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Poverty, undernutrition and vulnerability in rural India: public works versus food subsidy

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What is Chronic Poverty?

The distinguishing feature of chronic poverty is extended duration in absolute poverty.

Therefore, chronically poor people always, or usually, live below a poverty line, which is normally defined in terms of a money indicator (e.g. consumption, income, etc.), but could also be defined in terms of wider or subjective aspects of deprivation.

This is different from the transitorily poor, who move in and out of poverty, or only occasionally fall below the poverty line.

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Abstract

This paper analyses the effects of access to Rural Public Works (RPW) and the Public Distribution System (PDS), a public food subsidy programme, on consumption poverty, vulnerability and undernutrition in India drawing, on the large household datasets constructed with National Sample Survey (NSS) data, 50th round in 1993-1994 and 61st round in 2004-2005. The treatment effects model and propensity score matching (PSM) model are used to take account of the sample selection bias in evaluating the effects of RPW or PDS on poverty. We found significant and negative effects of household participation in RPW and food for work programmes on poverty, undernutrition (e.g. protein) and vulnerability in 1993 and 2004. Indeed, poverty and undernutrition were significantly higher for households with access to PDS than for those without, although PDS had significant effects in terms of reducing vulnerability of households in 1993 and 2004. We also applied the pseudo panel model, which confirmed that PDS decreased vulnerability based on 80 percent of the poverty threshold. However, state-wise results of the treatment effects model show considerable diversity of policy effects among different states.

Keywords: poverty, undernutrition, vulnerability, Rural Public Works (RPW), Public Distribution System (PDS), poverty reduction policy, treatment effects model, Propensity Score Matching (PSM) model, India.

JEL Codes: C21, C23, C31, I32, I38, O15, O22

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1 Introduction

Despite the recent economic growth at national level in India, concerns have been raised over the disparity of poverty levels as well as the speed of poverty reduction in recent years (e.g. Himanshu, 2007; Jha and Gaiha, 2003; Kijima, 2006). Disparity could arise from geographical locations (e.g. among different states or between urban and rural areas) or among social groups or castes (Gaiha *et al.*, 2007; Kijima, 2006; Gang *et al.*, 2006). However, there has been no consensus as to what is the best alternative for a set of policy options to reduce poverty efficiently at national scale. While policies to promote macroeconomic growth are necessary to reduce poverty, interventions targeted directly at the poor have been in operation and are considered the crucial component of public policy in India at both government and state levels, because economic growth *per se* is not sufficient to reduce poverty of those in backward areas or in disadvantaged social groups who lack easy access to markets or education.

Owing to the advantages arising from their salient features, such as self-targeting,[1] Rural Public Works (RPW) have been considered one of the best alternatives. However, a previous assessment of RPW points out that they do not reach the poor effectively (e.g. Gaiha *et al.*, 2001). Past literature also suggests that workers who are poor do not have enough incentives to participate in the scheme because of the poverty trap: those under the threshold will either be left out of the labour market (or unemployed) (e.g. Dasgupta, 1997) or receive only marginal wages, as they cannot carry out physically demanding tasks owing to undernutrition or poor health. This would imply difficulty in evaluating RPW and poverty, as poverty and undernutrition are not necessarily only their outcomes but also affect the participation decision. Rigorous empirical work to examine the relationship between RPW and poverty is of enormous help in driving policy implications. The purpose of this paper is to statistically assess whether participation in RPW affects poverty defined in consumption expenditure based on National Sample Survey (NSS) large national-scale household data in the 50th round in 1993-1994 and the 61st in 2004-2005. We use data on participation in RPW for the 50th round and those on FFW (Food for Work), a version of RPW, for the 61st round, because of the data constraints.[2]

As a comparison with RPW, the present study will evaluate the poverty-reducing effects of the Public Distribution System (PDS), the public scheme of food subsidy under which poor

[1] In self-targeting, the participants themselves decide to participate in the scheme explicitly or implicitly by comparing the potential benefits (e.g. wage incomes, reduction of seasonality or risk) and costs (e.g. physical labour, transportation costs, opportunity costs). Better targeting performance through work requirements would lead to the better cost effectiveness of poverty interventions as put forward as ‘screening arguments’ by Besley and Coates (1992).

[2] The data on RPW in the 50th round and those on FFW in the 61st round are the most reliable, with relatively few missing observations.

people are provided with basic food at subsidised prices (e.g. rice, wheat, sugar, edible oil, soft cake and kerosene oil). RPW has an advantage over PDS owing to the nature of self-selection, but PDS can be accessed by those who are unable to work (e.g. the elderly or the physically disabled). PDS is likely to have an impact on nutritional conditions of household members because of its provision of food. However, there are relatively few systematic and rigorous studies to evaluate the impact of PDS on poverty.[3/4]

However, it is not straightforward to evaluate the effects of RPW or PDS on poverty because of the endogeneity or the sample selection problem associated with access to these schemes. Participation in RPW is likely to be endogenous, either because of the endogenous programme placement, where policymakers purposefully allocate the fund according to the objectives of the programme (e.g. poverty alleviation in a remote area or disadvantage groups), or because of the self-selection. The geographical placement of PDS may not be random, or could be endogenous.

This paper will take into account the endogeneity in assessing RPW in two ways. First, we will employ the treatment effects model, a version of the Heckman sample selection model (Heckman, 1979), where the participation equation is estimated and in the second stage poverty or consumption is estimated by predicted participation, among other determinants. Second, the propensity score matching (PSM) model will be applied to statistically compare poverty measures for those who have access to RPW and for those who do not, matched by the propensity score derived by the probit or logit model, where the characteristics of households are taken into account.

The PSM first estimates the probit or logit model to estimate a function matching the proximity of one household to another in terms of household characteristics and then households are grouped to minimise the distance between matched cases. This has some advantages over the IV (instrumental variable) model (e.g. not requiring the instrument or linearity as in the IV model), but the sample selection bias will not be entirely corrected if there are important unobservable variables that affect the household decision to participate in programmes (e.g. health, intra-household bargaining or cultural or psychological factors not found in the data). The treatment effects model also estimates the probit model with

[3] An important exception is Bhalotra (2002), who analysed the effects of PDS on child nutrition. She found, based on household data collected by the National Council of Applied Economic Research (NCAER) in 1994, that (i) if the average subsidy for the average household on PDS is 23 percent, then the PDS-using household buys 23 percent more food; and (ii) the additional expenditure on food translates into statistically significant increases of 0.09 standard deviations in height and 0.05 standard deviations in weight for boys, and into smaller increases for girls.

[4] See Bhalotra (2002, Table 2) for the importance of PDS and RPW in central plan budgetary expenditure in India, where PDS had a share of 3.2 percent and rural employment programmes had 2.3 percent in 1997, the highest shares among other alternatives. This suggests that these are the two major programmes to support the rural poor in India.

similar specifications as in the first stage of PSM. In the second stage, the poverty measure is estimated by ordinary least square (OLS), while sample selection is corrected by using the estimates of probability of participating in the microfinance programmes. The model is fitted by a full maximum likelihood (Maddala, 1983). The merits of the treatment effects model over PSM include that: (i) the degree of sample selection is explicitly taken into account in the model; and (ii) the determinants of the dependent variable in the second stage are identified. However, the treatment effects model imposes strong distributional assumptions for the functions in both stages and the final results are highly sensitive to the choice of explanatory variables and the instrument. The presence of unobservable variables would also affect the results, as in PSM. Given these limitations, applying different models is useful, as one model serves to check the robustness of the results derived by another model.

The present study goes beyond the standard definition of poverty which concerns the binary measure defined by the national poverty line based on income or consumption data. First, for the 50th round, we use the data on undernutrition in terms of calories and proteins, which has been constructed by converting the detailed food expenditure data available in NSS 50-1.0 into their nutritional equivalents (Jha and Gaiha, 2003). That is, whether a household is poor defined not only by consumption but also by nutritional deficiencies. This is important in light of the link between labour market participation and nutrition, which leads to the nutrition-based poverty trap. Second, we have derived the vulnerability measures as the probability of a household falling into poverty using a cross-sectional estimation drawing on Chaudhuri (2003) and Chaudhuri *et al.* (2003). Although poverty and vulnerability are correlated, they are different, as some households above the poverty threshold may be vulnerable while those just below the poverty line but who have secure income sources may not be vulnerable (e.g. Gaiha and Imai, 2009). Hence, the effects of RPW or PDS on poverty and on vulnerability are likely to be different – given the high vulnerability in backward areas, the policy role of reducing vulnerability or protecting households from vulnerable shocks is very important.

The rest of the paper is organised as follows. Section 2 briefly explains the data. Section 3 describes the econometric methodologies used to estimate the treatment effects and PSM models. Section 4 provides the econometric results and main findings. Concluding remarks are given in the final section.

2 Data

2.1 NSS data

The NSS, set up by the government of India in 1950, is a multi-subject integrated sample survey conducted all over India, in the form of successive rounds relating to various aspects of social, economic, demographic, industrial and agricultural statistics.[5] We mainly use the data in the Household Consumer Expenditure schedule, called 'the scheduled 01', in the quinquennial surveys in the 50th round, 1993-1994 and in the 61st round, 2004-2005.[6] These form the repeated cross-section datasets, each of which covers a large number of households across India.[7] The consumption schedule contains a range of information related to mean per capita expenditure (MPCE) and disaggregated expenditure over many items, together with basic socioeconomic characteristics of households (e.g. sex, age, religion, caste and landholding). To derive wages at the level of the NSS region, we supplement the consumption schedule with the Employment and Unemployment schedule, called 'the scheduled 10', which has data on employment and unemployment situations.

The NSS covers the whole of the Indian Union except (i) Leh (Ladakh) and Kargil districts of Jammu and Kashmir; (ii) interior villages of Nagaland situated beyond the bus route; and (iii) villages in the Andaman and Nicobar Islands which remain inaccessible throughout the year. In this study, we will use data in the Household Consumer Expenditure schedule in the 50th and 61st round, because the data on RPW in Employment and Unemployment have many missing observations. Definitions and descriptive statistics of the variables are shown in Annex 1. The latter are presented for those with or without access to RPW (or PDS).

Data on which households participated in RPW were collected by the consumption schedule of the NSS 50th round, but only data on participation in FFW are available for the 61st round. Hence, these participation data are not strictly comparable, but we use these data as proxies for household-level access to RPW, that is, whether any member of the household participated in RPW. Access to PDS is defined as whether a household obtained any food items from PDS. One limitation in our approach is that we do not take account of how many days the household member participated in RPW or how much food a household obtained through PDS, assuming that a household as a unit, through collective decision making by household members, makes a decision on whether it should participate in RPW or use PDS

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[5] See National Sample Survey Organisation (NSSO) website http://mospi.nic.in/nsso_test1.htm for more details.

[6] We are not using the 55th round (1999-2000) as the consumption data are not comparable with those in the 50th or 61st round because of the change in the recalling periods. The consumption data are comparable between the 50th round and the 61st round.

[7] After dropping households with missing observations on one of the explanatory variables, the number of households used for the estimation was 69,206 and 78,999 for the 50th and 61st round, respectively.

given the household conditions. This assumption, which may not reflect the reality, is required, as data on RPW or FFW and PDS are available only at household level.

2.2 Computation of nutritional deficiency

For the NSS 50th round, we have derived the nutrition-based poverty cut-off points by taking into account calories and protein intakes as well as minimum cut-off points for either on the assumption of moderate work (Gopalan, 1992; Gopalan et al., 1971). The official poverty line takes into account the cost of a nutritionally adequate diet in terms of per capita consumption expenditure. The poverty line is taken as per capita consumption worth Rs. 49 (Rs. 57) at 1973-1974 prices for the rural (urban) sector. Expenditure is used as a proxy for income, since the NSS does not collect income data. Estimates using these poverty lines have been made by a number of authors. We calculated nutritional deficiency using nutritional equivalents of actual consumption baskets for households compared against recommended daily allowance. as elaborated in Gopalan *et al.* (1971). The daily nutritional requirements as reported by Gopalan *et al.* are reproduced in Annex 2. We use energy per capita and protein per capita from the NSS 50th round data files converted into nutritional equivalents. These data are computed as total consumption (of calories, protein and other nutrients) of households divided by variable 'members', where the number of members in a household is calculated by giving unit weights to the adults and 0.5 weight to the children. Age-specific weights for children are not possible since ages of children are not recorded.

3 Econometric models

3.1 Deriving vulnerability measures using large cross-sectional data

It would be ideal to use panel data to derive household's vulnerability measures. We were able to derive the measure of 'vulnerability as expected poverty' (VEP), an *ex ante* measure based on Chaudhuri (2003) and Chaudhuri *et al.* (2002), who applied this to a large cross-section of households in Indonesia[8] and defined vulnerability as the probability that a household will fall into poverty in the future.

$$VEP_{it} \equiv V_{it} = \Pr\left(c_{i,t+1} \le z\right) \quad (1)$$

where vulnerability of household i at time t, V_{it}, is the probability that the i-th household's level of consumption at time t+1 , $c_{i,t+1}$, will be below the poverty line, z.

[8]See a summary by Hoddinott and Quisumbing (2003a, b) of methodological issues in measuring vulnerability.

Three limitations, among others, should be noted in our measure of vulnerability. First, the present analysis is confined to a consumption (used synonymously with income) threshold of poverty. Second, our measure of vulnerability in terms of the probability of a household's consumption falling below the poverty threshold in the future is subject to the choice of a threshold.[9] Third, while income/consumption volatility underlies vulnerability, the resilience in mitigating welfare losses depends on assets defined broadly – including human, physical and social capital. A household with inadequate physical or financial asset or savings, for example, may find it hard to overcome loss of income. This may translate into lower nutritional intake and rationing out of its members from the labour market (Dasgupta, 1997; Foster, 1995). Lack of physical assets may also impede accumulation of profitable portfolios under risk and generate poverty traps (Zimmerman and Carter, 2003).

