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Impact of Market Reforms on Technology Adoption and Profitability: The Case of Tomato Farmers in India

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Abstract

Market reforms affect the development of agribusiness and remain contentious in many developing countries. This study contributes to the debate and the lack of evidence on the impact of marketing reforms on the welfare of farmers. It focused on the impact of direct marketing in tomato cultivating farmers with Super Markets (SMs) on the adoption of modern production technologies and the realization of net returns in India. Primary data was collected from 500 sample farmers and applied to the Seemingly Unrelated Regression (SUR) model to analyze the impact of SMs participation on the adoption of modern production technologies and the realization of net income. The findings revealed that SMs participation decisions, interactions with SMs personnel, land holding size and lucrative prices offered by SMs are influential factors in the use of modern inputs viz., organic manures, drip irrigation, micronutrients and for the realization of higher net income from tomato cultivation. Reduced transaction costs, assured marketing, the mitigation of

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both production and marketing risks, enhancing the commercial outlook of farmers, etc., are the other benefits due to market linkages of tomato farmers with corporate firms.

Keywords: market reforms, direct market linkages, supermarkets, technology adoption, SUR model
JEL Classification: M31, M38, Q13

1. Introduction

Market reforms in developing countries aim to increase the participation of smallholder farmers, whose income remains low. Connecting them to markets can increase the yields and quality of their outputs through the adoption of innovations. Increasing the channels of marketing with better backward and forward linkages and reform measures potentially removes their knowledge constraints and enables them to better negotiate their produce prices. Despite this, limited information is available concerning under what conditions the quantity and quality of outputs and income increase and when the market is opened up for the smallholders. The case of India is typical.

Agriculture is the largest source of livelihoods for smallholder farmers in India. Around 70% of India's rural households depend primarily on agriculture for their livelihood and 82% of farmers are smallholders. Agricultural transformation in India requires farmers to adopt modern agribusiness practices and connect to the emerging value chains to meet the needs of the markets. Since the 1950s, the State Governments of India have enacted the Agricultural Produce Market Committee (APMC) Act to regulate agricultural markets with the objective of protecting farmers from the exploitation of intermediaries and traders and to ensure better prices and timely payments for their produce. In 1976, the National Commission on Agriculture reviewed the performance of regulated agricultural markets and found that farmers benefitted from checking trade malpractices such as unauthorized market charges and falsification of weights and measures. However, a subsequent report submitted by the Shankerlal Guru Committee in 2001 showed that the regulated agricultural market approach restricted the expansion of agricultural marketing in India (Planning Commission, 2007). Since 2006, to promote direct marketing as an alternative marketing structure, the APMC Act underwent several reforms. As a result, several organized retail value chains, both private and public, have started operations. This helped to link the farmers directly to markets, especially corporate buyers, and thus enabled the farmers to understand the demand for their

products, orient themselves towards food quality requirements, and effectively use market intelligence. Vegetable farmers are a typical group that was able to integrate themselves into these expanding value chains.

Vegetable farmers typically grow traditional vegetable crops like tomato, brinjal, okra, cucumbers etc., and traditionally transact their produce in local markets. The produce then moves through a long chain of intermediaries comprising brokers/agents, village traders, wholesalers, retailers and finally reaches consumers. The wholesalers in local markets (mandis) sell the produce through various channels including cart vendors and small retail shops. In 2006, however, the Government of India relaxed APMC regulations; this was a key development towards market reforms and value chain development in the Indian agribusiness sector. Since then, the farmers have been in direct link with corporate buyers in the growing organized retail sector.

