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SUBJECT II
POST-HARVESTING REQUIREMENTS FOR REDUCING THE GAP
BETWEEN WHAT CONSUMERS PAY AND FARMERS RECEIVE

**Inclusiveness, Technology and Profitability in Supermarkets:
SUR Model Results from Semi-Arid Region**

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ABSTRACT

Enhancing productivity is not a sufficient condition to raise the farmers' income and enabling higher share of consumers' price through 'disintermediation' holds the key to this. This latter task needs ways and means to obviate market failures in developing countries perpetrated by missing markets, infrastructural bottlenecks and limitations of the state. Rapidly progressing agri-food system transformation across these countries presents solutions to some of these problems. Diffusion of supermarkets took off in the first few years of the new millennium and they have been procuring directly from the farming community through collection centres. Evidence shows that this can improve technology adoption and profitability, though concerns of exclusion remain. This paper analyses vegetable growers' farm household data from semi-arid region in South India for inclusiveness, technology adoption and profitability using Probit model in the first stage and seemingly unrelated regression in the second stage. Besides ordinary least squares, Tobit model is used as a robustness check to find out determinants where the share of produce sold to the new market channels is used as dependent variable. The results indicate inclusiveness of these value chains subject to the possession of irrigation resources. The participation resulted in higher adoption of new technologies in inputs and also higher income. These findings need to be cautiously interpreted as this paper uses data from the initial years of supermarket procurement in a particular agro-climatic zone and lacks a panel data approach.

Keywords: Supermarkets, Diffusion of technology, Probit model, Inclusiveness.

JEL: Q12, Q13, Q16.

I

INTRODUCTION

Reducing price spread between producer and consumer is one of the best ways of increasing farm income in the current milieu of agricultural marketing in the country. Enhancing productivity has its limitations and is not a sufficient condition for raising farm incomes (Narayanamoorthy, 2017; Narayanamoorthy *et al.*, 2017). Raising productivity can likely depress prices in the face of all-round spikes leading to higher overall production at the national level. On the other hand, reducing marketing costs by means of reducing the transaction costs can leave better share of consumer rupee with the farmer-producer. The central government, quite understandably, expects to double farmers' income in ten years with a lions' share of contribution from better

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price realisation to the tune of 13 per cent based on the experience of Karnataka (Chand, 2017a).

The price realised by farmers increased the highest in recent history during 2004-05 to 2011-12 to a tune of 0.78 per cent per annum, leading to better incomes to farming community (Chand, 2017b). The poverty reduction during this period progressed at an unprecedented 2.2 per cent per annum and agricultural income growth has contributed significantly to this (Dev, 2016). However, this growth in income through price realisation has experienced a downside in terms of higher price inflation. Balancing interests of the producers and consumers by way of remunerative prices and cheap food respectively can be achieved through productivity rise and reducing the chain of intermediaries (Rao, 1994). While the Green Revolution made the first one possible with simultaneous reduction in food prices, the latter is yet to happen in India. This latter route is also important because this price spread between producer and consumer is a “black box” composed of wholesale, processor, and retail segments and this “black box” comprises roughly one-third of the total consumer price (Reardon and Gulati, 2008). It is important to note that the overall prices will be lower in both the above means, while at the same time making the farmers better off. The recent policy focus on politically sensitive agricultural marketing reforms is justified from the above concerns in the differential impacts of disparate pathways for better price realisation for farm produce.

The recent paradigm on farm decision making moved beyond neoclassical assumptions about perfect and complete markets, absence of transaction costs and full information available to all participants (Williamson, 1985; de Janvry *et al.*, 1991; Binswanger *et al.*, 1993; Timmer, 1997; McIntire, 2017). Economists have been discussing in the past two decades on the ways and means to obviate these imperfections in terms of missing markets, transaction costs and information asymmetry that stifle developing country agriculture. Important here is to accentuate the fact that farmers are concerned *only* about what they receive after accounting for the transaction costs. Modern value chains represent an opportunity for the smallholders in developing countries to overcome market failures and reduce transaction costs. Besides, they act as a hedge against risks and encourage the farmers to upgrade technology and take decisions in line with economic logic in the specific agro-economic and policy milieu (Barrett *et al.*, 2012).

There has been a ‘silent revolution’ in food value chains in India with rapid rise of the supermarkets as a part of third wave of ‘supermarket revolution in developing countries (Reardon *et al.*, 2012). Recent IBEF report reveals that the country has 8500 supermarket stores in 2016, apart from 112 cash and carry stores. The sector has also been witnessing consolidation with the Future group acquiring Bharti’s Easy Day, Heritage, Sangam Direct, Nilgris, Big Apple, Hypercity and multinational chains like Alibaba and Amazon acquiring stakes in Big Basket, Flipkart. The recent liberalisation of food trade has opened the gates for foreign investors with the likes of Amazon and others firming up plans for investment. Many of the online retailers like

Big Basket, Flipkart, Amazon, Ninjakart have also opened collection centres and have been procuring from farmers. It is expected that these modern chains will grow and become significant players in agriculture and the resulting ‘disintermediation’ through cutting the length of value chain might have positive impact on farmers’ incomes.