The consumption function is estimated by the equation (2).[10]

$$\ln c_i = X_i \beta + e_i \quad (2)$$

where c_i is MPCE (i.e. food and non-food consumption expenditure) for the i-th household and X_i is a vector of observable household characteristics and other determinants of consumption.[11] These include:

A_i : A set of variables on household composition, such as whether a household is headed by a female member, number of adult male or female members, share of adult members in the household).

E_i: A set of the variables on the highest level of educational attainment of household members (e.g. whether completed primary school, secondary school or higher education).

L_i: Owned land as a measure of household wealth.

O_i: Occupation of parents in terms of whether the household is classified as (i) non-agricultural self-employment or (ii) agricultural self-employment.

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[9] One of the limitations of this definition of vulnerability is that it is sensitive to the choice of z. We have defined the poverty line based on the national poverty line and checked the sensitivity of the results by applying different levels of poverty line (i.e. 120 percent and 80 percent).

[10] We have used the White-Huber sandwich estimator to overcome heteroscedasticity in the sample.

[11] See Annex 1 for definitions of the variables. These variables are used to estimate poverty and undernutrition equations.

B_i: Social backwardness of the household in terms of (i) whether a household belongs to a scheduled caste (SC) and (ii) whether it belongs to a scheduled tribe (ST).

D: A vector of state dummy variables.

β is a vector of coefficients of household characteristics, and e_i is a mean-zero disturbance term that captures idiosyncratic shocks to per capita consumption. It is assumed that the structure of the economy is relatively stable over time and, hence, future consumption stems solely from the uncertainty about the idiosyncratic shocks, e_i. It is also assumed that the variance of the disturbance term depends on:

$$\sigma^2_{e,i} = X_i\theta \quad (3)$$

The estimates of β and θ are obtained using a three-step feasible generalised least squares (FGLS).[12] Using the estimates $\hat{\beta}$ and $\hat{\theta}$, we can compute the expected log consumption and the variance of log consumption for each household as follows:

$$E[\ln C_i | X_i] = X_i\hat{\beta} \quad (4)$$

$$V[\ln C_i | X_i] = X_i\hat{\theta} \quad (5)$$

By assuming $\ln c_i$ as normally distributed and letting $\Phi(\cdot)$ denote the cumulative density function of the standard normal distribution, the estimated probability that a household will be poor in the future (say, at time t+1) is given by:

$$V\hat{E}P_i \equiv \hat{v}_i = \hat{P}r(\ln c_i < \ln z | X_i) = \Phi\left(\frac{\ln z - X_i\hat{\beta}}{\sqrt{X_i\hat{\theta}}}\right) \quad (6)$$

This is an *ex ante* vulnerability measure that can be estimated with cross-sectional data. Note that this expression also yields the probability of a household at time t becoming poor at t+1 given the distribution of consumption at t.

A merit of this vulnerability measure is that it can be estimated with cross-sectional data. However, it correctly reflects a household's vulnerability only if the distribution of

[12] See Chaudhuri (2003), Chaudhuri *et al.* (2002) and Hoddinott and Quisumbing (2003b) for technical details.

consumption across households, given the household characteristics at time t, represents time series variation of household consumption. Hence, this measure requires a large sample in which some households experience a good time and others suffer from negative shocks. Also, the measure is unlikely to reflect unexpected large negative shocks (e.g. Asian financial crisis), if we use the cross-section data for a normal year.

3.2 Estimation of wage equations

As the employment schedule of the NSS provides us with individual data on earnings during the previous week of the survey date, these could be used as proxies for wages. We estimate the male and female wage equations by tobit model.

$$w_j^{Male} = w_j^{Male}\left(E_j, A_j, B_i, O_i, M_i, L_i, D\right) \quad (7)$$

$$w_j^{Female} = w_j^{Female}\left(E_j, A_j, B_i, O_i, M_i, L_i, S_i, D\right) \quad (7)'$$

Here, wage for workers is estimated by a set of variables at individual levels for the individual j, such as a set of education dummies, E_j, age or its square, denoted as a vector, A_j. Other variables include B_i: social backwardness of the household; O_i: occupation; M_i: religion of the household, L_i: owned land as defined before. This will give us predicted wages for male and female workers, $\hat{w}_j^{Male}$ and $\hat{w}_j^{Female}$, which will be aggregated at the level of NSS regions and used as one of the determinants of participation in RPW. Aggregation is necessary because the consumption schedule and the employment schedule survey different samples of households. These are used as instruments for access to RPW. For the instrument of PDS, we use the food price index derived from the method of Deaton and Tarozzi (2000).

3.3 Treatment effects model

We employ the treatment effects model, a version of the Heckman sample selection model (Heckman, 1979), which estimates the effect of an endogenous binary treatment. This would enable us to take account of the sample selection bias associated with access to RPW or PDS. In the first stage, access to RPW (or PDS) is estimated by the probit model. In the second, we estimate poverty (or a binary variable on whether the household is below the poverty threshold), undernutrition (or a binary variable on whether the household is below the threshold of calorie or protein intakes), only for the NSS 50th round, and the vulnerability measure after controlling for the inverse Mill's ratio which reflects the degree of sample selection bias. The instruments are the predicted individual wages aggregated at the level of NSS regions for RPW and the food price index for PDS. These are admittedly not ideal instruments in terms of the exclusion restrictions, but the dataset does not contain any better variables for instruments, which are correlated with RPW or PDS but not with poverty.

The merit of the treatment effects model is that the sample selection bias is explicitly estimated by using the results of the probit model. Also, it would not require the two conditions necessary for PSM, which will be discussed in the next subsection. However, the weak aspects include the following: (i) the strong assumptions are imposed on distributions of the error terms in the first and the second stages; (ii) the results are sensitive to choice of the explanatory variables and instruments; and (iii) the valid instruments are rarely found in the non-experimental data.

The selection mechanism by the probit model above can be more explicitly specified as (e.g. Greene, 2003):

$D_i^* = \gamma X_i + u_i$ (8) and $D_i^* = 1 \quad \text{if } D_i^* = \gamma X_i + u_i > 0$

$D_i^* = 0 \ \text{ otherwise}$

where $\Pr\{D_i = 1 | X_i\} = \Phi(\gamma' X_i)$

$\Pr\{D_i = 0 | X_i\} = 1 - \Phi(\gamma' X_i)$

D_i^* is a latent variable. In our case, D_i takes 1 if a household has access to RPW (or PDS) and 0 otherwise and X_i is a vector of household characteristics and other determinants. Φ denotes the standard normal cumulative distribution function.

The linear outcome regression model in the second stage is specified below to examine the determinants of poverty, undernutrition or vulnerability denoted as W_i. That is,

$W_i = \beta' Z_i + \theta D_i + \varepsilon_i$ (9)

$(u_i \ \varepsilon_i)$ ~ bivariate normal $[0, 0, 1, \sigma_\varepsilon, \rho]$

where θ is the average net wealth benefit of accessing RPW or PDS.

Using a formula for the joint density of bivariate normally distributed variables, the expected poverty (or undernutrition or vulnerability) for those with access to RPW (or PDS) is written as:

$$E\left[W_i \middle| D_i = 1\right] = \beta' Z_i + \theta + E\left[\varepsilon_i \middle| D_i = 1\right]$$
$$= \beta' Z_i + \theta + \rho\sigma_\varepsilon \frac{\phi(\gamma' X_i)}{\Phi(\gamma' X_i)} \quad (10)$$

where ϕ is the standard normal density function. The ratio of ϕ and Φ is called the inverse Mill's ratio.

Expected poverty (or undernutrition or vulnerability) for non-clients is:

$$E\left[W_i \middle| D_i = 0\right] = \beta' Z_i + E\left[\varepsilon_i \middle| D_i = 0\right]$$
$$= \beta' Z_i - \rho\sigma_\varepsilon \frac{\phi(\gamma' X_i)}{1 - \Phi(\gamma' X_i)} \quad (11)$$

The expected effect of poverty reduction associated with RPW (or PDS) is computed as (Greene, 2003: 787-789):

$$E\left[W_i \middle| D_i = 1\right] - E\left[W_i \middle| D_i = 0\right] = \theta + \rho\sigma_\varepsilon \frac{\phi(\gamma' X_i)}{\Phi(\gamma' X_i)\left[1 - \Phi(\gamma' X_i)\right]} \quad (12)$$

If ρ is positive (negative), the coefficient estimate of θ using OLS is biased upward (downward) and the sample selection term will correct this. Since σ_ε is positive, the sign and significance of the estimate of $\rho\sigma_\varepsilon$ (usually denoted as β_λ) will show whether any selection bias exists. To estimate the parameters of this model, the likelihood function given by Maddala (1983: 122) is used where the bivariate normal function is reduced to the univariate function and the correlation ρ. The predicted values of (10) and (11) are derived and compared by the standard t test to examine whether the average treatment effect or poverty-reducing effect is significant.

The results of the treatment effects model will have to be interpreted with caution because the results are sensitive to the specification of the model or the selection of explanatory variables and/or the instrument. Also important are the distributional assumptions of the model. However, applying the treatment effects model would overcome the potential limitation in PSM to evaluate the impacts of RPW or PDS.

3.4 Propensity score matching model

Our main hypothesis is that access to RPW (or PDS) reduces poverty (or undernutrition or vulnerability). Because we have only cross-sectional data, we can compare poverty status of households with access to RPW (or PDS) and those without, as long as RPW (or PDS) are randomly distributed across the sample. However, we cannot simply statistically compare the average of poverty or vulnerability measures for those with access to RPW (or PDS) and those without because of the sample selection bias. The sample selection problem may arise from: (i) the self selection, where the households themselves decide whether they should participate in RPW (or PDS), which depends on household observable and unobservable characteristics; and (ii) the endogenous programme placement, where those who implement these programmes would select (a group of) households with specific characteristics (e.g. high poverty or low nutrition). Statistical matching, such as PSM, could be used to take account of the sample selection bias or the endogeneity associated with household access to RPW (or PDS).

Statistical matching has been used widely in medical studies, where dose response of patients is analysed. The first stage specifies a function matching the proximity of one household to another in terms of household characteristics and then households are grouped to minimise the distance between matched cases in the second stage (Foster, 2003). Merits of using statistical matching over the IV estimation include the following: the former does not assume linearity; it is valid even though distributions of explanatory variables of treatment and control groups overlap relatively little; and it does not require a valid instrument. Rosenbaum and Rubin (1983) proposed statistical matching using the propensity score, the predicted probability that an individual receives the treatment of interest to make comparisons between individuals with the treatment and those without. Methodological issues and programmes for propensity score matching estimation are discussed in detail, for example, by Becker and Ichino (2002), Dehejia (2005), Dehejia and Wahba (2002), Ravallion (2008), Smith and Todd (2005) and Todd (2008). .

While there are some advantages in using PSM to estimate the impact of the policy, the derived impact depends on the variables used for matching and the quantity and quality of available data and the procedure to eliminate any sample selection bias is based on observables (Ravallion, 2008). If there are important unobservable variables in the model, the bias is still likely to remain in the estimates. For example, if the selection bias based on unobservables counteracts that based on observables, then eliminating only the latter bias may increase aggregate bias, while the replication studies comparing non-experimental evaluations, such as PSM, with experiments for the same programmes do not appear to have found such an example in practice (ibid).

The discourse between Smith and Todd (2005) and Dehejia (2005) further draws our attention to the limitations of PSM in particular based on cross-sectional data. First, unmeasured characteristics or time effects cannot be controlled for by cross-sectional data. Second, bias associated with cross-sectional matching estimators may be large without a good set of covariates or if treated and control households are not strictly comparable, for example, located in different markets (Smith and Todd, 2005). To partly overcome the limitation of PMS, we will also use the treatment effects model.

We summarise below the estimation methods for the PSM. The propensity score is the conditional probability of receiving a treatment (or of having access to RPW or PDS) given pre-treatment characteristics, X (or household characteristics).

$$p(X) = Pr\{D = 1|X\} = E\{D|X\} \quad (13)$$

where $D = \{0, 1\}$ is the binary variable on whether a household has access to RPW (1) or not (0) and X is the multidimensional vector of pre-treatment characteristics or time invariant or relatively stable household characteristics in our context. It was shown by Rosenbaun and Rubin (1983) that if the exposure to RPW is random within cells defined by X, it is also random within cells defined by p(X) or the propensity score.

The policy effect of RPW (or PDS) can be estimated in the same way as in Becker and Ichino (2002) as:

$$\begin{aligned} \tau &\equiv E\{W_{1i} - W_{0i} | D_i = 1\} \\ &= E\{E\{W_{1i} - W_{0i} | D_i = 1, p(X_i)\}\} \\ &= E\{E\{W_{1i} | D_i = 1, p(X_i)\} - E\{W_{0i} | D_i = 0, p(X_i)\} | D_i = 1\} \quad (14) \end{aligned}$$

where i denotes the i-th household, W_{1i} is the potential outcome (e.g. poverty) in the two counterfactual situations with access to RPW (or PDS) and without.

The first line of the equation states that the policy effect is defined as the expectation of the difference of poverty or undernutrition of the i-th household with access to RPW and that for the same household in the counterfactual situation where it would not have had access to RPW. The second line is the same as the first line except that the expected policy effect is defined over the distribution of the propensity score. The last line is the policy effect as an expected difference of poverty or undernutrition for the i-th household with access to RPW given the distribution of the probability of accessing RPW and that for the same household without RPW given the same distribution.

Formally, the following two hypotheses are needed to derive (14) given (13).

