wages and Unemployment" *Review of Economic Studies*, vol.26, no.3, pp.190-197.

Mirrlees, J. (1975) "A Pure Theory of Underdeveloped Economies" in L. Reynolds (ed.) *Agriculture in Development Theory*, New Haven: Yale University Press, pp. 84-108.

Smith, D. and R. Brame (2003) "Tobit Models in Social Science Research: Some Limitations and a More General Alternative" *Sociological Methods and Research*, vol. 31, no.3, pp. 364-388.

Srinivasan, T. (1994) "Destitution: A Discourse" *Journal of Economic Literature*: Vol. 32, no.4, pp. 1842-1855.

Strauss, J. and D. Thomas (1998) "Health, Nutrition and Economic Development" *Journal of Economic Literature*, vol.36, no.3, pp.766-817.

Strauss, J. (1986) "Does Better Nutrition raise Farm Productivity?" *Journal Of Political Economy*, vol. 94, no.2, pp.297-320.

Subramanian, S. and A. Deaton (1996) "The Demand for Food and Calories" *Journal of Political Economy*, vol. 104, no.1, pp.133-162.

Thomas, D. and J. Strauss (1997) "Health and Wages: Evidence on men and women in urban Brazil" *Journal of Econometrics*, vol. 77, no.1, pp.159-185.

Tobin, J. (1958) "Estimation of Relationships for Limited Dependent Variables" *Econometrica*, vol. 26, no.1, pp. 24-36.