Therefore, the rise of organised retailing (supermarkets) is viewed with optimism, for the defining feature of supermarkets is direct procurement from farmers without intermediaries. It is expected that they enable better prices to the farmers and at the same time improve the value chains through back-end investments in storage, warehousing, transport and related services (Joseph *et al.*, 2008; Reardon and Gulati, 2008). It is shown in some studies that a 1 per cent increase in supermarket participation can lead to 0.38 per cent increase in farmers’ income and a total increase of 23 per cent in income (Rao *et al.*, 2017). Rigorous study of literature show higher returns through selling to supermarkets with few exceptions and exclusion of resource poor farmers with few exceptions (Rao *et al.*, 2016; Singh, 2012). Therefore, both these are empirical questions needing dispassionate research for policy guide.

Against this background, this paper analyses household data from 253 vegetable growers¹ in Telangana to find out inclusiveness of supermarket procurement systems for resource poor farmers with small size of holdings and then goes on to examine their impacts on technology adoption and profitability. These sample households sold their vegetables to supermarkets like Reliance Fresh, More, Heritage Fresh and others in Hyderabad and consisted of both supermarket farmers and conventional market sellers in almost equal numbers. The novelty of this study is in bringing evidence from household data as well as to use advanced econometric model that gives efficient estimates by considering correlation between error terms of different equations.

II

METHODOLOGY

In the first stage of econometric exercise, Probit model is used to examine various factors that influence the decision of farmers to participate in the supermarket driven market channel. The dependent variable in this case falls in the dichotomous variable category and the kind of regression that can accommodate this variable is either the probit or the logit model. However, since the idea is to use predicted value of the dependent variable subsequently in finding out the impacts on technology through technology matrix, we preferred probit model, which is based on standard normal cumulative distribution function, as specified below.

$$E(SM_{it}) = Pr(SM_{it} = 1) = \Phi(x_{it} \gamma) \quad \dots(1)$$

where SM is a dummy indicator denoting that respondent farmer i participated in the purchases of supermarket collection centre in period t . It takes the value of ‘1’ in case

of participation or '0' otherwise. $\Phi(\cdot)$ is the standard normal cumulative distribution function, and γ is a vector of coefficients. In equation 1, x is a vector of 9 variables that account for household characteristics, farm related characteristics, physical capital and social capital.

To take care of heteroscedasticity of the disturbance term and to see that the predicted value lies within the range of 1 and 0, the discrete dependent variable model is cast in the form of index function model as below, assuming that for each individual farmer Z_t^* represents the critical cut-off value which translated the underlying strength of inclination of the farmer 'i' for participating in supermarket led marketing channel into a participation decision:

$$Z_t^* = \gamma_1 + \gamma_2 x_{2t} + \dots \gamma_{22} x_{22t} + \varepsilon_t \quad \dots(2)$$

$$\text{where } Z_t = 1 \text{ if } Z_t > Z_t^* \quad \dots(2a)$$

$$Z_t = 0 \text{ if } Z_t \leq Z_t^* \quad \dots(2b)$$

We assume that ε_t has a normal distribution with mean zero and variance one and the model is estimated by maximum likelihood method. It is also assumed that Z_t^* is a normally distributed random variable so that the probability that Z_t^* is less than (or equal to) Z_i can be computed from the cumulative normal distribution function. The cumulative normal function assigns to a number Z the probability that any arbitrary Z_t^* will be less than or equal to Z . The standardised cumulative normal distribution function is written as:

$$P_i = F(Z_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Z_i} e^{-s^2/2} ds \quad \dots(3)$$

Where s is a random variable that is normally distributed with mean zero and unit variance. By construction, the variable P_i will lie in the (0,1) interval. P_i represents the probability of an event's occurring, in this case the probability of participation in supermarket led marketing channel. Since this probability is measured by the area under the standard normal curve from $-\infty$ to Z_i , the event will be more likely to occur the larger the value of Z_i .

The inverse of the cumulative normal distribution function in equation (3) is applied to get the estimate of the index Z_i :

$$Z_i = F^{-1}(P_i) = \alpha + \beta X_i \quad \dots(4)$$

The P_i in the probit model is in fact an estimate of the conditional probability that an individual will participate in the supermarket led channel, given that the presence or absence of the 19 variables taken in the equation.

Tobit Model Equation: The field data revealed wide variations in the per cent share of produce sold to the modern retail chains by individual farmers. In such a situation, considering participation dummy as a dependent variable cannot always give the real picture. Therefore, the per cent share of produce sold to supermarkets is also used as dependent variable and determinants are worked out by Tobit model.