Lemma 1 Balancing hypothesis (balancing of pre-treatment variables given the propensity score)

If p (X) is the propensity score, then $D \perp X \mid p(X)$

This implies that, given a specific probability of having access to RPW, a vector of household characteristics, X, is orthogonal to (or uncorrelated to) the access to RPW. In other words, for a specific propensity score, the RPW is randomly distributed and thus, on average, households with RPW and those without are observationally identical (given a propensity score). Otherwise, one cannot statistically match households of different categories.

Lemma 2 Unconfoundedness given the propensity score

If treatment (or whether a household has access to RPW) is unconfounded, i.e. $W_1, W_2 \perp D \mid X$

Then, assignment to treatment is unconfounded given the propensity score, i.e.

$$W_1, W_2 \perp D \mid p(X)$$

The latter implies that, given a propensity score, poverty or undernutrition is uncorrelated to the access to RPW. If the above lemmas are satisfied, the policy effect can be estimated by the procedures described in Becker and Ichino (2002) and Smith and Todd (2005). Each procedure involves estimating the probit model: $\Pr\{D_i = 1 | X_i\} = \Phi(h(X_i))$ (15) where Φ denotes the logistic (or normal) cumulative distribution function (CDF) and $h(X_i)$ is a starting specification. We use the probit model whereby whether a household has access to RPW is estimated by a vector of household and socioeconomic characteristics. Because using a same set of the determinants of consumption would not only lead to the rejection of the balancing hypothesis but also be unfeasible with the large data, we take the minimalist approach, where a considerably smaller number of explanatory variables are chosen.

One possible procedure for statistical matching is stratification matching, whereby the sample is split in k equally spaced intervals of the propensity score to ensure that within each interval the average propensity scores of treated and control households do not differ. We did not use stratification matching, as observations are discarded when either treated or control units are absent. Instead, we use other variants in matching estimators of the average effect of treatment on the treated, namely, nearest neighbour matching and kernel matching.13 Nearest neighbour matching is the method to take each treated unit and search for the control unit with the closest propensity score, whereas with kernel matching all treated are matched with a weighted average of all controls with weights that are inversely proportional to the distance between the propensity scores of treated and controls (see Becker and Ichino, 2002 for details).

[13] We did not use radius matching either as the results are sensitive to the predetermined radius.

3.5 Pseudo panel and IV model

One of the limitations in the above models is that each round of the NSS is used separately for the cross-sectional estimations. To overcome this, we apply the pseudo panel model, which aggregates micro-level household data by any meaningful unit or cohort (e.g. geographical areas or categorisation by household characteristics) that is common across cross-sectional datasets in different years. We apply the pseudo panel model for the cohort k based on the 78 NSS regions. The cohort is denoted as k in the equation (16) below.

$$\overline{W}_{i\,kt} = \alpha + \overline{X}_{i\,kt}\beta_1 + \beta_2\overline{D}_{i\,kt} + \gamma T_t + \mu_i + e_{kt} \quad (17)$$

where k denotes cohort (i.e. NSS region) and t stands for survey years for three rounds of NSS, 1993 and 2005. The upper bar means that the average of each variable is taken for each cohort, k for each round t. $\overline{W}_{i\,kt}$ is thus the regional average of poverty measure (undernutrition or vulnerability measure), $\overline{X}_{i\,kt}$ is a vector of the average of household and other characteristics, $\overline{D}_{i\,kt}$ is the average of access to RPW (or PDS), T_t is a time dummy variable, $\overline{\mu}_{kt}$ is the unobservable fixed or random effect at cohort level and $\overline{e}_{kt}$ is the error term.

$$\overline{W}_{i\,kt} = \alpha + \overline{X}_{i\,kt}\beta_1 + \beta_2\overline{D}_{i\,kt} + \gamma T_t + \overline{\mu}_{kt} + \overline{e}_{kt} \quad (17)$$

The equation (17) can be estimated by the standard static panel mode, such as the fixed effects or random effects model. The issue is whether equation (17) is a good approximation of the underlying household panel models for household i in the equation (17)' below.

$$W_{it} = \alpha + W_{it}\beta_1' + \beta_2' D_{it} + \gamma' T_t + \mu_{it}' + e_{it} \quad (17)'$$

It is not straightforward to check this as we do not have 'real' panel data. However, as shown by Verbeek and Nijman (1992) and Verbeek (1996), if the number of observations in cohort k tends to infinity, $\bar{\mu}_{kt} \rightarrow \mu_k{}^*$ and the estimator is consistent. In our case, k is very large and thus the estimator is likely to be almost consistent. Once we take account of the cohort population, the equation (17) will become the model developed by Deaton (1985), whereby $\bar{n}_{ikt}$ and $\bar{x}_{ikt}$ are considered to be error-ridden measurements of unobservable cohort means, which leads to so-called 'error-in-variables estimator' (see Fuller, 1987 for more details). As an extension, because RPW or PDS could be endogenous, we apply the G2SLS random effects IV regression where $\overline{D}_{i\,kt}$ is instrumented by either average wages or the food price index.

4 Results

In this section we will summarise key findings obtained from the econometric estimations of the models we described in the last section.

4.1 Vulnerability estimates

Table 1 presents the regression results for vulnerability estimations for NSS 50 (1993-1994) and NSS 61 (2004-2005). The results for consumption (equation (2)) or log MPCE (equation (3)) are reported. A few results are surprising. For example, in 1993, the coefficient estimate of the number of adult female members is negative and highly significant, that of being headed by a female member is *positive* and significant. Both are negative and significant in 2004. The proportion of adult members is positive and highly significant in 1993 and 2004, reflecting the negative effects of the dependency burden on children and the elderly on per capita consumption. While the age of the household head is negative and significant to explain per capita household expenditure in 1993, with a significant non-linear effect suggested by a positive and significant coefficient estimate of its square, the signs are the opposite in 2004. Higher levels of educational attainment are positively and significantly associated with higher per capita consumption in both 1993 and 2004. Dummy variables associated with larger areas of land owned are also positively associated with per capita expenditure in 1993 and 2004. Dummy variables on household head's occupation show the similar pattern of the results for two rounds. Belonging to SCs or STs is negative and highly significant in 1993 and 2004. While the results of state dummies are omitted from the table, they indicate the high degree of geographical differences in household consumption in 1993 and 2004.

Table 1: Estimation of vulnerability equations

	NSS 50 (1993-1994)						NSS 61 (2004-2005)					
	Consumption						Consumption					
	Log (MPCE)			Variance			Log (MPCE)			Variance		
	Coef.	T		Coef.	t		Coef.	t		Coef.	t	
Whether a household is headed by a female member	0.205	(24.15)	**	0.439	(12.31)	**	-0.021	(-3.67)	**	0.230	(8.09)	**
Number of adult female members	-0.325	(-98.54)	**	-0.027	(-2.28)	*	-0.123	(-51.36)	**	-0.049	(-4.08)	**
Number of adult male members	-0.261	(-89.61)	**	0.061	(5.25)	**	-0.101	(-43.24)	**	-0.025	(-2.10)	*
Proportion of adults in a household	2.177	(222.41)	**	0.260	(6.05)	**	0.627	(81.53)	**	-0.063	(-1.62)	
Age of household head	-1.010	(-10.19)	**	-3.366	(-8.74)	**	0.560	(7.52)	**	-0.814	(-2.10)	*
Age squared	1.052	(10.30)	**	3.475	(8.67)	**	-0.250	(-3.33)	**	1.184	(3.05)	**
Max. education of adult (primary)	0.125	(20.15)	**	0.078	(2.62)	**	0.081	(18.09)	**	-0.058	(-2.23)	*
Max. education of adult (middle)	0.211	(29.58)	**	0.163	(5.14)	**	0.197	(45.30)	**	0.069	(2.85)	**
Max. education of adult (>=matriculates)	0.392	(51.19)	**	0.309	(9.50)	**	0.416	(74.64)	**	0.328	(11.49)	**
Land (0.1<=2.5 ha) (default: the landless)	0.129	(22.93)	**	0.064	(2.43)	*	0.051	(13.37)	**	-0.048	(-2.37)	*
Land (>2.5 ha) (default: the landless)	0.503	(8.11)	**	0.298	(1.40)		0.273	(39.42)	**	0.158	(4.49)	**
Whether self-employed in non-agriculture	-0.076	(-8.60)	**	-0.082	(-2.15)	*	-0.118	(-21.33)	**	-0.032	(-1.15)	
Whether agricultural labour	-0.266	(-34.27)	**	-0.299	(-8.73)	**	-0.318	(-52.90)	**	-0.329	(-10.33)	**
Whether non-agricultural labour	-0.176	(-18.03)	**	-0.207	(-4.58)	**	-0.241	(-37.52)	**	-0.201	(-5.99)	**
Whether self-employed in agriculture	-0.078	(-10.13)	**	-0.156	(-4.72)	**	-0.129	(-24.63)	**	-0.132	(-4.91)	**
Whether a household belongs to SC	-0.178	(-27.18)	**	-0.015	(-0.44)		-0.156	(-32.62)	**	-0.088	(-3.17)	**
Whether a household belongs to ST	-0.116	(-23.60)	**	-0.039	(-1.59)		-0.102	(-25.19)	**	-0.092	(-4.04)	**
Constant	8.833	(329.31)		-2.434	(-22.69)		9.741	(489.22)		-2.992	(-27.98)	
Number of obs		58664			58664			78873			78873	
F(31, 58632)		2610			41		F(51, 78821)	1065			45	
Prob > F		0			0			0			0	
Root MSE		0			2			0			2	

**=significant at 1% level. *=significant at 5% level. +=significant at 10% level.

Table 1 also shows the results of variance of log MPCE. Female member's headedness of the household is positively and significantly associated with higher variance in consumption in 1993 and 2004, implying the wider range of (conditional) distribution of consumption for female-headed households than for male-headed households. Thus, the possibility is not precluded that some female-headed households have very low consumption in 1993. Higher level of educational attainment of household members and larger landholdings (more than 2.5 hectares) seems associated with higher consumption variance in both years. Not being agricultural labourers or not belonging to an SC or ST is associated with higher variance of consumption. These estimation results are used to derive vulnerability measures.

Annex 3 presents the results for the wage equations for male and female workers based on the employment schedule of the NSS 50th and 61st rounds. While most of the results are expected, a few unexpected results are also found. For example, owned land of the household to which the worker belongs is negatively associated with female wages in both 1993 and 2004 and land area is positively associated with male wages with a significant coefficient estimate for 2004 and not significant for 1993. The underlying reasons are not clear, but it could owe to the fact that men's ownership of land may serve as a source for better wages through bargaining with employers or that only men can control household assets, including land. The coefficients for ST or SC are negative and significant in determining wages. Workers in the households classified as non-agricultural or agricultural self-employed tend to have higher wages. Age is positive significant, while its square is negative and significant in both years. Because there are not many observations for female wages and they are not significant in the equation of RPW, we use predicted male wage as an instrument for the participation equation in RPW.

4.2 Treatment effects model

Tables 2 and 3 present the results of the treatment effects model. Table 2 reports the regression results in the first stage, whereby access to RPW or PDS is estimated by probit model (for equation (8)) and those in the second stage for the equation of poverty (or vulnerability or undernourishment) taking account of sample selection bias (for equation (8)). Table 3 summarises the treatment effects for various cases. Four cases are highlighted in Tables 2, 3 and 4, namely, Case 1: where the treatment effect of RPW is estimated by the NSS 50th round in 1993; Case 2: PDS in 1993 or NSS 50; Case 3: RPW (where it is proxied by FFW, a version of RPW, owing to data constraints) in 2004 or NSS 61; and Case 4: PDS in 2004 or NSS 61.

Table 2: Treatment effects model (regression results)

1st stage probit	Case 1		Case 2		Case 3		Case 4	
	NSS50		NSS50		NSS61		NSS61	
	RPW		PDS		RPW		PDS	
	Coef.	z	Coef.	Z	Coef.	z	Coef.	z
Whether a household is headed by a female member	-0.172	(-4.22)**	0.034	(1.40)	-0.107	(-2.46)*	0.039	(2.10)*
Number of adult female members	-0.003	(-0.27)	0.056	(6.91)**	0.022	(1.29)	0.105	(13.07)**
Number of adult male members	0.047	(4.18)**	0.009	(1.16)	0.080	(4.89)**	0.039	(5.15)**
Proportion of adults in a household	-0.053	(-1.21)	-0.192	(-6.37)**	-0.091	(-1.68)+	-0.375	(-15.28)**
Age of household head	0.406	(1.04)	1.755	(6.42)**	-0.663	(-1.24)	3.397	(13.90)**
Age squared	-0.513	(-1.26)	-1.606	(-5.67)**	0.614	(1.12)	-2.854	(-11.60)**
Max. education of adult (primary)	-0.091	(-2.87)**	-0.022	(-1.10)	-0.065	(-2.13)*	0.011	(0.63)
Max. education of adult (middle)	-0.094	(-2.73)**	-0.046	(-2.06)*	-0.211	(-6.77)**	-0.062	(-3.91)**
Max. education of adult (>=matriculates)	-0.055	(-1.61)	-0.112	(-4.90)**	-0.466	(-10.45)**	-0.228	(-12.32)**
Land (0.1<=2.5 ha) (default: the landless)	0.055	(2.05)*	-0.158	(-8.56)**	0.100	(3.71)**	0.190	(14.29)**
Land (>2.5 ha) (default: the landless)	-0.059	(-0.23)	-0.308	(-1.89)+	-0.066	(-1.33)	-0.029	(-1.30)
Whether self-employed in non-agriculture	-0.095	(-2.28)*	0.070	(2.74)**	0.496	(8.43)**	0.206	(11.74)**
Whether agricultural labour	0.093	(2.66)**	0.102	(4.48)**	1.023	(17.32)**	0.350	(16.81)**
Whether non-agricultural labour	0.247	(5.71)**	0.200	(6.77)**	1.112	(18.79)**	0.268	(12.18)**
Whether self-employed in agriculture	-0.082	(-2.37)*	-0.067	(-2.99)**	0.691	(12.41)**	0.137	(7.95)**
Whether a household belongs to SC	0.156	(5.15)**	0.098	(4.50)**	0.285	(9.50)**	-0.015	(-0.82)
Whether a household belongs to ST	0.078	(3.13)**	0.025	(1.41)	0.105	(3.53)**	0.092	(5.92)**
Predicted male wages (at NSS region)	0.002	(2.54)*	-	-	-0.086	(-34.92)**	-	-
Food price index	-	-	0.061	(32.14)**	-	-	0.156	(19.10)**
Constant	-2.248	(-17.83)**	-7.632	(-35.42)**	0.643	(3.70)	-2.246	(-18.50)
Number of obs		58664		58663		76686		78873
LR chi2(52)		442	LR chi2(31)	13637	LR chi2(42)	5477		16624
Prob > chi2		0		0		0		0
Log likelihood		-9804		-24761		-7537		-36841