Figure 1: The Capacity Curve

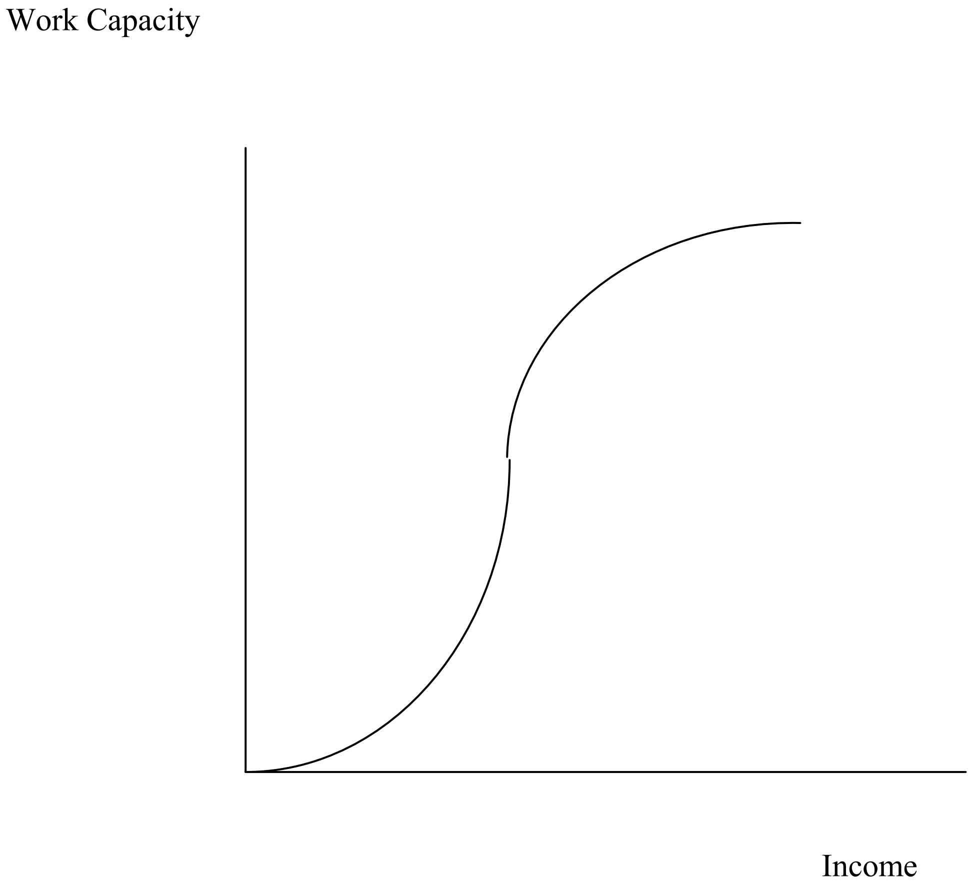


Figure 2: Individual and Aggregate Labour Supply

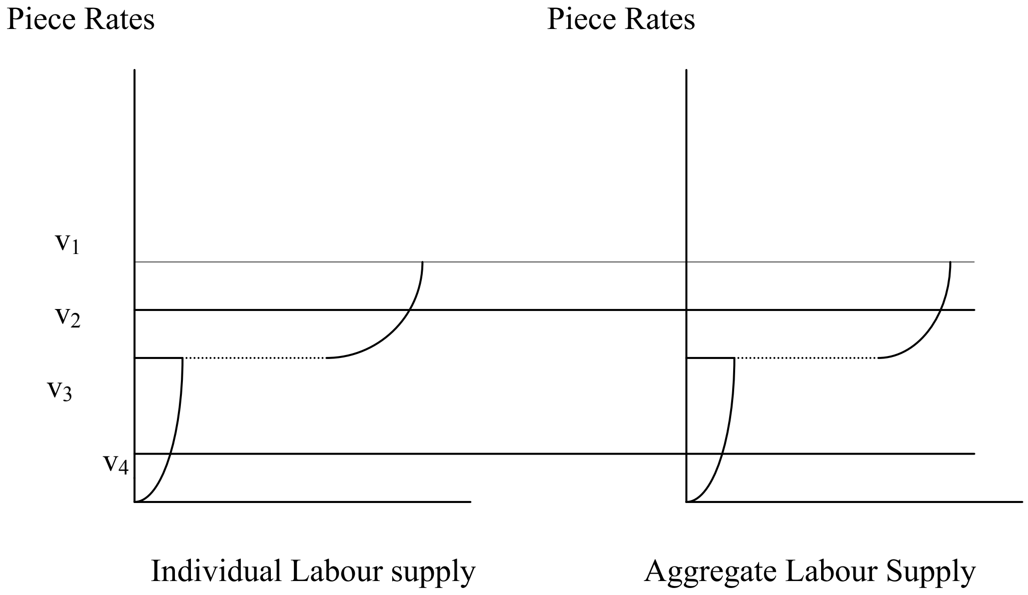
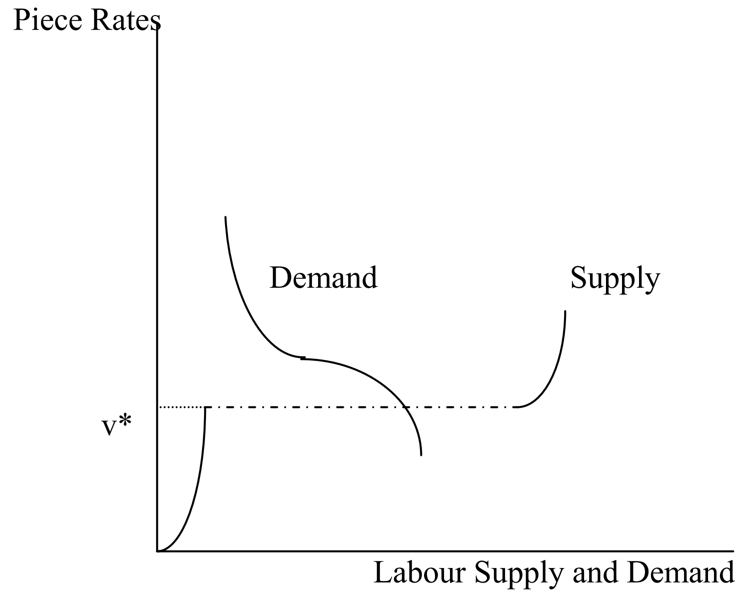


Figure 3: "Equilibrium" in the Labour Market



Source: Ray (1998).