The censored regression applications of Tobit model are used because there is a variable with quantitative meaning, y^* and we are interested in the population regression $E(y^*)$. If y^* were observed for everyone in the population, we could use OLS etc. However, a data problem arises in that y^* is censored from above and/or below, i.e., it is not observed for some part of the population. The function is estimated using left censored Tobit model, with lower limit at 0, as large number of observations indicating share of produce sold by farmer households to supermarket are concentrated at 0.

The structural equation in the Tobit model is:

$$y_i^* = X_i\beta + \varepsilon_i \quad \dots(5)$$

where $\varepsilon_i \sim N(0, \sigma^2)$. y^* is a latent variable that is observed for values greater than τ and censored otherwise. The observed y is defined by the following measurement equation:

$$y_i = \begin{cases} y^* & \text{if } y^* > \tau \\ T_y & \text{if } y^* \leq \tau \end{cases} \quad \dots(6)$$

In the typical Tobit model, we assume that $\tau = 0$, i.e., the data are censored at 0. Thus, we have

$$y_i = \begin{cases} y^* & \text{if } y^* > 0 \\ 0 & \text{if } y^* \leq 0 \end{cases} \quad \dots(7)$$

where L denotes likelihood of selling to supermarket.

Second Stage of Estimation: In the second stage of econometric exercise, the impact of participation in supermarket led marketing channel on technology adoption is examined by taking higher spending on key agricultural inputs as proxies, apart from using net margin for assessing income gains. For this, the data are analysed. And a matrix of dependent and independent variables is worked out by using the seemingly unrelated regression (SUR) to examine the various factors that may influence the technology adoption and income earnings. The predicted value of the probability of market participation by a farmer (Z_i^*) from the probit equation above is taken as one of the explanatory variables in all the nine equations.

The above matrix is a system of equations where the dependent variables are expenditures on critical inputs in the cultivation of vegetable crops of sample farmers and net margin from vegetable cultivation to farmers. All the equations have nine independent variables representing transaction costs, human capital, physical capital and social capital. The estimation of all these equations can be done individually by using ordinary least squares (OLS) method directly. However, there can be problem of not using all the information in the system of equations and that can also neglect

any correlation between error terms across different equations. The issue of correlation between disturbance terms can also arise if there are some omitted variables that are common to all equations (Maddala, 1977).

In this kind of situation, it is imperative that the analytical tool has to be selected in such a way as to take care of this particular problem. Therefore, we have chosen Seemingly Unrelated Regression (SUR) as proposed by Zellner (1962), in which the computation is done as a single equation using generalised least squares and hence the results can be asymptotically more efficient than ordinary least squares. Alternatively, analyses are carried out using OLS with robust standard errors to see if any of those methods could have been more appropriate than using SUR. Theoretically, applying SUR can be justified if the correlation between the error terms across equation is high and the efficiency gains with SUR are directly proportional to this correlation. Contrarily, as the correlation (σ_{ij}) is nearing zero, the estimates in SUR done with generalised least squares become inefficient with higher standard errors than those obtained through OLS (Johnston, 1972).

Suppose that y_{it} is a dependent variable, with k_i — vector of explanatory variables for observational unit i , and u_{it} is an unobservable error term, where the double index 'it' denotes the t-th observation (253 in the present study) of the i-th equation in the system. The classical linear SUR for the proposed technology matrix is set-up as a system of linear regressions.

let $Y_i = [y_{1t}, \dots, y_{9t}]'$, $\tilde{X} = \text{diag}(x_{1t}, x_{2t}, \dots, x_{9t})$, a block-diagonal matrix with x_{1t}, \dots, x_{9t} on its diagonal, $U_i = [u_{1t}, \dots, u_{9t}]'$, and $\beta = [\beta'_1, \dots, \beta'_9]'$. From this, it can be written as

$$Y_i = X_i \beta_i + u_i \quad i = 1, 2, \dots, 9 \quad \dots(8)$$

It can be represented in matrix form as below:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \dots \\ Y_9 \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \dots & 0 \\ 0 & X_2 & \dots & 0 \\ \dots & \dots & \dots & \dots \\ 0 & 0 & \dots & X_9 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \dots \\ \beta_9 \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ \dots \\ u_9 \end{bmatrix} \quad \dots(9)$$

where $Y = 9n \times 1$ matrix

$$X = 9n \times \left(\sum_{i=1}^9 k_i \right) \text{ matrix}$$

$$\beta = \left(\sum_{i=1}^9 k_i \right) \times 1 \text{ matrix}$$

$$u = 9n \times 1 \text{ matrix}$$

As a robustness check, percent share of produce sold to supermarkets is also used as an independent variable in the SUR model.