2nd stage (a)	Case 1		Case 2		Case 3		Case 4	
	NSS50		NSS50		NSS61		NSS61	
	RPW		PDS		RPW		PDS	
	Coef.	z	Coef.	Z	Coef.	z	Coef.	z
Poor (consumption)	Poor (consumption)		Poor (consumption)		Poor (consumption)		Poor (consumption)	
Whether a household is headed by a female member	-0.007	(-1.15)	-0.014	(-2.26) *	0.010	(2.39) *	0.011	(2.61) **
Number of adult female members	0.010	(4.86) **	0.011	(5.59) **	0.055	(29.57) **	0.058	(29.60) **
Number of adult male members	0.022	(10.75) **	0.024	(12.74) **	0.037	(20.81) **	0.039	(22.14) **
Proportion of adults in a household	-0.026	(-3.44) **	-0.034	(-4.51) **	-0.306	(-52.01) **	-0.318	(-49.50) **
Age of household head	-0.511	(-7.79) **	-0.441	(-6.78) **	-0.164	(-2.79) **	-0.036	(-0.56)
Age squared	0.492	(7.23) **	0.421	(6.28) **	-0.024	(-0.40)	-0.131	(-2.11) *
Max. education of adult (primary)	-0.039	(-7.49) **	-0.044	(-8.81) **	-0.067	(-16.96) **	-0.068	(-17.21) **
Max. education of adult (middle)	-0.059	(-10.49) **	-0.065	(-12.00) **	-0.129	(-34.52) **	-0.135	(-36.14) **
Max. education of adult (>=matriculates)	-0.110	(-19.53) **	-0.116	(-21.05) **	-0.173	(-39.05) **	-0.186	(-39.99) **
Land (0.1<=2.5 ha) (default: the landless)	-0.032	(-6.97) **	-0.034	(-7.29) **	-0.031	(-9.90) **	-0.021	(-6.39) **
Land (>2.5 ha) (default: the landless)	-0.057	(-1.41)	-0.069	(-1.75) +	-0.106	(-19.80) **	-0.108	(-20.17) **
Whether self-employed in non-agriculture	-0.003	(-0.51)	-0.005	(-0.84)	0.041	(9.78) **	0.051	(11.51) **
Whether agricultural labour	0.072	(12.02) **	0.081	(13.77) **	0.158	(31.53) **	0.182	(33.29) **
Whether non-agricultural labour	0.037	(4.39) **	0.059	(7.37) **	0.081	(14.93) **	0.105	(19.12) **
Whether self-employed in agriculture	-0.010	(-1.66) +	-0.016	(-2.77) **	0.017	(4.04) **	0.027	(6.46) **
Whether a household belongs to SC	0.106	(17.81) **	0.118	(21.27) **	0.106	(24.16) **	0.108	(25.44) **
Whether a household belongs to ST	0.035	(7.97) **	0.040	(9.36) **	0.046	(13.35) **	0.050	(14.17) **
Θ	-0.595	(-5.81) **	-0.115	(-3.39 **	0.275	(9.00) **	-0.144	(-5.61) **
β_λ	-0.261	(-5.65) **	0.100	(5.20) **	-0.097	(-6.52) **	0.096	(6.52) **
Constant	0.717	(7.00)	0.133	(7.42)	0.229	(14.04)	0.295	(14.51)
Number of obs		58664		58663		76686		78873
Wald chi2(103)	Wald chi2(62)	8662	Wald chi2(62)	15635	Wald chi2(103)	26299		33759
Prob > chi2		0		0		0		0

2nd stage (b)	Case 1			Case 2			Case 1			Case 2		
	NSS50			NSS50			NSS61			NSS61		
	RPW			PDS			RPW			PDS		
	Coef.	z		Coef.	Z		Coef.	z		Coef.	z	
	Vulnerability			Vulnerability			Vulnerability			Vulnerability		
Whether a household is headed by a female member	-0.126	(-28.69)	**	0.034	(1.40)		-0.002	(-0.86)		-0.003	(-1.51)	
Number of adult female members	0.147	(106.54)	**	0.056	(6.91)	**	0.050	(49.97)	**	0.048	(46.05)	**
Number of adult male members	0.119	(86.24)	**	0.009	(1.16)		0.040	(41.87)	**	0.040	(42.45)	**
Proportion of adults in a household	-1.418	(-276.53)	**	-0.192	(-6.37)	**	-0.221	(-69.10)	**	-0.212	(-61.86)	**
Age of household head	1.096	(24.45)	**	1.755	(6.42)	**	-0.100	(-3.10)	**	-0.172	(-5.07)	**
Age squared	-1.014	(-21.83)	**	-1.606	(-5.67)	**	-0.041	(-1.28)		0.023	(0.69)	
Max. education of adult (primary)	-0.072	(-20.11)	**	-0.022	(-1.10)		-0.084	(-38.86)	**	-0.085	(-40.57)	**
Max. education of adult (middle)	-0.142	(-36.66)	**	-0.046	(-2.06)	*	-0.130	(-63.92)	**	-0.131	(-66.07)	**
Max. education of adult (>=matriculates)	-0.275	(-71.46)	**	-0.112	(-4.90)	**	-0.134	(-55.45)	**	-0.134	(-54.23)	**
Land (0.1<=2.5 ha) (default: the landless)	-0.074	(-23.67)	**	-0.158	(-8.56)	**	-0.030	(-17.76)	**	-0.031	(-17.24)	**
Land (>2.5 ha) (default: the landless)	-0.285	(-10.35)	**	-0.308	(-1.89)	+	-0.066	(-22.55)	**	-0.065	(-22.75)	**
Whether self-employed in non-agriculture	0.027	(5.96)	**	0.070	(2.74)	**	0.007	(3.17)	**	0.006	(2.38)	*
Whether agricultural labour	0.128	(31.06)	**	0.102	(4.48)	**	0.191	(69.90)	**	0.192	(66.01)	**
Whether non-agricultural labour	0.093	(15.98)	**	0.200	(6.77)	**	0.072	(24.26)	**	0.077	(26.48)	**
Whether self-employed in agriculture	0.030	(7.63)	**	-0.067	(-2.99)	**	0.011	(4.78)	**	0.012	(5.30)	**
Whether a household belongs to SC	0.099	(24.16)	**	0.098	(4.50)	**	0.121	(50.76)	**	0.123	(54.43)	**
Whether a household belongs to ST	0.062	(20.39)	**	0.025	(1.41)		0.052	(27.33)	**	0.051	(27.40)	**
Θ	0.157	(1.93)	+	-0.014	(-2.68)	**	0.223	(14.19)	**	0.047	(3.44)	**
β_λ	-0.071	(-1.94)	**	-0.058	(-4.24)	**	-0.107	(-14.02)	**	-0.034	(-4.27)	**
Constant	0.405	(4.98)		-0.716	-1.42		0.139	(15.68)		0.119	(10.96)	
Number of obs		58664			58663			76687			78874	
Wald chi2(103)		131349			137687			65896.43			75524.38	
Prob > chi2		0			0			0			0	

***=significant at 1% level. *=significant at 5% level. +=significant at 10% level.*

2nd Stage (c)	Case 1			Case 2			Case 1			Case 2		
	NSS50			NSS50			NSS50			NSS50		
	RPW			PDS			RPW			PDS		
	Coef.	Z		Coef.	Z		Coef.	z		Coef.	z	
	poor (calorie)			poor (calorie)			poor (protein)			poor (protein)		
Whether a household is headed by a female member	-0.016	(-2.59)	**	0.004	(1.77)	+	-0.007	(-1.13)		-0.012	(-2.28)	*
Number of adult female members	0.003	(1.78)	+	0.017	(9.19)	**	0.004	(2.35)	*	0.005	(2.50)	*
Number of adult male members	0.016	(8.12)	**	-0.011	(-1.52)		0.014	(7.68)	**	0.016	(9.33)	**
Proportion of adults in a household	-0.009	(-1.29)		-0.426	(-6.64)	**	-0.017	(-2.48)	*	-0.020	(-2.99)	**
Age of household head	-0.444	(-6.97)	**	0.402	(6.08)	**	-0.424	(-7.16)	**	-0.393	(-6.73)	**
Age squared	0.422	(6.39)	**	-0.048	(-9.76)	**	0.415	(6.76)	**	0.381	(6.34)	**
Max. education of adult (primary)	-0.046	(-9.01)	**	-0.075	(-13.92)	*	-0.036	(-7.54)	**	-0.039	(-8.73)	**
Max. education of adult (middle)	-0.072	(-13.11)	**	-0.124	(-22.83)	**	-0.053	(-10.42)	**	-0.057	(-11.72)	**
Max. education of adult (>=matriculates)	-0.122	(-22.39)	**	-0.026	(-5.80)	**	-0.095	(-18.81)	**	-0.098	(-19.91)	**
Land (0.1<=2.5 ha) (default: the landless)	-0.028	(-6.20)	**	-0.128	(-3.30)	**	-0.021	(-5.02)	**	-0.019	(-4.70)	**
Land (>2.5 ha) (default: the landless)	-0.126	(-3.21)	**	-0.001	(-0.16)		-0.079	(-2.17)	*	-0.083	(-2.36)	*
Whether self-employed in non-agriculture	0.001	(0.18)		0.093	(16.13)	**	0.000	(0.03)		-0.003	(-0.49)	
Whether agricultural labour	0.090	(15.46)	**	0.057	(7.21)	**	0.072	(13.19)	**	0.076	(14.49)	**
Whether non-agricultural labour	0.048	(5.78)	**	-0.008	(-1.42)		0.032	(4.22)	**	0.046	(6.44)	**
Whether self-employed in agriculture	-0.005	(-0.94)		0.094	(17.08)	**	-0.004	(-0.74)		-0.008	(-1.56)	
Whether a household belongs to SC	0.088	(15.17)	**	0.050	(12.09)	**	0.081	(15.17)	**	0.090	(18.02)	**
Whether a household belongs to ST	0.048	(11.23)	**	-0.008	(-0.22)		0.033	(8.28)	**	0.036	(9.56)	**
Θ	0.335	(2.97)	**	0.032	(1.68)	**	0.492	(5.16)	**	-0.025	(-0.82)	
β_λ	-0.145	(-2.86)	**	0.186	(10.50)	**	-0.216	(-5.02)	**	0.043	(2.47)	**
Constant	`	(4.47)	**				0.601	(6.30)		0.119	(7.37)	**
Number of obs		58664			58663			58664			58663	
Wald chi2(103)		8662.06			16730			8390.33			15405.57	
Prob > chi2		0			0			0			0	

***=significant at 1% level. *=significant at 5% level. +=significant at 10% level.*

Table 3: Treatment effects model (summary of final results)
Policy effects on poverty and undernutrition

	NSS50	Effects on poverty (consumption based)					
Case 1	RPW	Effects on poverty					
	RPW	Effects on poverty (consumption based)					
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		3232		65947	-0.00483	0.000964	-5.01	**
	RPW	Effects on poverty (calorie based)					
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		3232		65947	0.000821	0.001014	0.81	
	RPW	Effects on poverty (protein based)					
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		3232		65947	-0.00376	0.000864	-4.35	**
Case 2	PDS	Effects on poverty					
	PDS	Effects on poverty (consumption based)					
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		17287		51917	0.077031	0.000832	92.62	**
	PDS	Effects on poverty (calorie based)					
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		17287		51917	0.054593	0.000925	58.99	**
	PDS	Effects on poverty (protein based)					
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		17287		51917	0.057819	0.00076	76.06	**
	NSS61	Effects on poverty (consumption based)					
Case 3	RPW						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		2,290		76,709	-0.01565	0.001071	-14.61	**
Case 4	PDS						

	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		20,700		58,544	0.031625	0.000894	35.36	*

Policy effects on vulnerability

	NSS50	Effects on vulnerability						
Case 1	RPW	Effects on vulnerability						
	RPW	Effects on vulnerability (based on 100% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		3232		65947	0.004171	0.002312	1.804	+
	RPW	Effects on vulnerability (based on 80% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		3232		65947	-0.00641	0.002228	-2.879	**
	RPW	Effects on vulnerability (based on 120% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		3232		65947	-0.00641	0.002228	1.048	
Case 2	PDS	Effects on vulnerability						
	PDS	Effects on vulnerability (based on 100% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		17287		51917	-0.0064	0.016	-2.5	*
	PDS	Effects on vulnerability (based on 80% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		17287		51917	-0.01357	0.002223	-6.104	*
	PDS	Effects on vulnerability (based on 80% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		17287		51917	-0.00112	0.002233	-0.503	*