Table 1a: Existence of PNT - Female Harvest Wages

Heckman Selection Model

Heckman selection model -- two-step estimates		Number of obs	=	6594
(regression model with sample selection)		Censored obs	=	2134
		Uncensored obs	=	4460
		Wald chi2(23)	=	1313.11
		Prob > chi2	=	0

	Coef.	Std. Err.	Z	P>z
Fem_harvest				
Bimaru	-8.31628	0.736491	-11.29	0
Enepchat	0.013905	0.004224	3.29	0.001
enepchat2	-2.13E-06	8.57E-07	-2.48	0.013
Pr_pulses	-0.19393	0.06206	-3.12	0.002
pr_gur_sugar	-0.27138	0.161881	-1.68	0.094
pr_oil	0.068766	0.013702	5.02	0
pr_milk	-0.07809	0.034139	-2.29	0.022
Headage	0.054676	0.085533	0.64	0.523
Headage2	-0.00097	0.000869	-1.12	0.263
NO.ADULTMALE	-1.44647	0.28626	-5.05	0
NO.ADULTFEMALE	1.331039	0.28769	4.63	0
Hhsize	0.067531	0.229362	0.29	0.768
SC/ST	2.477348	0.769413	3.22	0.001
RAINFALLINDEX	0.002109	0.000495	4.26	0
Coastal	3.215776	1.01557	3.17	0.002
_cons	0.554281	4.368315	0.13	0.899
Select				
Headage	-0.00384	0.007484	-0.51	0.608
Headage2	2.98E-05	7.67E-05	0.39	0.698
NO.ADULTMALE	-0.03827	0.019037	-2.01	0.044
NO.ADULTFEMALE	0.049924	0.022145	2.25	0.024
SC/ST	0.496191	0.036991	13.41	0
Land_own	-0.00463	0.000427	-10.84	0
Land_own2	-6.04E-08	1.77E-07	-0.34	0.734
RAINFALLINDEX	8.92E-05	0.000052	1.71	0.087
Landrain	4.84E-06	6.13E-07	7.9	0
Bimaru	0.306848	0.041688	7.36	0
Coastal	1.004761	0.066374	15.14	0
FEMALE_HHHEAD	0.246493	0.085797	2.87	0.004
_cons	0.289162	0.166635	1.74	0.083
Mills				
Lambda	-0.5846	1.792234	-0.33	0.744
Rho	-0.04972			
Sigma	11.75735			
Lambda	-0.5846	1.792234		

Table 1b: Existing of PNT - Female Sowing wages

Heckman selection model -- two-step estimates	Number of obs	=		6594
(regression model with sample selection)	Censored obs	=		2134
	Uncensored obs	=		4460
	Wald chi2(23)	=		1175.47
	Prob > chi2	=		0

	Coef.	Std. Err.	z	P>z
fem_sowing				
Bimaru	-5.88153	0.627624	-9.37	0
Enepchat	0.017007	0.003599	4.73	0
enepchat2	-3.39E-06	7.30E-07	-4.65	0
pr_pulses	-0.0691	0.05287	-1.31	0.191
pr_gur_sugar	0.103302	0.137909	0.75	0.454
pr_oil	-0.08489	0.011671	-7.27	0
pr_milk	-0.07162	0.029082	-2.46	0.014
Headage	0.180339	0.072909	2.47	0.013
headage2	-0.00209	0.000741	-2.82	0.005
NO.ADULTMALE	-0.73618	0.243956	-3.02	0.003
NO.ADULTFEMALE	0.912363	0.245196	3.72	0
Hhsize	-0.53584	0.195397	-2.74	0.006
SC/ST	4.987092	0.655711	7.61	0
RAINFALLINDEX	-0.00227	0.000422	-5.38	0
Coastal	3.226689	0.8655	3.73	0
_cons	-7.22458	3.722152	-1.94	0.052
Select				
Headage	-0.00384	0.007484	-0.51	0.608
headage2	2.98E-05	7.67E-05	0.39	0.698
NO.ADULTMALE	-0.03827	0.019037	-2.01	0.044
NO.ADULTFEMALE	0.049924	0.022145	2.25	0.024
SC/ST	0.496191	0.036991	13.41	0
Land_own	-0.00463	0.000427	-10.84	0
Land_own2	-6.04E-08	1.77E-07	-0.34	0.734
RAINFALLINDEX	8.92E-05	0.000052	1.71	0.087
Landrain	4.84E-06	6.13E-07	7.9	0
Bimaru	0.306848	0.041688	7.36	0
Coastal	1.004761	0.066374	15.14	0
FEMALE_HHHEAD	0.246493	0.085797	2.87	0.004
_cons	0.289162	0.166635	1.74	0.083
Mills				
Lambda	0.867331	1.527327	0.57	0.57
Rho	0.08649			
Sigma	10.02806			
Lambda	0.867331	1.527327		