III

BASIC CHARACTERISTICS OF PARTICIPANTS AND INCLUSIVENESS
OF SUPERMARKET PROCUREMENT

Descriptive statistics reveal the sellers to supermarket collection centres, vis-à-vis traditional market farmers, to be younger, better educated, possess larger land under high value crops, better irrigation facilities, farmer asset endowment, lower participation in off-farm employment and larger number of friends and relatives in supermarket network (Table 1). These variables were used to find out the determinants of participation in the procurement systems of modern retail chains and presented in Table 2.

TABLE 1. COMPARISON OF SUPERMARKET AND TRADITIONAL MARKET FARMERS

Characteristics (1)	Supermarket farmers		Traditional market farmers	
	Mean (2)	S.D. (3)	Mean (4)	S.D. (5)
Age of head of household (hhh) (years)	44.74*	10.82	47.15	11.23
Education of hhh (years of schooling)	3.5***	2.45	2.57	2.25
Total high value land (acres)	3.66***	2.51	2.92	1.80
Family size (persons)	4.73	1.66	4.83	1.65
Share of irrigated plot lagged at 5 years (per cent)	86.32*	32.92	78.32	39.43
Off farm participation (lagged at 5 years ago, 1=participation, 0 otherwise)	0.36**	0.48	0.51	0.50
Supermarket network, lagged at 5 years ago (persons)	0.68***	1.38	0.03	0.22
Total livestock now (Rs.)	43859	90445	40596	51553
Total farm equipment (Rs.)	76984**	110580	51525	66895

*** p<0.01, ** p<0.05, * p<0.1

Source: Field surveys.

These estimates in Table 2 show that having friends and relatives in supermarket network plays a major role in driving farmers to sell to the modern retailers followed by share of high value crops in total land, education of head of household and irrigation facility. The tobit estimates are given in fourth and fifth columns of Table 2. These estimates also corroborate the above results, except that high value land does not significantly influence farmer's participation in modern chains. Non-significance of high value land in tobit land can be understood from the fact that the procurement of supermarket, both in terms of quality and quantity, is low. In such a situation, once a threshold of minimum high value land is met (as indicated by significance of the variable in probit model), the share of how much will the farmer sell to supermarket does not depend so much on land ownership as it depends on access to irrigation which ensure his capacity to supply the produce to supermarket regularly. Mangala and Chengappa (2008) and Chengappa *et al.*, (2016) from their analysis in Karnataka also found that area under high value crops determines

participation, rather than the extent of owned land. Exclusion on the basis of land was reported in Guatemala and Mexico and Kenya (Berdegue *et al.*, 2005; Reardon *et al.*, 2009; Rao and Qaim, 2011), these chains were found to be inclusive in China, Nicaragua and Indonesia subject to possession of non-land assets (Maertens and Swinnen, 2009; Miyata *et al.*, 2009; Wang *et al.*, 2009; Bellemare, 2012). It was found that having irrigation facilities played crucial role in some of the other studies (Balsevich, 2005; Hernandez *et al.*, 2007; Neven *et al.*, 2009; Rao *et al.*, 2017).

TABLE 2. PROBIT ESTIMATES OF DETERMINANTS OF SUPERMARKET PARTICIPATION

Independent Variables	Probit model (Dep.variable: Dummy for SM participation (Yes=1))		Tobit model (Dep.variable: Share of produce sold to Supermarket)	
	Coefficient	Stand. Error	Coefficient	Stand. Error
1	2	3	4	5
Age of head of hh (years)	-0.007	0.009	0.111	0.204
Education of head of hh (years)	0.095**	0.042	1.842*	0.958
Family size (Persons)	-0.030	0.053	-1.049	1.284
Share of irrigated plot, lagged at 5 years	0.005**	0.002	0.144**	0.060
Total high value land (acres)	0.098**	0.047	1.014	0.908
Farm equipment values lagged at 5 yrs.	0.001	0.002	-0.013	0.063
Total livestock values lagged at 5 years	-0.002	0.002	-0.051	0.052
Off farm participation, lagged at 5years ago, 1=participation, 0 otherwise	-0.157	0.182	-1.015	4.332
Supermarket network, lagged at 5 years	0.956***	0.266	9.801***	2.110
Constant	-0.394	0.577	-14.717	13.999
Observations	253		253	
Pseudo R ²	0.1554		0.022	
Sigma	-		29.64	1.89
Log likelihood	144.853		-783.46	
LR chi2	53.29		34.57	
Prob>chi2	0.0000		0.0001	

Source: Field surveys.