	NSS61	Effects on vulnerability						
Case 3	RPW							
	PDS	Effects on vulnerability (based on 100% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		2,290		76,709	-0.09649	0.001013	-95.29	**
	PDS	Effects on vulnerability (based on 80% of poverty line)						

	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		2,290		76,709	-0.06807	0.000419	-162.32	**
	PDS	Effects on vulnerability (based on 120% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		2,290		-0.17155	0.001817	0.001013	-94.425	**
Case 4	PDS	Effects on vulnerability						
	PDS	Effects on vulnerability (based on 100% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		20,700		58,544	-0.01436	0.000828	-17.357	**
	PDS	Effects on vulnerability (based on 80 % of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		20,700		58,544	-0.01576	0.001486	-10.61	**
	PDS	Effects on vulnerability (based on 120% of poverty line)						
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		20,700		58,544	-0.01436	0.000828	-17.357	**

We will briefly explain the determinants of participation in RPW and access to PDS in 1993 and 2004. Female member headedness of the household is a negative and significant determinant of RPW participation in Cases 1 and 3 and a positive determinant of PDS access, which is significant in Case 4. The more female adult members, the more likely it is for a household to have access to PDS (Cases 2 and 4). More male adult members would drive the household to participate in RPW in 1993 and 2004 and to access PDS in 2004. The dependency burden is positively and significantly associated with PDS access, as suggested by the negative coefficient estimates for the share of adult members in the household. The household with an older head is more likely to have access to PDS in 1993 and 2004. Education dummies are negative and significant in most of the cases, which implies that the household with lower levels of educational attainment or without literate members tends to access RPW and PDS. This is indirect evidence of good targeting performances of these schemes. Households with owned land area from 0.1 to 2.5 hectares are more likely to participate in RPW than the landless or those with land larger than 2.5 hectares in 1993 and 2004 (Cases 1 and 3). The landless are more likely to have access to PDS than those with land in 1993 (Case 2), but those with land from 0.1 to 2.5 hectares are more likely to access PDS than the rest in 2004 (Case 4). The agricultural or non-agricultural labourer tends to join RPW and PDS. The schemes are more likely to be utilised by those belonging to SCs or STs. While predicted male wage is positive and significant in 1993, it is negative and highly significant in 2004 in the RPW participation equation. The coefficient estimate of food price index is positive and significant in the PDS equation.

Table 2 reports the results of the second-stage regressions, where the dependent variable is: (a) consumption-based poverty (in the first panel of the second stage results); (b) vulnerability estimate (in the second panel); and (c) undernutrition based on calories and protein only for the NSS 50^{th} round (in the third panel). We only summarise the key results. First, the coefficient of β_λ, the degree of sample selection, is significant in all the cases (most of which are negative as in Cases 1, 2, and 4 in (a) consumption-based poverty, in Cases 1 to 4 in (b) vulnerability, the first and the third columns of RPW for (c) nutrition-based poverty. The actual poverty-reducing effects are affected by the sample selection effects and direct effects of the schemes, θ. The treatment effects are calculated and summarised in Table 3.

The comparison of determinants of (a) consumption-based poverty, (b) vulnerability estimate and (c) undernutrition based on calories and protein for the cases of RPW and PDS would be of empirical significance in itself. Overall, determinants of poverty, vulnerability and undernutrition are similar, with a few exceptions. Female member headedness is considered a factor increasing the probability of being poor, but we observe a negative and significant coefficient estimate in Case 2 (NSS 50) of consumption poverty, Case 1 (NSS 50) of vulnerability, Case 1 of calorie poverty and Case 2 of protein poverty (NSS 50). Household composition is significantly associated with poverty, vulnerability and undernutrition. For example, they are negatively affected by dependency burden or the number of adult female members. The household with an older household head is more likely to be poor with some non-linear effect, with an exception of Case 2 in (c), calorie-based poverty, which shows the positive sign. Higher levels of educational attainment and larger land area tend to decrease the probability of being poor, vulnerable and undernourished. Belonging to SCs or STs is highly correlated with not only poverty but also vulnerability and undernutrition.

Table 3 summarises the treatment effects associated with RPW and PDS. RPW decreases consumption-based poverty and protein-based significantly in 1993, but not calorie-based poverty as shown by Case 1. This might reflect the fact that RPW is sometimes physically demanding and requires calories. In 1993, significant *vulnerability*-reducing effects are observed only for the vulnerability calculated based on 80 percent of the national poverty line (and the effects are positive for 100 percent and 120 percent). In 2004, RPW is confirmed to have a significant impact on reducing poverty and vulnerability. On the contrary, PDS significantly *increased* consumption-based poverty and nutrition-based poverty in 1993 and consumption-based poverty in 2003 (Cases 2 and 4). However, PDS significantly *decreased* vulnerability in both 1993 and 2003. This may reflect the aspect of social protection in PDS.

4.3 Propensity score matching

Because of the difficulty of obtaining the convergence and the tendency to violate the balancing hypothesis, we have taken the minimalist approach and avoided using the binary variable in estimating PSM models. We have kept the number of adult male members, the proportion of adults in the household, age of the household head, land per capita and predicted male wages (only for RPW) and food price index (only for PDS). The balancing hypothesis (Lemma 1) which tests for equality of means between the treated and untreated observations for each of the covariates is satisfied in every case. The results are shown in Table 4. The distributions of propensity scores are presented in Annex 4.

Table 4: Summary of results of propensity score matching models

Probit models

	NSS50						NSS61					
	Case 1			Case 2			Case 3			Case 4		
	RPW			PDS			RPW			PDS		
RPW	Coef.	z		Coef.	z		Coef.	z		Coef.	z	
Number of adult male members	0.047	(5.92)	**	-0.039	(-7.27)	**	0.036	(3.23)	**	0.035	(6.06)	**
Proportion of adults in a household	-0.015	(-0.41)		0.138	(5.67)	**	-0.063	(-1.50)		-0.242	(-11.22)	**
Age of household head	-0.273	(-4.08)	**	0.233	(5.39)	**	-0.416	(-5.81)	**	0.557	(15.13)	**
land_pc	-0.040	(-2.46)	**	-	(-	**	0.000	(0.56)		-0.001	(-1.01)	

				0.272	21.55)							
Predicted agricultural wage rate for males	0.002	(4.70)	**	-			-0.004	(-7.27)	**	-		
Food price index	-			0.058	(68.45)	**	-			0.025	(10.26)	**
Constant	-1.744	(-42.62)		-6.605	(-75.60)		-1.448	(-28.43)		0.234	(7.88)	
Number of obs	69206			69206			77043			79253		
LR chi2(5)	69.39			69.39			106.07			530.91		
Prob > chi2	0			0			0			0		

***=significant at 1% level. *=significant at 5% level. +=significant at 10% level.*

Policy effects on poverty and undernutrition (based on bootstrapped standard errors)

	NSS50	Effects on poverty						
Case 1	RPW	Effects on poverty						
	RPW	Effects on poverty (consumption based)						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3926	-0.01	0.012	-0.809	
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3088	-0.016	0.014	-1.084	
	RPW	Effects on poverty (calorie based)						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3926	-0.004	0.009	-0.4	
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3089	-0.019	0.009	-2.062	*
	RPW	Effects on poverty (protein based)						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3926	-0.008	0.006	-1.219	

	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3088	-0.006	0.01	-0.594	
Case 2	PDS	Effects on poverty						
	PDS	Effects on poverty (consumption based)						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3930	0.011	0.013	0.822	
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3131	0.019	0.008	2.446	*
	PDS	Effects on poverty (calorie based)						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3930	0.014	0.011	1.304	
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3131	0.02	0.012	1.635	
	PDS	Effects on poverty (protein based)						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3930	0.001	0.009	0.135	
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3131	0.008	0.008	0.971	

	NSS61	Effects on poverty (consumption based)						
Case 3	RPW							
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	

		44153		8810	-0.011	0.006	-1.741	+
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		44153		4773	-0.012	0.009	-1.312	
Case 4	PDS							
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		45364		9112	0.011	0.005	2.252	*
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		45364		5199	0.007	0.012	0.591	

Policy effects on vulnerability (based on bootstrapped standard errors)

	NSS50	Effects on vulnerability						
Case 1	RPW	Effects on vulnerability						
	RPW	Effects on vulnerability						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3926	-0.225	0.008	-28.576	**
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3089	-0.197	0.022	-9.085	**
Case 2	PDS	Effects on vulnerability						
	PDS	Effects on vulnerability						
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3930	-0.241	0.017	-14.387	**
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		34908		3131	-0.188	0.025	-7.646	*
	NSS61	Effects on vulnerability						
Case 3	RPW							
	Kernel matching							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		44153		8810	0.03	0.03	-9.43	**
	Nearest neighbour matching method							
	n.	Treat.	n.	Contr.	ATT	Std. err.	t	
		44153		4605	-0.022	0.005	-4.312	**
Case 4	PDS							
	Kernel matching							

n.	Treat.	n.	Contr.	ATT	Std. err.	t	
	45364		9112	-0.032	0.002	-14.221	**
Nearest neighbour matching method							
n.	Treat.	n.	Contr.	ATT	Std. err.	t	
	45364		5002	-0.023	0.003	-6.766	**

Table 4 summarises the final results of PSM. The results are sensitive to our choice of the method of matching, kernel matching or nearest neighbour matching.

In Case 1, where we analyse the effects of RPW on poverty, undernutrition and poverty in 1993, we observe a significant poverty-reducing effect on calorie-based poverty where nearest neighbour matching is used. It is not significant in the case where kernel matching is used. However, significantly negative impacts of household participation in RPW are found on vulnerability in Case 1 for both kernel matching and nearest neighbour matching.

In Case 3 for RPW in 2004, we find a significant poverty-reducing effect on consumption-based poverty in the kernel matching method. The average treatment effect is negative, but not significant, when nearest neighbour matching is applied. Again, RPW reduces vulnerability significantly in 2004.

In Case 2 for the evaluation of PDS in 1993, the average treatment effect is positive and not significant, except one case of nearest neighbour matching for consumption-based poverty. In Case 4, we find a poverty-*increasing* effect of PDS on consumption-based poverty when kernel matching is used. As long as we use the static indicators of poverty, PDS appears to increase poverty. However, once we use the vulnerability measures, we find significant poverty-reducing effects of PDS in 1993 and 2004. The results obtained by PSM are broadly consistent with those of the treatment effects model.

4.4 State-wise results

One of the major limitations of PSM and the treatment effects model is that neither model takes account of heterogeneity within the sample. Because of the large country size, a concern arises on the geographical diversity of the results. In the previous regression models, we have included state dummy variables to consider this. However, dummy variables only capture the difference of constant in the regression, not the difference of the slope. We have thus applied the treatment effects model for the Indian states with a reasonably large number of observations for NSS 50 and NSS 61. The results are shown in Table 5.

Table 5: Summary of state-wise results of treatment effects models

	NSS 50	RPW						NSS 50	PDS				
	Estimated poverty							Estimated poverty					
	A	B	A-B					A	B	A-B			
	With RPW	Without RPW	ATT	t value		No. of observations		With PDS	Without PDS	ATT	t value		Number of observations
State							State						
Punjab	0.096	0.054	0.042	12.34	**	2046	Punjab	0.333	0.041	0.292	122.87	**	2046
Haryana	0.071	0.038	0.033	30.86	**	1040	Haryana	0.13	0.028	0.102	21.07	**	1040
Rajasthan	**0.247**	**0.268**	**-0.021**	**-11.29**	**	3097	Rajasthan	0.566	0.216	0.35	194.62	**	3097
Uttar Pradesh	0.112	0.077	0.035	34.03	**	9010	Uttar Pradesh	0.625	0.045	0.58	347.11	**	9010
Bihar	0.498	0.115	0.383	115.9	**	6976	Bihar	0.166	0.134	0.032	17.7	**	6976
Assam	0.162	0.146	0.016	6.479	**	3199	Assam	0.193	0.128	0.065	26.52	**	3199
West Bengal	0.206	0.139	0.067	38.11	**	5581	West Bengal	0.207	0.126	0.081	47.95	**	5581
Orissa	**0.18**	**0.213**	**-0.033**	**-9.779**	**	3330	Orissa	0.293	0.212	0.081	27.22	**	3330
Madhya Pradesh	**0.139**	**0.182**	**-0.043**	**-19.074**	**	5331	Madhya Pradesh	0.214	0.172	0.042	14.5	**	5331
Gujarat	0.408	0.299	0.109	26.02	**	2219	Gujarat	0.327	0.287	0.04	11.4	**	2219
Maharashtra	0.45	0.448	0.002	0.594		4440	Maharashtra	0.499	0.423	0.076	24.38	**	4440
Andhra Pradesh	0.167	0.162	0.005	2.445	*	4908	**Andhra Pradesh**	**0.148**	**0.174**	**-0.026**	**-17.28**	**	4908
Karnataka	0.502	0.502	0.0003	0.053		2617	Karnataka	0.551	0.4495	0.1015	20.4	**	2617
Kerala	0.35	0.277	0.073	16.54	**	2553	**Kerala**	**0.27**	**0.298**	**-0.028**	**-6.208**	**	2553
Tamil Nadu	**0.172**	**0.231**	**-0.059**	**-21.12**	**	3901	**Tamil Nadu**	**0.187**	**0.229**	**-0.042**	**-5.542**	**	3901
All India	**0.157**	**0.162**	**-0.005**	**-5.01**	**	69206	All India	0.227	0.15	0.077	92.63	**	69206