This reform turned out to be a win-win situation for both farmers and corporate buyers, as the farmers get assured prices (fixed at the beginning of the crop season) and the buyers will have an assured supply of (quality) farm produce (Andersson et al., 2015; Barrett et al., 2012). Thus, linking the farmers to retail outlets or Super Markets (SMs) through contract farming strengthens the vertical linkages in the distribution channel and further allows better control over quality, reliability of supply, and variety of produce that the retailer could procure from farmers. In recent years, SMs have gained importance in transacting perishables in addition to processed products and this will have profound implications for farmers. These markets aim to provide a complete food service both to farmers and consumers. Further, they meet consumers' demand by offering a variety of fresh farm produce (vegetables) in requisite quantities at affordable prices. So, the present market reforms aim to ensure that both farmers and SMs have an adequate incentive in the form of vertical linkages through the gaining of a reliable and remunerative market for the former and a profitable investment for the latter. However, as shown by the recent protest of farmers in India in 2020-21, there has not been adequate research to establish the benefits that accrue to farmers from market reforms. To be more precise, no previous work systematically analyzed the effects of SMs in offering remunerative prices to the farmers in transacting fresh vegetables and consequently in implementing modern production technologies. Hence, this study made an attempt in this direction with respect to transacting fresh tomatoes in SMs in Telangana, India.

Tomatoes are one of the major horticulture crops and the most consumed vegetable in India. They are widely used for culinary purposes and also form part of the wide range of value-

added products like soup, salad, pickles, ketchup, puree, and sauces. China is the largest tomato producer in the world. In 2018, the country produced approximately 61.5 m. tons. This is approximately three times more than India, with 19.3 m. tons. Around 11% of the world's production of tomatoes is cultivated in India. The USA is third with 12.6 m. tons. In India, the major tomato producing states include Andhra Pradesh, Madhya Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Chhattisgarh, Maharashtra, Bihar, Haryana, Uttar Pradesh, Telangana, and Tamil Nadu. These states account for 91% of total tomato production in the country (Government of India, 2019). In Telangana, where this study focus, tomato cultivation accounts for around 52% of the total area for vegetable cultivation. The production volume of tomatoes in Telangana was 1.85 m. tons in the 2018-19 crop season. In Telangana, the Ranga Reddy district led other districts in tomato cultivation both in terms of area (0.09 m. ha) and production (0.53 m. tons) during 2018-19, followed by Siddipet, Nizamabad, Sanga Reddy, and Vikarabad districts (Government of Telangana, 2020). Accordingly, Ranga Reddy district was purposively selected for this in-depth study. In the past few years, an increasing number of corporate companies, namely Big Basket, More, Spencers, Ushodaya, Ratnadeep, Amazon, and Metro have begun to procure raw tomatoes directly from the farmers at their farm gates. This direct linkage of farmers with retail outlets gained momentum in this district for transacting raw tomatoes. Technical experts from these corporate buyers guide the farmers from land preparation to harvesting. The respective collection centers of these companies collect the produce at the farm gate and supply to the SMs in the urban outlets. The reduced transaction costs on the part of farmers seemingly increased their participation in this vertical linkage. The other advantages are: reduced post-harvest losses, good access to embedded extension and training services from corporate buyers, adoption of new varieties, adoption of new production techniques, access to modern inputs and services, enhanced value chain competitiveness, etc. At the same time, companies benefit from a regular and prompt supply of quality produce, establishment of collection centers to procure farmers' produce at the right time, designing new business models from time to time, and increased understanding with participant farmers.

This transformation towards a direct-marketing system through strengthening vertical linkages in the form of organized retail chains is increasing rapidly in the nearby district of Hyderabad in Telangana. This is especially true with respect to the Ranga Reddy district in transacting raw tomatoes by farmers in the SM outlets. The proponents of market reforms have

made several arguments. Firstly, the rise of organized retailing (SMs) enables the direct procurement of tomatoes by the collection centers from participant-farmers without any intermediaries. This participation of farmers in vertical linkages with big corporations further helps them to employ modern techniques in production such as the use of more organic manure relative to chemical fertilizers, use of micro nutrients to enrich crop health, and adoption of drip irrigation to ensure water use efficiency. Further, this form of vertical linkage ensures disintermediation and thus shows a positive impact on the realization of remunerative prices for tomato farmers. However, research-based evidence to support these claims remain limited. In this context, this study is certainly a contributing one and formulated with the following specific objectives:

- To analyze the determinants of SMs' Participation Decisions (SMPD) of sample farmers
- To analyze the extent of participation of tomato farmers in transacting produce through SMs
- To analyze the impact of vertical integration of tomato farmers with SM outlets on the adoption of production technologies and the realization of higher net returns.