IV

IMPACT OF PARTICIPATION ON NET INCOME AND TECHNOLOGY ADOPTION

The second stage of the econometric model, as explained in detail above uses the predicted value of supermarket participation as an independent variable to find out the impact in seemingly unrelated regression (SUR) model. As observed above, there are significant variations in the characteristics of the farmers selling to supermarkets and traditional markets that might influence their participation and therefore the adoption of technologies and net income has been analysed through SUR taking care of the correlation of the error terms. The results are presented in Table 3. Before we examine the findings, it is crucial to know if the application of this model is warranted. This can be done by looking at the standard errors of the equations in SUR model and comparing them with standard errors of the same equations when estimated with ordinary least squares. Therefore, the OLS estimates are presented in Appendix 1 for comparison and a glance through Table 3 and Appendix 1 clearly

TABLE 3. RESULTS OF SEEMINGLY UNRELATED REGRESSION (SUR) EQUATIONS WITH EXPENDITURE OF DIFFERENT INPUTS AND NET MARGIN PER ACRE AS DEPENDENT VARIABLE

Variables (1)	Seeds (2)	Fertilisers (3)	Chemicals (4)	Organic manures (5)	Micro- nutrients (6)	Labour (7)	Irrigation (8)	Machinery (9)	Net margin (10)
Age of head of hh (Years)	6.431 (6.737)	4.649 (4.942)	3.555 (3.838)	0.074 (3.815)	0.859 (0.627)	10.415 (6.681)	2.206 (1.746)	2.683 (2.833)	-91.541 (389.499)
Education of head of hh (Years)	29.640 (34.000)	42.780** (24.943)	-26.128 (19.372)	-4.622 (19.252)	0.389 (3.163)	-20.060 (33.717)	-2.389 (8.813)	10.744 (14.298)	-3,825.585* (1,965.800)
Family size (Persons)	-12.386 (41.715)	-2.528 (30.603)	10.990 (23.768)	-19.008 (23.620)	-4.551 (3.881)	-55.767 (41.367)	-11.307 (10.813)	-20.089 (17.543)	-636.282 (2,411.852)
Share of irrigated plot, lagged at 5 years ago (per cent)	4.434*** (1.995)	1.669 (1.464)	-0.431 (1.137)	3.031*** (1.130)	-0.311* (0.186)	4.382*** (1.979)	1.960*** (0.517)	2.833*** (0.839)	38.576 (115.364)
Total high value land (acres)	-82.839*** (34.084)	-115.569*** (25.005)	-61.799*** (19.420)	26.987 (19.300)	-4.721 (3.171)	-114.835*** (33.800)	-40.896*** (8.835)	-24.227* (14.334)	-4,049.045*** (1,970.659)
Total farm equipment values (‘000 Rs.), lagged at 5 years ago	6.129*** (1.966)	2.680** (1.442)	3.829*** (1.120)	0.310 (1.113)	0.305* (0.183)	3.790** (1.950)	0.004 (0.510)	0.444 (0.827)	-12.743 (113.664)
Total livestock values (‘000 Rs.), lagged at 5 years ago	0.183 (1.724)	0.441 (1.265)	1.054 (0.982)	0.218 (0.976)	0.363*** (0.160)	-1.860 (1.709)	-0.011 (0.447)	-0.213 (0.725)	-18.315 (99.658)
Dummy for off farm participation, lagged at 5 years ago, 1=participation, 0 otherwise	288.203*** (147.001)	233.848*** (107.843)	190.196*** (83.757)	2.668 (83.237)	6.502 (13.677)	68.301 (145.776)	51.339 (38.104)	9.223 (61.820)	22,069.735*** (8,499.276)
Predicted value of supermarket participation (1st stage probit reg)	194.644 (455.534)	92.513 (334.191)	599.339*** (259.552)	-589.688*** (257.941)	126.338*** (42.384)	691.782 (451.740)	128.680 (118.078)	-151.111 (191.572)	87,032.768*** (26,338.037)
Constant	1,003.152*** (495.788)	1,448.124*** (363.723)	666.796*** (282.488)	727.994*** (280.734)	-42.590 (46.129)	2,362.429*** (491.659)	254.478** (128.513)	871.220*** (208.501)	-1,546.906 (28,665.433)
Observations	253	253	253	253	253	253	253	253	253
R-squared	0.089	0.117	0.097	0.052	0.082	0.103	0.155	0.068	0.074

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Calculated by the authors from field surveys.

demonstrate the superiority of results from SUR model with consistently lower standard errors.