	NSS 50 RPW Vulnerability estimate (based on 100% poverty line)					
	A With RPW	B Without RPW	A-B ATT	t value		Number of observations
State						
Punjab	**0.214**	**0.296**	**-0.082**	**-8.006**	**	**2046**
Haryana	0.489	0.467	0.022	1.298		1040
Rajasthan	0.879	0.511	0.368	35.5	**	3097
Uttar Pradesh	0.654	0.638	0.016	2.967	**	9010
Bihar	0.705	0.704	0.001	0.199		6979
Assam	0.659	0.639	0.02	0.2096		3199
West Bengal	0.5365	0.536	0.0005	0.056		5581
Orissa	**0.661**	**0.682**	**-0.021**	**-2.281**	**	**3330**
Madhya Pradesh	0.678	0.669	0.009	1.15		5331
Gujarat	0.531	0.508	0.023	1.969	*	2219
Maharashtra	0.578	0.574	0.004	0.503		4440
Andhra Pradesh	0.481	0.45	0.031	3.832	**	4908
Karnataka	0.608	0.582	0.026	2.4	**	2617
Kerala	0.247	0.258	-0.011	-1.21		2555
Tamil Nadu	**0.364**	**0.424**	**-0.06**	**-6.211**	**	**3901**
All India	0.479	0.475	0.004	1.804	+	69206

	NSS 50 PDS Vulnerability estimate (based on 100% poverty line)						
	A With PDS		B Without PDS	A-B ATT	t value		Number of observations
State							
Punjab	**0.228**	**0.296**	**-0.068**	**-6.629**	**		**2046**
Haryana	0.57	0.455	0.115	6.483	**		1040
Rajasthan	0.535	0.525	0.01	1.02			3097
Uttar Pradesh	0.629	0.638	-0.009	-0.008			9010
Bihar	0.722	0.703	0.019	2.931	**		6979
Assam	0.646	0.641	0.005	0.585			3199
West Bengal	0.538	0.535	0.003	0.366			5581
Orissa	0.672	0.683	-0.011	-1.106			3330
Madhya Pradesh	**0.627**	**0.678**	**-0.051**	**-6.868**	**		**5331**
Gujarat	0.704	0.353	0.351	30.39	**		2219
Maharashtra	0.708	0.501	0.207	23.85	**		4440
Andhra Pradesh	0.612	0.29	0.322	40.559	**		4908
Karnataka	0.713	0.434	0.279	0.278			2617
Kerala	**0.185**	**0.424**	**-0.239**	**-26.29**	**		**2555**
Tamil Nadu	0.634	0.152	0.482	29.15	**		3901
All India	**0.4524**	**0.4591**	**-0.0067**	**-2.5**	**		**69206**

State	NSS 61 RPW Estimated poverty A With FFW	B Without FFW	A-B ATT	t value		Number of observations	State	NSS 61 PDS Estimated poverty A With PDS	B Without PDS	A-B ATT	t value		Number of observations
Punjab	**-3.73**	**0.03**	**-3.76**	**-5.25**	**	**2444**	**Punjab**	**0.006**	**0.031**	**-0.025**	**-18.39**	**	**2431**
Haryana	**-0.293**	**0.052**	**-0.345**	**-50.84**	**	**1680**	Haryana	0.066	0.039	0.027	12.71	**	1680
Rajasthan	0.101	0.104	-0.003	-1.169		3536	Rajasthan	0.115	0.089	0.026	10.59	**	3536
Uttar Pradesh	0.99	0.234	0.756	99.12	**	7787	Uttar Pradesh	0.243	0.185	0.058	22.6	**	7810
Bihar	0.826	0.321	0.505	63.82	**	4283	Bihar	0.323	0.309	0.014	2.667	**	4319
Assam	0.766	0.111	0.655	96.23	**	3317	Assam	0.118	0.095	0.023	7.754	**	3324
West Bengal	**0.132**	**0.16**	**-0.028**	**-9.97**	**	**4962**	**West Bengal**	**0.159**	**0.18**	**-0.021**	**-7.523**	**	**4967**
Orissa	0.703	0.453	0.25	49.37	**	3800	Orissa	0.479	0.406	0.073	12.51	**	3805
Madhya Pradesh	0.337	0.332	0.005	1.11		3832	**Madhya Pradesh**	**0.236**	**0.505**	**-0.269**	**-51.56**	**	**3833**
Gujarat	0.768	0.09	0.678	47.87	**	2302	Gujarat	0.12	0.082	0.038	11.25	**	2302
Maharashtra	**0.093**	**0.202**	**-0.109**	**-32.75**	**	**5000**	Maharashtra	0.196	0.193	0.003	0.812		5000
Andhra Pradesh	**0.118**	**0.174**	**-0.056**	**-16.09**	**	**5500**	Andhra Pradesh	0.185	0.129	0.056	23.23	**	5500
Karnataka	0.639	0.199	0.44	23.11	**	2880	Karnataka	0.218	0.138	0.08	19.75	**	2880
Kerala	0.679	0.044	0.635	10.82	**	3292	Kerala	0.44	0.036	0.404	7.09	**	3292
Tamil Nadu	0.719	0.169	0.55	44.43	**	4137	Tamil Nadu	0.171	0.087	0.084	28.99	**	4137
All India	**0.164**	**0.179**	**-0.015**	**-14.61**	**	**76687**	All India	0.186	0.154	0.032	35.37	**	78874

	NSS 61 RPW Vulnerability estimate (based on 100% poverty line)							NSS 61 PDS Vulnerability estimate (based on 100% poverty line)					
	A	B	A-B					A	B	A-B			
	With FFW	Without FFW	ATT	t value		Number of observations		With PDS	Without PDS	ATT	t value		Number of observations
State							State						
Punjab	9.05	0.003	9.047	5.455	**	2444	**Punjab**	**0.00015**	**0.0004**	**-0.00025**	**-2.607**	**	**2431**
Haryana	0.0008	0.001	-0.0002	18.98	**	1680	Haryana	0.0147	-0.008	0.0227	84.57	**	1680
Rajasthan	0.127	0.001	0.126	97.18	**	3536	**Rajasthan**	**0.0172**	**0.0195**	**-0.0023**	**-2.02**	*	**3536**
Uttar Pradesh	2.708	0.053	2.655	406.66	**	7787	Uttar Pradesh	0.0609	0.0622	-0.0013	-0.638		7810
Bihar	**0.142**	**0.225**	**-0.083**	**-7.436**	**	**4283**	Bihar	0.224	0.226	-0.002	-0.192		4319
Assam	0.027	0.016	0.011	8.39	**	3317	**Assam**	**0.014**	**0.024**	**-0.01**	**-10.75**	**	**3324**
West Bengal	0.023	0.035	-0.012	-6.78	**	4962	**West Bengal**	**0.031**	**0.065**	**-0.034**	**-19.34**	**	**4967**
Orissa	0.432	0.41	0.022	2.433	*	3800	**Orissa**	**0.375**	**0.531**	**-0.156**	**-17.4**	**	**3805**
Madhya Pradesh	1.591	0.209	1.382	174.96	**	3832	**Madhya Pradesh**	**0.147**	**0.377**	**-0.23**	**-31.48**	**	**3833**
Gujarat	0.25	0.0009	0.2491	47.22	**	2302	**Gujarat**	**0.012**	**0.032**	**-0.02**	**-15.01**	**	**2302**
Maharashtra	0.0945	0.0675	0.027	9.547	**	5000	Maharashtra	0.067	0.067	0.0004	0.158		5000
Andhra Pradesh	0.312	0.009	0.303	226.28	**	5500	Andhra Pradesh	-0.033	0.138	-0.171	-14	**	5501
Karnataka	2.033	0.098	1.935	136.05	**	2880	**Karnataka**	**0.085**	**0.147**	**-0.062**	**-12.31**	**	**2880**
Kerala	**-0.0003**	**0.0004**	**-0.0007**	**-9.803**	**	**3292**	**Kerala**	**-0.002**	**0.005**	**-0.007**	**-66.08**	**	**3292**
Tamil Nadu	0.076	0.025	0.051	13.7	**	4137	Tamil Nadu	0.024	0.019	0.005	3.33	**	4137
All India	**-0.015**	**0.082**	**-0.097**	**-95.29**	**	**76687**	**All India**	**0.077**	**0.091**	**-0.014**	**-17.36**	**	**78874**

**=significant at 1% level. *=significant at 5% level. +=significant at 10% level.

The states with negative average treatment effect are shown in bold in Table 5, which shows a significant degree of diversity among different states. For example, although RPW has a negative and significant effect on reducing poverty in 1993, the significant and negative effects of RPW are observed in several states only, such as Rajasthan, Orissa, Madhya Pradesh and Tamil Nadu. We observe a positive and significant effect of PDS on poverty for all India in 1993, but the effects are negative and significant in Andhra Pradesh, Kerala and Tamil Nadu.

The pattern of diversity differs considerably once we focus on vulnerability. RPW increases vulnerability for all India, but negative and significant average treatment effects of RPW are observed for Punjab, Orissa and Tamil Nadu in 1993. The negative and significant effects of PDS on vulnerability are found only for Punjab, Madhya Pradesh and Kerala, despite the negative and significant estimate for all India.

For NSS 61 in 2004, we found a negative and significant average treatment effect of RPW on poverty for all India. However, the state-wise results show that the treatment effects are significant and negative only in Punjab, Haryana, West Bengal, Maharashtra and Andhra Pradesh. Many of the other states show the positive and significant treatment effects. PDS, on the other hand, has a positive and significant treatment effect on poverty for all India, with a significant degree of diversity. Punjab, West Bengal and Madhya Pradesh are among the states with a negative and significant treatment effect of PDS on poverty.

It is found that RPW reduces vulnerability significantly for all India in 2005; many states show positive and significant treatment effects. The negative and significant effects are found only for Bihar, West Bengal and Kerala. On the other hand, the average effect of PDS on vulnerability is negative and significant in most of the states in 2005, with the exception of Haryana and Tamil Nadu, which show positive and significant effects.

4.5 Pseudo panel model

The results based on IV regression for pseudo panel data model are reported in Table 6. The results must be interpreted with caution, in particular because the instrument for RPW, aggregation of predicted wages, is not significant in the first stage. Focusing on the coefficient estimates of RPW or PDS, that is instruments, we do not find any significant results, except one case where PDS reduces vulnerability significantly at a 5 percent level when it is defined based on 80 percent of the poverty threshold. This is consistent with the earlier results of treatment effects model.

Table 6: Pseudo panel model

G2SLS random effects IV regression

	1st stage RPW			1st stage PDS			1st stage RPW			1st stage PDS		
	Coef.	z		Coef.	z		Coef.	z		Coef.	z	
Whether a household is headed by a female member	-0.088	(-0.49)		0.705	(1.37)		0.095	(0.54)		-0.404	(-0.64)	
Number of adult female members	0.042	(0.52)		0.296	(1.14)		0.014	(0.19)		0.734	(2.88)	**
Number of adult male members	-0.074	(-1.00)		-0.453	(-2.12)	*	-0.013	(-0.20)		-0.748	(-3.31)	**
Proportion of adults in a household	0.104	(0.59)		0.020	(0.04)		0.139	(0.97)		-0.019	(-0.03)	
Age of household head	-1.496	(-0.65)		9.725	(1.43)		-1.153	(-0.50)		3.892	(0.48)	
Age squared	1.168	(0.51)		-9.895	(-1.40)		0.622	(0.27)		-3.359	(-0.41)	
Max. education of adult (primary)	0.069	(0.87)		0.532	(2.00)		0.077	(1.25)		0.192	(0.86)	
Max. education of adult (middle)	0.039	(0.44)		0.724	(2.59)	*	0.038	(0.52)		0.965	(3.68)	**
Max. education of adult (>=matriculates)	0.010	(0.08)		0.174	(0.47)		0.001	(0.01)		0.192	(0.50)	
Land (0.1<=2.5 ha) (default: the landless)	0.039	(0.98)		0.157	(1.16)		-0.009	(-0.30)		0.061	(0.62)	
Land (>2.5 ha) (default: the landless)	0.100	(1.95)	+	0.517	(3.15)	**	0.066	(1.73)	+	0.623	(4.39)	**
Whether self-employed in non-agriculture	-0.173	(-1.39)		0.420	(1.10)		-0.177	(-1.56)		-0.076	(-0.19)	
Whether agricultural labour	-0.083	(-0.78)		0.645	(2.36)	*	0.047	(0.49)		0.216	(0.68)	
Whether non-agricultural labour	0.006	(0.07)		0.494	(1.64)		0.003	(0.03)		0.121	(0.31)	
Whether self-employed in agriculture	-0.027	(-0.29)		0.309	(1.08)		0.067	(0.79)		-0.094	(-0.29)	
Whether a household belongs to SC	0.011	(0.95)		-0.050	(-1.34)		0.007	(0.67)		-0.029	(-0.76)	
Whether a household belongs to ST	0.009	(0.67)		-0.032	(-0.68)		0.008	(0.63)		0.019	(0.42)	
Predicted agricultural wage rate for males	0.000	(-0.63)		-	-		0.000	(0.22)		-	-	
Food price index	-	-		0.010	(2.60)	*	0.000	(0.22)		0.010	(2.80)	**
Whether in 1993	0.057	(0.94)		-0.923	(-2.07)	*	0.060	(1.06)		-0.888	(-2.17)	*
Constant	0.422	(0.84)		-2.426	(-1.75)		0.277	(0.55)		-0.939	(-0.55)	
2nd stage	Poverty			Poverty			Vulnerability (100%)			Vulnerability (100%)		
	Coef.	Z		Coef.	z		Coef.	Z		Coef.	Z	
RPW	**0.038**	**(0.01)**					**-8.477**	**(-0.21)**		**-**		
PDS	**-**	**-**		**0.351**	**(1.25)**		**-**			**-0.262**	**(-1.34)**	
Whether a household is headed by a female member	-0.293	(-0.46)		-0.410	(-0.97)	**	1.170	(0.28)		-0.297	(-0.83)	
Number of adult female members	0.238	(0.87)		0.119	(0.55)		0.127	(0.14)		0.118	(0.61)	
Number of adult male members	-0.180	(-0.48)		-0.024	(-0.12)	**	0.258	(0.33)		0.006	(0.03)	
Proportion of adults in a household	-0.717	(-1.19)		-0.742	(-1.85)	**	1.038	(0.18)		-0.705	(-2.19)	*