Table 2: Nutritional Requirement to break Poverty Nutrition Trap

Nutritional Category Calories (Calories/day)	Requirement to Break PNT	Minimum Equivalent Per Capita Expenditure per year
HFH	3,264.08	3011
HFS	2,508.41	981.44

Appendix Table 1: Variables Used in the Analysis

Household Level Variables	
Variable Name	*Variable Description*
headage	Age of Household Head
headage2	Square of Age of Household Head
NO.ADULTMALE	no. of adult males in HH
NO.ADULTFEMALE	no. of adult females in HH
hhgrp	HH Group Dummy Variable 1 if SC/ST HH and 0 Otherwise
HINDU, MUSLIM, CHRISTIAN, SIKH, BUDDHIST, TRIBAL, JAIN, OTHERS	Religion dummies.
FEMALE_HHHEAD	Whether head of household is female.
HIGHESTFEMEDUPRIMARY	Highest level of education for any adult female in household is primary
HIGHESTFEMEDUMIDDLE	Highest level of education for any adult female in household is middle
HIGHESTFEMEDUMATRIC	Highest level of education for any adult female in household is matric
land_own	Land Owned in Acres
land_own2	Square of Land Owned
Other Variables	
RAINFALLINDEX	Rainfall Index (actual - normal rain fall) for 76 agroclimatic zones in India.
bimaru	Dummy for Bimaru states (Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh)
coastal	Dummy for Coastal districts
landrain	Landowned*rainfall
pr_pulses	Price of Pulses
pr_gur_sugar	Price of Gur Sugar
pr_oil	Price of Oil
pr_milk	Price of Milk
Generated Variables	
Enepchat	Predicted value of calorie consumption per capita
Enepchat2	Predicted value of square of calorie consumption per capita

Endnotes

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[2] In this paper we use the terms efficiency wage hypothesis and PNT interchangeably.

[3] For an analysis of how idiosyncratic and covariate shocks can lead to entrapment in a PNT in a dynamic framework see Lybbert et al. (2004).

[4] For a comprehensive review see Strauss and Thomas (1998) and Lipton (2001).

[5] Calorie deprivation is more likely to have an impact on nutrition than other forms of deprivation. An aggregate of deprivation across various nutrients is essentially arbitrary and does not indicate which the most pressing deprivation is.

[6] The following exposition is based on Ray (1998).

[7] For critiques of PNT hypothesis, see Srinivasan (1994), and Subramanian and Deaton (1996).

[8] Since we have cross section data at our disposal we cannot pursue the analysis of PNT as dynamic multiple equilibria as in Barrett and Swallow (2006).

[9] Appendix Table 1 provides details of the variables used in the analysis.

[10] Because of space considerations we only report results from the Heckman procedure. Results from the estimated Tobit models are available from the corresponding author.

[11] It should be noted that the calorie requirements in Table 2 could overstate the calorie requirements to break out of the PNT because these workers would not be performing the demanding tasks of harvesting or sowing throughout the year. However, since these workers are classified according to their primary functions, the extent of such overestimation may be limited. Furthermore, this view should be viewed with some scepticism since we do not have accurate estimates of the calorific requirements of the household and related work that these workers perform.

[12] The equivalent magnitudes of calories (per capita expenditure per year) for Tobit Female Harvest, Tobit Male Other, Tobit Female Other categories of wages are, respectively 3,340.15 calories (Rs. 3142 per year), 3,037.86 (Rs. 2068 per year), and 3,212.47 (Rs. 1630.25).