The variable of interest in this matrix is the predicted value of supermarket participation (10th row in Table 3) with respect to net income and various technology indicators. This coefficient was positively significant for net income, micronutrients and chemical use and negatively significant for organic manures. These imply that participation in supermarket procurement system increases the net incomes of farmers. Participation in these modern chains also seems to have influenced in adopting better technology in terms of micronutrients for crop growth and chemical for plant protection. It is well documented that pests and diseases are not effectively controlled in tropical agriculture and therefore efficient agriculture methods will increase plant protection expenditure (Rao, 2013). The determinants of chemical use in Table 3 also indicate that availability of higher resources as a result of non-farm employment increased chemical use, while higher area under vegetable crops in fact drove down their use indicating a pull factor. On the other hand, availability of organic manures for sustainable intensification methods of agriculture is a problem in the study area and the negatively significant coefficient for organic manures may be understood in this background. Apart from major nutrients represented nitrogen, phosphorous and potassium, micronutrients like zinc, iron and others play a crucial role in promoting crop growth and yielding higher outputs. It is because better quality products demanded by supermarket has propelled them to use those more than what traditional market farmers' use. There are also other interesting findings from the SUR model. Engaging households in non-farm employment increased net income from vegetable farming as revealed by positively significant coefficient in the last column. The coefficient for land is negatively significant indicating the limits of supervision and other inputs in handling intensive cultivation of vegetables which requires lot of effort in cultivation, plant protection and also the staggered harvesting.

The results in the two-stage estimation process, though a rigorous exercise, would need robustness checks to validate and confirm them. Therefore, another SUR model was run with the same variables except the independent variable of interest, viz., supermarket participation. Dummy for supermarket participation was used in Table 3 for this purpose. However, the extent of participation varies and therefore the share of produce sold to modern retail chains is used and the results are presented in Table 4. All the equations in the SUR model are estimated using ordinary least squares separately (Appendix A2) and comparison of standard errors in both tables show that SUR model is more efficient and justified in its use. Looking at the coefficients in Table 4, the significant and positive coefficient for net margin in the last column for the share of produce sold indicates that a 1 per cent increase in share of produce sold to modern retail chains increases income by Rs.559/-. Apart from net income, higher share of produce sold to supermarkets also increase adoption of technologies in inputs and higher employment of hired labour. These results corroborate those in the two-step econometric model in Table 3.

TABLE 4. RESULTS OF SEEMINGLY UNRELATED REGRESSION (SUR) EQUATIONS WITH EXPENDITURE OF DIFFERENT INPUTS AND NET MARGIN PER ACRE AS DEPENDENT VARIABLE

Variables (1)	Seeds (2)	Fertilisers (3)	Chemicals (4)	Organic manures (5)	Micro- nutrients (6)	Labour (7)	Irrigation (8)	Machinery (9)	Net margin (10)
Age of head of Hh (years)	4.457 (6.472)	3.376 (4.757)	1.545 (3.798)	1.528 (3.799)	0.455 (0.624)	6.899 (6.382)	1.625 (1.708)	2.926 (2.792)	-389.351 (385.675)
Education of head of hh (years)	23.750 (30.989)	37.422 (22.778)	-13.141 (18.183)	-21.414 (18.187)	3.273 (2.989)	-14.221 (30.557)	-0.743 (8.176)	5.450 (13.370)	-1,984.942 (1,846.584)
Family size (Persons)	-6.978 (40.562)	1.600 (29.814)	8.696 (23.800)	-14.307 (23.806)	-5.124 (3.912)	-52.845 (39.997)	-11.105 (10.701)	-18.281 (17.500)	-941.951 (2,417.033)
Share of irrigated plot, lagged at 5 years ago (per cent)	3.890*** (1.845)	1.221 (1.356)	0.204 (1.082)	2.108** (1.083)	-0.166 (0.178)	4.436*** (1.819)	2.012*** (0.487)	2.523*** (0.796)	127.397 (109.916)
Total high value land (acres)	-82.109*** (29.759)	-116.542*** (21.874)	-43.507*** (17.461)	6.920 (17.465)	-0.790 (2.870)	-98.439*** (29.344)	-37.558*** (7.851)	-29.880*** (12.839)	-1,416.038 (1,773.288)
Total farm equipment values ('000 Rs.), lagged at 5 years ago	6.200*** (1.914)	2.722** (1.407)	3.938*** (1.123)	0.217 (1.123)	0.327** (0.185)	3.948*** (1.888)	0.032 (0.505)	0.424 (0.826)	3.265 (114.068)
Total livestock value ('000 Rs.), lagged at 5 years ago	0.386 (1.654)	0.614 (1.216)	0.743 (0.971)	0.644 (0.971)	0.293* (0.160)	-1.944 (1.631)	-0.044 (0.436)	-0.074 (0.714)	-62.137 (98.567)
Dummy for off farm participation, lagged at 5 years ago, 1=participation, 0 otherwise	278.392*** (136.870)	231.181*** (100.604)	135.697** (80.310)	59.422 (80.329)	-5.101 (13.201)	12.537 (134.964)	40.529 (36.110)	24.540 (59.050)	14,190.982** (8,155.943)
Share of produce sold to supermarket	11.752*** (3.180)	8.272*** (2.337)	3.519* (1.866)	0.751 (1.866)	0.589* (0.307)	13.666*** (3.135)	1.954*** (0.839)	1.232 (1.372)	558.548*** (189.475)
Constant	1,038.690*** (433.580)	1,451.727*** (318.697)	937.838*** (254.408)	440.472** (254.467)	15.303 (41.818)	2,627.761*** (427.543)	306.742*** (114.391)	792.395*** (187.062)	37,577.455 (25,836.655)
Observations	253	253	253	253	253	253	253	253	253
R-squared	0.135	0.159	0.090	0.033	0.063	0.158	0.169	0.069	0.066

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysed by the authors using data from field surveys.