Age of household head	1.715	(0.21)		-3.752	(-0.58)	**	-16.422	(-0.32)		1.372	(0.30)	
Age squared	-1.242	(-0.17)		4.148	(0.62)		11.429	(0.34)		-0.283	(-0.06)	
Max. education of adult (primary)	0.450	(1.32)		0.275	(0.97)		0.487	(0.16)		0.188	(1.36)	
Max. education of adult (middle)	0.195	(0.68)		-0.040	(-0.14)	**	-0.018	(-0.01)		0.045	(0.20)	
Max. education of adult (>=matriculates)	-0.444	(-1.38)		-0.398	(-1.39)	**	-0.765	(-0.89)		-0.265	(-1.24)	
Land (0.1<=2.5 ha) (default: the landless)	0.189	(1.00)		0.105	(0.91)		-0.062	(-0.14)		0.110	(1.89)	+
Land (>2.5 ha) (default: the landless)	0.231	(0.53)		0.039	(0.20)		0.369	(0.14)		0.055	(0.35)	
Whether self-employed in non-agriculture	-0.657	(-0.95)		-0.596	(-2.23)	**	-1.885	(-0.25)		-0.291	(-1.33)	
Whether agricultural labour	0.010	(0.03)		0.019	(0.09)	+	0.444	(0.24)		0.037	(0.23)	
Whether non-agricultural labour	-0.438	(-1.72)	+	-0.508	(-2.08)	**	0.139	(0.15)		0.146	(0.70)	
Whether self-employed in agriculture	-0.653	(-2.71)	**	-0.482	(-2.60)	**	0.462	(0.17)		-0.216	(-1.14)	
Whether a household belongs to SC	0.014	(0.26)		0.041	(1.28)		0.102	(0.34)		0.025	(1.14)	
Whether a household belongs to ST	-0.007	(-0.14)		0.009	(0.24)		0.097	(0.28)		0.019	(0.78)	
Whether in 1993	0.159	(0.56)		1.402184	(0.24)		0.17	(0.01)		0.4	(3.66)	**
Constant	0.281	(0.13)		0.158	(1.16)		4.196	(0.34)		0.036	(0.04)	
Number of obs		136			136			127			136	
Wald chi(18)		83.42			47			75			348	
Prob > chi2		0			0			0			0	

***=significant at 1% level. *=significant at 5% level. +=significant at 10% level.*

2nd stage	Vulnerability (80%)		Vulnerability (80%)		Vulnerability (120%)		Vulnerability (120%)	
	Coef.	Z	Coef.	z	Coef.	Z	Coef.	Z
RPW	-0.09	(-049)			0.19	(0.32)	-	
PDS	-	-	-0.65	(-2.44)*	-		0.05	(0.23)

***=significant at 1% level. *=significant at 5% level. +=significant at 10% level.*

5 Conclusion

This paper analyses the effects of access to RPW and PDS, a public food subsidy programme, on consumption poverty, vulnerability and undernutrition in India, drawing on the NSS 50 (1993-1994) and NSS 61 (2004-2005) large household datasets. Vulnerability is defined as the probability of a household falling into poverty and is estimated using the methodology put forward by Chaudhuri (2003) and Chaudhuri *et al.* (2002). Undernutrition measures are derived by converting detailed expenditure data into the nutritional equivalent of calorie or protein intake.

The need has arisen to take account of sample selection in evaluating policy effects because access to RPW or PDS is not randomly distributed across the sample, owing to self selection, whereby a household opts to take up the programme in light of its specific characteristics or circumstances (e.g. hunger, lack of human resources), and/or to the endogenous programme placement, that is, policymakers select, for example, geographical areas in reflection of policy needs (e.g. poverty reduction). The treatment effects model, a version of the Heckman sample selection model and the PSM model were used, at least partly, to take account of the sample selection bias in evaluating the effects of RPW or PDS on poverty. However, the results must be interpreted with caution, because of the presence of unobservable factors that are important in decision making to participate in RPW or to access PDS, which cannot be controlled by the survey data.

We have found significant and negative effects of household participation in RPW and FFW programmes on poverty, undernutrition (e.g. protein) and vulnerability in 1993 and 2004. Broadly similar results were obtained by the treatment effects model and PSM. However, once we apply the treatment effects model separately for each state, a great degree of diversity is observed. Also, we do not find any significant results for RPW in pseudo panel data models.

Prevalence of poverty and undernutrition is significantly higher for households with access to PDS than for those without. However, PDS has significant effects on reducing vulnerability of households in 1993 and 2004, which has been confirmed by the treatment effects model and PSM. The effects of PDS are different among the different results. PDS decreased vulnerability based on 80 percent of the poverty threshold in the IV model applied to the pseudo panel.

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Annex

Annex 1: Definitions and descriptive statistics of the variables

Variable	Definition
Whether a household is headed by a female member	Whether a household is headed by a female member (=1 if yes, =0 if no)
Number of adult female members	Number of adult female members (15 years old or above) in a household
Number of adult male members	Number of adult male members (15 years old or above) in a household
The proportion of adults in a household	Share of adults (15-60 years) in the total number of household members
Age of household head	Age of household head (years)
Age squared	Square of age of household head
Max. education of adult (primary)	Maximum level of educational attainment of adult member in the household is completion of primary school
Max. education of adult (middle)	Maximum level of educational attainment of adult member in the household is completion of middle school.
Max. education of adult (>=matriculates)	Maximum level of educational attainment of adult member in the household is matriculates or higher
Land (0.1<=2.5 ha) (default: the landless)	Area of owned land of household is from 0.1 to 2.5 ha
Land (>2.5 ha) (default: the landless)	Area of owned land of the household is larger than 2.5 ha
Land pc	Area of owned land per capita
Whether self-employed in non-agriculture	Whether occupation type of household head is self-employed in non-agriculture (=1 if yes, =0 if no); default of the four choices is 'others'
Whether agricultural labour	Whether occupation type of household head is agricultural labour (=1 if yes, =0 if no)
Whether non-agricultural labour	Whether occupation type of household head is labour in non-agriculture (=1 if yes, =0 if no)
Whether self-employed in agriculture	Whether occupation type of household head is self-employed in agriculture (=1 if yes, =0 if no)
Whether a household belongs to SC	Whether a household belongs to SC (scheduled caste) (=1 if yes, =0 if no)
Whether a household belongs to ST	Whether a household belongs to ST (scheduled tribe) (=1 if yes, =0 if no)
PDS	Whether a household has access to PDS
RPW	Whether a household has access to RPW
FFW	Whether a household has access to food for work programme
Predicted agricultural wage rate for males	Agricultural wage rate for male workers averaged at NSS region
Food price index	Food price index based on Deaton and Tarozzi (2000)
Poor	Whether household per capita expenditure is under the national poverty line for rural areas

Poor (calorie based)	Whether household is undernourished in terms of calorie intakes
Poor (protein based)	Whether household is undernourished in terms of protein intakes
Vulnerability measure (based on 100% income poverty line)	Whether household is vulnerable (based on 100% of national poverty line)
Vulnerability measure (based on 80% income poverty line)	Whether household is vulnerable (based on 80% of national poverty line)
Vulnerability measure (based on 120% income poverty line)	Whether household is vulnerable (based on 120% of national poverty line)

NSS 50

Without RPW						With RPW				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Whether a household is headed by a female member	65974	0.097	0.295	0	1	3232	0.066	0.248	0	1
Number of adult female members	65974	1.613	0.961	0	20	3232	1.611	0.948	0	8
Number of adult male members	65974	1.661	1.092	0	25	3232	1.750	1.094	0	14
Proportion of adults in a household	65974	0.683	0.234	0	1	3232	0.681	0.230	0	1
Age of household head	65974	0.445	0.139	0	0.99	3232	0.439	0.134	0	0.92
Age squared	65974	0.217	0.133	0	0.9801	3232	0.211	0.126	0	0.8464
Max. education of adult (primary)	65974	0.106	0.308	0	1	3232	0.078	0.268	0	1
Max. education of adult (middle)	65974	0.090	0.287	0	1	3232	0.066	0.249	0	1
Max. education of adult (>=matriculates)	65974	0.250	0.433	0	1	3232	0.334	0.472	0	1
Land (0.1<=2.5 ha) (default: the landless)	6597	0.266	0.442	0	1	3232	0.231	0.422	0	1

	4									
Land (>2.5 ha) (default: the landless)	65974	0.149	0.356	0	1	3232	0.258	0.438	0	1
Whether self-employed in non-agriculture	65974	0.122	0.327	0	1	3232	0.091	0.288	0	1
Whether agricultural labour	65974	0.240	0.427	0	1	3232	0.287	0.453	0	1
Whether non-agricultural labour	65974	0.071	0.257	0	1	3232	0.124	0.329	0	1
Whether self-employed in agriculture	65974	0.425	0.494	0	1	3232	0.358	0.479	0	1
Whether a household belongs to SC	65974	0.147	0.354	0	1	3232	0.212	0.409	0	1
Whether a household belongs to ST	65974	0.187	0.390	0	1	3232	0.213	0.409	0	1
PDS	65972	0.248	0.432	0	1	3232	0.289	0.454	0	1
RPW	65974	0.000	0.000	0	0	3232	1.000	0.000	1	1
Predicted agricultural wage rate for males	65974	65.329	20.145	29.56	141.06	3232	67.055	20.456	29.55586	141.0612
Food price index	65974	100.348	6.433	91.8	116.5	3232	100.107	5.886	91.8	116.5
Poor	56263	0.199	0.399	0	1	2401	0.252	0.434	0	1
Poor (calorie based)	56263	0.202	0.401	0	1	2401	0.253	0.435	0	1
Poor (protein based)	56263	0.154	0.361	0	1	2401	0.200	0.400	0	1
Vulnerability measure (based on 100% income poverty line)	56263	0.571	0.478	0	1	2401	0.632	0.467	0	1
Vulnerability measure (based on 80% income poverty	5626	0.432	0.476	0	1	2401	0.491	0.480	0	1

line)	3									
Vulnerability measure (based on 120% income poverty line)	5626 3	0.668	0.456	0	1	2401	0.715	0.437	0	1

Without PDS						With PDS				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Whether a household is headed by a female member	51917	0.086	0.281	0	1	17287	0.123	0.328	0	1
Number of adult female members	51917	1.605	0.964	0	16	17287	1.638	0.948	0	20
Number of adult male members	51917	1.681	1.098	0	14	17287	1.618	1.074	0	25
Proportion of adults in a household	51917	0.679	0.235	0	1	17287	0.694	0.232	0	1
Age of household head	51917	0.443	0.141	0	0.99	17287	0.449	0.133	0	0.99
Age squared	51917	0.216	0.134	0	0.9801	17287	0.219	0.128	0	0.9801
Max. education of adult (primary)	51917	0.103	0.303	0	1	17287	0.112	0.316	0	1
Max. education of adult (middle)	51917	0.091	0.288	0	1	17287	0.083	0.276	0	1
Max. education of adult (>=matriculates)	51917	0.237	0.425	0	1	17287	0.303	0.459	0	1
Land (0.1<=2.5 ha) (default: the landless)	51917	0.292	0.455	0	1	17287	0.181	0.385	0	1
Land (>2.5 ha) (default: the landless)	51917	0.131	0.337	0	1	17287	0.223	0.416	0	1
Whether self-employed in non-agriculture	51917	0.119	0.324	0	1	17287	0.124	0.330	0	1
Whether agricultural labour	51917	0.231	0.421	0	1	17287	0.277	0.448	0	1
Whether non-agricultural labour	51917	0.064	0.245	0	1	17287	0.102	0.303	0	1
Whether self-employed in agriculture	51917	0.449	0.497	0	1	17287	0.338	0.473	0	1
Whether a household belongs to SC	51917	0.139	0.346	0	1	17287	0.182	0.386	0	1
Whether a household belongs to ST	51917	0.193	0.394	0	1	17287	0.174	0.379	0	1
PDS	51917	0.000	0.000	0	0	17287	1.000	0.000	1	1
RPW	51917	0.044	0.206	0	1	17287	0.054	0.226	0	1
Predicted agricultural wage rate for males	51917	63.104	19.911	29.56	141.06	17287	72.332	19.312	29.55586	141.0612
Food price index	51917	99.353	6.164	91.8	116.5	17287	103.290	6.219	91.8	116.5
Poor	45217	0.168	0.374	0	1	13446	0.312	0.463	0	1

Poor (calorie based)	45217	0.175	0.380	0	1	13446	0.301	0.459	0	1
Poor (protein based)	45217	0.128	0.334	0	1	13446	0.250	0.433	0	1
Vulnerability measure (based on 100% income poverty line)	45217	0.584	0.476	0	1	13446	0.539	0.479	0	1
Vulnerability measure (based on 80% income poverty line)	45217	0.447	0.478	0	1	13446	0.392	0.466	0	1
Vulnerability measure (based on 120% income poverty line)	45217	0.677	0.453	0	1	13446	0.646	0.462	0	1