V

CONCLUDING OBSERVATIONS

Politically sensitive reforms in agricultural marketing have come to the centrestage of policy making in the country in the context of the avowed objective of 'doubling farmers' income'. The government has the option of unleashing market forces to increase competition and efficiency, apart from strengthening marketing infrastructure. The broader context of global developments in value chains and demand-driven value chains has its manifestations in India too with the emergence of newer marketing channels. They have been in existence for the last decade and gradually progressing and the phase of initial apprehensions have by and large subsided, though empirical research on their diffusion and impacts is yet to emerge.

The present study attempted to analyse field data from farm households in semi-arid region using a two-step estimation procedure harnessing seemingly unrelated regression equations (SUR) model. The results indicate inclusiveness of the small farmers subject to the possession of irrigation resources. It fits into the arguments on Green Revolution that they are scale neutral but not resource neutral.² The farmers' participation in selling to procurement of supermarkets like Reliance Fresh, More and Heritage Fresh resulted in both higher net income and adoption of new technologies in inputs. The results of this study have to be interpreted keeping in view of some its limitations. First, this study is undertaken in the initial years of supermarket procurement system evolution and farmers' participation in a single agro-climatic region. Second, medium term panels are needed to authentically conclude on the impacts of the modern chains, duly controlling for endogeneity (Barrett *et al.*, 2012; Andersson *et al.*, 2015). Pan-India generalisations need studies that can capture the agro-climatic and socio-economic diversity and the arising complexities in specific settings. Future research may focus on research on these issues with due consideration to overcome these shortcomings.

NOTES

1. Small famers take to diversification into high value crops in general and cultivation of fruits and vegetables in particular in the country (Birthal *et al.*, 2013).
2. Rao and Dev (2009) discussed this in more detail.

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APPENDIX 1. RESULT OF OLS REGRESSION OF EXPENDITURE ON DIFFERENT INPUTS AND NET MARGIN PER ACRE AS DEPENDENT VARIABLE

Independent Variables	Seeds	Fertilizers	Chemicals	Organic manures	Micro-nutrients	Labour	Irrigation	Machinery	Net margin
1	2	3	4	5	(6)	(7)	(8)	(9)	(10)
Age of head of hh (Years)	6.431 (6.874)	4.649 (5.043)	3.872 (3.930)	0.074 (3.892)	0.839 (0.640)	10.415 (6.817)	2.206 (1.782)	2.683 (2.891)	-83.214 (396.383)
Education of head of hh (Years)	29.640 (34.692)	42.780** (25.451)	-24.133 (19.823)	-4.622 (19.644)	0.389 (3.228)	-20.060 (34.403)	-2.389 (8.993)	10.744 (14.590)	-3,773.086** (1,999.387)
Family size (Persons)	-12.386 (42.564)	-2.528 (31.226)	12.417 (24.346)	-19.008 (24.102)	-4.551 (3.960)	-55.767 (42.210)	-11.307 (11.033)	-20.089 (17.900)	-598.737 (2,455.667)
Share of irrigated plot, lagged at 5 years ago (in per cent)	4.434** (2.036)	1.669 (1.494)	-0.501 (1.164)	3.031*** (1.153)	-0.311 (0.189)	4.382*** (2.019)	1.960*** (0.528)	2.833*** (0.856)	36.720 (117.455)
Total high value land (in acres)	-82.839*** (34.778)	-115.569*** (25.514)	-60.230*** (19.884)	26.987 (19.693)	-4.721 (3.236)	-114.835*** (34.488)	-40.896*** (9.015)	-24.227** (14.626)	-4,007.763*** (2,005.571)
Total farm equipment values (in 000 Rs), lagged at 5 years ago	6.129*** (2.006)	2.680** (1.472)	3.863*** (1.148)	0.310 (1.136)	0.305 (0.187)	3.790** (1.989)	0.004 (0.520)	0.444 (0.844)	-11.837 (115.776)
Total livestock values (in 000 Rs), lagged at 5 years ago	0.183 (1.759)	0.441 (1.290)	1.121 (1.006)	0.218 (0.996)	0.363*** (0.164)	-1.860 (1.744)	-0.011 (0.456)	-0.213 (0.740)	-16.556 (101.453)
Dummy for off farm participation, lagged at 5 years ago, 1= participation, 0 otherwise	288.203** (149.995)	233.848*** (110.040)	203.463*** (85.516)	2.668 (84.933)	6.502 (13.956)	68.301 (148.746)	51.339 (38.880)	9.223 (63.079)	22,418.900*** (8,625.447)
supermarket network, lagged at 5 years	-	-	-	-	-	-	-	-	-
Predicted value of supermarket participation (column 1)	194.644 (464.813)	92.513 (340.998)	619.595*** (265.770)	-589.688*** (263.195)	126.338*** (43.247)	691.782 (460.942)	128.680 (120.484)	-151.111 (195.474)	87,565.834*** (26,806.399)
Constant	1,003.152*** (505.887)	1,448.124*** (371.131)	614.909*** (288.039)	727.994*** (286.452)	-42.590 (47.068)	2,362.429*** (501.673)	254.478** (131.130)	871.220*** (212.748)	-2,912.382 (29,052.583)
Observations	253	253	253	253	253	253	253	253	253
R-squared	0.089	0.117	0.097	0.052	0.082	0.103	0.155	0.068	0.074