NSS 61

Without RPW						With RPW				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Whether a household is headed by a female member	76709	0.109	0.311	0	1	2290	0.072	0.259	0	1
Number of adult female members	76709	1.337	0.807	0	11	2290	1.313	0.727	0	6
Number of adult male members	76709	1.344	0.939	0	12	2290	1.383	0.830	0	6
Proportion of adults in a household	76709	0.555	0.248	0	1	2290	0.553	0.224	0	1
Age of household head	76708	0.462	0.135	0	1.08	2290	0.445	0.127	0.1	0.85
Age squared	76708	0.232	0.133	0	1.1664	2290	0.215	0.122	0.01	0.7225
Max. education of adult (primary)	76414	0.191	0.393	0	1	2287	0.272	0.445	0	1
Max. education of adult (middle)	76414	0.354	0.478	0	1	2287	0.333	0.471	0	1
Max. education of adult (>=matriculates)	76414	0.233	0.423	0	1	2287	0.079	0.270	0	1
Land (0.1<=2.5 ha) (default: the landless)	76709	0.519	0.500	0	1	2290	0.597	0.491	0	1
Land (>2.5 ha) (default: the landless)	76709	0.100	0.300	0	1	2290	0.069	0.254	0	1
Whether self-employed in non-agriculture	76654	0.228	0.419	0	1	2289	0.127	0.333	0	1
Whether agricultural labour	76654	0.144	0.351	0	1	2289	0.228	0.419	0	1
Whether non-agricultural labour	76654	0.105	0.307	0	1	2289	0.239	0.427	0	1
Whether self-employed in agriculture	76654	0.352	0.478	0	1	2289	0.377	0.485	0	1
Whether a household belongs to SC	76689	0.155	0.362	0	1	2288	0.362	0.481	0	1

Whether a household belongs to ST	76689	0.173	0.378	0	1	2288	0.201	0.401	0	1
PDS	76709	0.735	0.441	0	1	2290	0.892	0.311	0	1
RPW	76709	0.000	0.000	0	0	2290	1.000	0.000	1	1
Predicted agricultural wage rate for males	74755	60.891	18.226	35.4	123.65	2289	58.012	9.653	35.4	123.65
Food price index	76709	9.691	2.014	6.66	15.691	2290	9.900	2.330	6.660041	14.85233
Poor	76708	0.176	0.381	0	1	2290	0.325	0.468	0	1
Vulnerability measure (based on 100% income poverty line)	76339	0.078	0.241	0	1	2285	0.166	0.334	0	1
Vulnerability measure (based on 80% income poverty line)	76339	0.014	0.101	0	1	2285	0.047	0.190	0	1
Vulnerability measure (based on 120% income poverty line)	76339	0.203	0.370	0	1	2285	0.363	0.436	0	1

Without PDS						With PDS				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Whether a household is headed by a female member	20700	0.101	0.302	0	1	58554	0.110	0.312	0	1
Number of adult female members	20700	1.283	0.819	0	8	58554	1.356	0.799	0	11
Number of adult male members	20700	1.323	0.924	0	10	58554	1.353	0.940	0	12
Proportion of adults in a household	20700	0.570	0.257	0	1	58554	0.550	0.243	0	1
Age of household head	20700	0.447	0.139	0	1	58553	0.467	0.133	0	1.08
Age squared	20700	0.219	0.133	0	1	58553	0.235	0.133	0	1.1664
Max. education of adult (primary)	20486	0.164	0.370	0	1	58469	0.204	0.403	0	1
Max. education of adult (middle)	20486	0.353	0.478	0	1	58469	0.353	0.478	0	1
Max. education of adult (>=matriculates)	20486	0.291	0.454	0	1	58469	0.208	0.406	0	1
Land (0.1<=2.5 ha) (default: the landless)	20700	0.447	0.497	0	1	58554	0.547	0.498	0	1
Land (>2.5 ha) (default: the landless)	20700	0.140	0.347	0	1	58554	0.086	0.280	0	1
Whether self-employed in non-agriculture	20682	0.214	0.410	0	1	58512	0.229	0.420	0	1
Whether agricultural labour	20682	0.111	0.314	0	1	58512	0.158	0.365	0	1

Whether non-agricultural labour	20682	0.093	0.290	0	1	58512	0.115	0.319	0	1
Whether self-employed in agriculture	20682	0.353	0.478	0	1	58512	0.352	0.478	0	1
Whether a household belongs to SC	20696	0.219	0.413	0	1	58536	0.142	0.349	0	1
Whether a household belongs to ST	20696	0.147	0.354	0	1	58536	0.182	0.386	0	1
PDS	20700	0.000	0.000	0	0	58554	1.000	0.000	1	1
RPW	20576	0.012	0.109	0	1	58423	0.035	0.184	0	1
Predicted agricultural wage rate for males	20037	62.310	17.651	35.4	123.65	57261	60.283	18.113	35.4	123.65
Food price index	20700	9.586	2.098	6.66	15.691	58554	9.743	1.999	6.660041	15.69119
Poor	20699	0.126	0.332	0	1	58554	0.199	0.399	0	1
Vulnerability measure (based on 100% income poverty line)	20464	0.063	0.220	0	1	58410	0.086	0.252	0	1
Vulnerability measure (based on 80% income poverty line)	20464	0.011	0.087	0	1	58410	0.017	0.110	0	1
Vulnerability measure (based on 120% income poverty line)	20464	0.155	0.335	0	1	58410	0.226	0.383	0	1

Annex 2: Daily allowances of nutrients for Indians (recommended by the Nutrition Expert Group in 1968)

Group	Particulars	Cals	Proteins (gm.)	Calcium (gm.)	Iron (mg.)	Vitamin A		Thiamine (mg.)	Ribo-flavin (mg.)	Nictonic acid (mg.)	Ascorbic acid (mg.)	Folic acid (μ_g)	Vitamin B12	D
						Retinol (μ_g)	β-carotene (μ_g)							200
Man	Sedentary work	2400	55	0.4 to 0.5	20	750	3000	1.2	1.3	16	50	100	1	200
	Mode rate work	2800	55	0.4 to 0.5	20	750	3000	1.4	1.5	19	50	100	1	200
	Heavy work	3900	55	0.4 to 0.5	20	750	3000	2.0	2.2	26	50	100	1	200
Woman	Sedentary work	1900	45	0.4 to 0.5	30	750	3000	1.0	1.0	13	50	100	1	200
	Mode rate work	2200	45	0.4 to 0.5	30	750	3000	1.1	1.2	15	50	100	1	200
	Heavy work	3000	45	0.4 to 0.5	30	750	3000	1.5	1.7	20	50	100	1	200
	Second half of pregnancy	+300	+10	1.0	40	750	3000	+0.2	+0.2	+2	50	150-300	1.5	200
	Lactation up to one year	+700	+20	1.0	30	1150	4600	+0.4	+0.4	+5	80	150	1.5	200
Infants	0-6 months	120/kg	2.3-1.8/kg		1 mg/kg	400				30				200
	7-12 months	100/kg	1.8-1.5/kg	0.5-0.6		300	1200			30	25	0.2		200
Children	1 year	1200	17	0.4-0.5	15-20	250	1000	0.6	0.7	8	30-50	50--100	0.5-1	200
	2 years	1200	18	0.4-0.5	15-20	250	1000	0.6	0.7	8	30-50	50—100	0.5-1	200
	3 years	1200	20	0.4-0.5	15-20	250	1000	0.6	0.7	8	30-50	50—100	0.5-1	200
	4-6 years	1500	22	04-0.5		300	1200	0.8	0.8	10	30-50	50—100	0.5-1	200

	7-9 years	1800	33	04-0.5		400	1600	0.9	1.0	12	30-50	50—100	0.5-1	200
	10-12 years	2100	41	04-0.5		600	2400	1.0	1.2	14	30-50	50—100	0.5-1	200
Adolescents	13-15 years ,boys	2500	55	0.6-0.7	25	750	3000	1.3	1.4	17	30-50	50--100	0.5-1	200
	13-15 years, girls	2200	50	0.6-0.7	35	750	3000	1.1	1.2	14	30-50	50—100	0.5-1	200
	16-18 years, boys	3000	60	0.5-0.6	25	750	3000	1.5	1.7	21	30-50	50--100	0.5-1	200
	16-18 years, girls	2200	50	0.5-0.6	35	750	3000	1.1	1.2	14	30-50	50--100	0.5-1	200

Source: Gopalan et al. (1971: 27).

Annex 3: Wage equations for male and female workers in rural areas based on NSS data in 1993 and 2004

	1993		2004	
	Male wage Coef. (t value)	Female Wage Coef. (t value)	Male wage Coef. (t value)	Female Wage Coef. (t value)
Land owned	0.349	-0.324	0.00	-0.082
	(0.98)	(4.86)**	(2.39)*	(8.35)**
ST dummy (ST=1, otherwise=0)	-322.569	-1,018.14	-121.41	-108.96
	(0.87)	(4.08)**	(9.13)**	(7.53)**
SC dummy (SC=1, otherwise=0)	-2,177.57	-381.166	-	-
	(7.95)**	(1.89)		
Non-agricultural self employment dummy (non-agricultural self employment=1 otherwise)	7,216.57	2,324.92	1,859.26	566.23
	(10.27)**	(5.49)**	(68.44)**	(21.97)**
Agricultural self employment dummy (agricultural self employment=1 otherwise=0)	7,899.48	5,204.41	2,196.08	880.79
	(15.13)**	(14.37)**	(69.07)**	(22.83)**
Muslim dummy (Muslim=1, otherwise=0)	746.744	185.894	113.494	-330.9
	(1.61)	(0.46)	(5.59)**	(10.79)**
Age	662.822	204.695	139.625	49.933
	(8.65)**	(3.65)**	(37.08)**	(10.15)**
Age^2	-4.072	-1.257	-1.638	-0.637
	(4.17)**	(1.69)	(39.07)**	(10.24)**
Whether is literate, but has not completed primary school	3,542.99	2,126.39	92.081	-205.98
	(12.71)**	(7.36)**	(5.10)**	(8.72)**
Whether mother completed primary school	7,518.66	3,208.70	175.043	-227.04
	(23.01)**	(7.49)**	(9.45)**	(9.53)**
Whether mother completed middle school	14,163.75	10,200.92	360.514	-192.21
	(29.57)**	(8.09)**	(19.49)**	(7.37)**
Whether completed secondary or higher secondary school	35,055.00	38,201.86	810.913	201.04
	(56.87)**	(26.88)**	(33.86)**	(5.63)**
Whether completed higher education	57,151.06	53,253.26	1,473.09	1,004.51
	(47.65)**	**(17.32)****	**(64.15)****	**(20.43)****
Constant	-2,171.00	4,216.78	-2,940.20	-1,749.97
	(1.50)	(4.18)**	(34.97)**	(16.65)**
Observations	33720	15849	67168	59221

Robust z-statistics in parentheses

** significant at 5% level; ** significant at 1% level*

Annex 4: Distributions of propensity scores

Case 1 NSS 50, RPW

RPW		Freq.	Percent	Cum.
	0	65,974	95.33	100
	1	3,232	4.67	4.67
	Total	69,206	100	

Case 1

	Percentiles	Smallest		
1%	0.9343881	0.695964		
5%	0.9420734	0.7824953		
10%	0.9452703	0.8199315	Obs	69206
25%	0.9496597	0.8401137	Sum of wgt.	69206
50%	0.9537689		Mean	0.9532995
		Largest	Std. dev.	0.0067562
75%	0.957319	0.9978209		
90%	0.9608813	0.9984333	Variance	0.0000456
95%	0.9633145	0.9997452	Skewness	-1.717206
99%	0.9677861	0.9998932	Kurtosis	45.64713

Case 2 NSS 50, RPW

PDS		Freq.	Percent	Cum.
	0	51,917	75.02	75.02
	1	17,287	24.98	100
	Total	69,204	100	

Case 2

	Percentiles	Smallest		
1%	0.0688306	9.02E-09		
5%	0.1033367	7.27E-08		
10%	0.1135362	1.51E-06	Obs	69194
25%	0.1487656	3.36E-06	Sum of wgt.	69194
50%	0.2280811		Mean	0.2494196
		Largest	Std. dev.	0.1237115
75%	0.3274996	0.666051		
90%	0.4201916	0.6677483	Variance	0.0153045
95%	0.5159592	0.6677483	Skewness	0.8970378
99%	0.5957185	0.6694421	Kurtosis	3.352018

Case 3 NSS 61, RPW

FFW	work	Freq.	Percent	Cum.
	0	76,709	97.1	97.1
	1	2,290	2.9	100
	Total	78,999	100	

Case 3

	Percentiles	Smallest		
1%	0.0127803	0.0110351		
5%	0.0183658	0.0110357		
10%	0.0218692	0.011036	Obs	76935
25%	0.0261054	0.0110371	Sum of wgt.	76935
50%	0.03031		Mean	0.0297765

Case 4 NSS 61, PDS

PDS	Freq.	Percent	Cum.
0	58,554	73.88	100
1	20,700	26.12	26.12
Total	79,254	100	

		Largest	Std. dev.	0.0061051
75%	0.0341994	0.0475447		
90%	0.0370002	0.0475723	Variance	0.0000373
95%	0.0384776	0.0475776	Skewness	-0.5237902
99%	0.041977	0.0476086	Kurtosis	3.257123

Case 4

	Percentiles	Smallest		
1%	0.6507831	0.3185633		
5%	0.6816596	0.6100912		
10%	0.6959432	0.6124564	Obs	79253
25%	0.7159724	0.6126622	Sum of wgt.	79253
50%	0.7373254		Mean	0.7387706
		Largest	Std. dev.	0.0355197
75%	0.7613883	0.8623071		
90%	0.7859754	0.8624616	Variance	0.0012617
95%	0.799535	0.8629799	Skewness	0.0085923
99%	0.8221764	0.8725297	Kurtosis	3.381942

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