Source: Analysed by the authors using data from field surveys.

APPENDIX 2. RESULT OF OLS REGRESSION OF EXPENDITURE OF DIFFERENT INPUTS AND NET MARGIN PER ACRE AS DEPENDENT VARIABLES

Independent variables	Seed	Fertilizer	Chemical	Organic	Micro-nutrient	Labour	Irrigation	Machine rent	Net margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Age of head of hh (Years)	4.457 (6.604)	3.376 (4.854)	1.545 (3.875)	1.528 (3.876)	0.455 (0.637)	6.899 (6.512)	1.625 (1.742)	2.926 (2.849)	-389.351 (393.530)
Education of head of hh (Years)	23.750 (31.620)	37.422 (23.242)	-13.141 (18.553)	-21.414 (18.558)	3.273 (3.050)	-14.221 (31.180)	-0.743 (8.342)	5.450 (13.642)	-1,984.942 (1,884.196)
Family size (Persons)	-6.978 (41.388)	1.600 (30.422)	8.696 (24.285)	-14.307 (24.290)	-5.124 (3.992)	-52.845 (40.812)	-11.105 (10.919)	-18.281 (17.856)	-941.951 (2,466.265)
Share of irrigated plot, lagged at 5 years ago (in per cent)	3.890*** (1.882)	1.221 (1.383)	0.204 (1.104)	2.108** (1.105)	-0.166 (0.182)	4.436*** (1.856)	2.012**** (0.497)	2.523**** (0.812)	127.397 (112.155)
Total high value land (in acres)	-82.109**** (30.365)	-116.542**** (22.319)	-43.507*** (17.817)	6.920 (17.821)	-0.790 (2.929)	-98.439**** (29.942)	-37.558**** (8.011)	-29.880*** (13.100)	-1,416.038 (1,809.407)
Total farm equipment values (in 000 Rs), lagged at 5 years ago	6.200**** (1.953)	2.722** (1.436)	3.938**** (1.146)	0.217 (1.146)	0.327** (0.188)	3.948*** (1.926)	0.032 (0.515)	0.424 (0.843)	3.265 (116.392)
Total livestock values (in 000 Rs), lagged at 5 years ago	0.386 (1.688)	0.614 (1.241)	0.743 (0.990)	0.644 (0.991)	0.293** (0.163)	-1.944 (1.664)	-0.044 (0.445)	-0.074 (0.728)	-62.137 (100.574)
Dummy for off farm participation, lagged at 5 years ago, 1= participation, 0 otherwise	278.392*** (139.658)	231.181*** (102.653)	135.697** (81.946)	59.422 (81.965)	-5.101 (13.470)	12.537 (137.713)	40.529 (36.846)	24.540 (60.253)	14,190.982** (8,322.069)
Supermarket network, lagged at 5 years ago (persons)	-	-	-	-	-	-	-	-	-
Share of produce sold to supermarket (Column 1) (Same question as in SUR for share of produce sold?)	11.752**** (3.244)	8.272**** (2.385)	3.519* (1.904)	0.751 (1.904)	0.589* (0.313)	13.666**** (3.199)	1.954*** (0.856)	1.232 (1.400)	558.548**** (193.334)
Constant	1,038.690*** (442.412)	1,451.727**** (325.189)	937.838**** (259.590)	440.472** (259.650)	15.303 (42.670)	2,627.761**** (436.252)	306.742**** (116.721)	792.395**** (190.872)	37,577.455 (26,362.914)
Observations	253	253	253	253	253	253	253	253	253
R-squared	0.135	0.159	0.090	0.033	0.063	0.158	0.169	0.069	0.066

Source: Analysed by the authors using data from field surveys.

Standard errors in parentheses; **** p<0.01, *** p<0.05, ** p<0.1