2. Literature review

Market linkages of farmers are essential to produce commodities in tune with customers' needs. According to Mathenge et al. (2010), in the absence of market linkages, farmers transact their produce in the local market because, with a low volume of marketable surplus, they could not demand higher prices for their produce. Bellemare and Barret (2006), Omiti et al. (2009), Goetz (1992), and Rios et al. (2008) identified major determinants for the market participation of smallholder farmers including household head characteristics (age, sex, education level, and household size), livestock ownership (cattle, goats, and poultry), crop production factors (land, oxen, farm equipment, and family labor), natural resources influencing crop production (rainfall, altitude, humidity, and temperature), market factors (distance to nearest marketplace, road facilities, transport ownership, marketing experience, price information), and institutional services (access to extension and credit services, contract marketing). Mbitsemunda and Karangwa (2017) also concluded that farmers' participation in output markets is also a function of farm productivity. With reference to direct market channels, Donkor et al. (2018), in their investigation of cassava in the Oyo State of Nigeria, revealed that human capital, physical capital, social capital, and market conditions had significant effects on farmers' decisions, unlike natural and financial capitals. They

further opined that improving rural roads, access to market information, and farmers' cooperatives, etc., will promote better market linkages. Chandrasekhara et al. (2018) studied the impact of SMs participation of tomato farmers in Telangana through fitting the SUR model. The study concluded that the share of produce sold through SMs had a significant influence on the net margin of farmers, i.e., a 1% increase in the share of produce sold through SMs increases income by Rs.559 (US$ 7.55). Further, it identified a positive influence on the adoption of modern production technologies and higher employment of hired labor. Hung Anh and Bokelmann (2019) studied the market preferences of smallholder coffee farmers in Vietnam. Their study revealed that the probability of choosing a buyer viz., processor/exporter, buying agent, and local trader was determined by price uncertainty, market competition, transportation cost, quantity of procurement, age of household, and farm size. The results of the SUR model determined that speed of payment, quantity of procurement, age of household, and farm size are the most important determinants for the probability of farmers' participation in processor/exporter markets. The driving factors for the probability of choosing buying agent markets are price uncertainty, market competition, higher transportation cost, fixed procurement quantity, age of household, ethnicity, and farm size. However, the probability of farmers' participation in local trader markets was influenced by price uncertainty, fixed procurement quantity, trust in buyers, and farm size. They further opined that the market preferences of coffee farmers should be considered to strengthen forward market linkages in coffee market transformation.

3. Methodology

In Telangana, Ranga Reddy is the leading district in tomato production and is dominated by smallholder farmers. Consequently, their linkages with the big SMs will insure them against marketing risks and also make them adopt modern production technologies. From this district, the top five mandals with respect to the area under tomato cultivation are Yacharam, Ibrahimpatnam, Kandukur, Maheshwaram, and Chevella. From each mandal, 100 tomato cultivating farmers (comprising small, medium, and large farmers) are randomly selected through consultations with the local Horticulture Officers, thus resulting in a total sample size of 500 farmers for this study. The relevant data are collected from the farmers with the help of a pre-tested schedule during 2019-20.

3.1. Probit model

In the first stage, a Probit model was employed to analyze the determinants of SMPD of farmers, as the dependent variable is a dichotomous variable (Table 1). The probability P_i of choosing any alternative over not choosing it was expressed as in Equations 1 and 2, where ϕ represents the cumulative distribution of a standard normal random variable:

$$P_i = \text{prob}[Y_i = 1 \mid X] = \int_{-\infty}^{x_i'\beta} (2\pi)^{-1/2} \exp\left(-\frac{t^2}{2}\right) dt \quad (1)$$

$$= \Phi(x_i'\beta) \quad (2)$$

Considering the variables selected (Table 1), the Probit model is:

$$P(0, 1) = \text{SMPD} = \beta_0 + \beta_1 \text{LH} + \beta_2 \text{EDU} + \beta_3 \text{OFFEMP} + \beta_4 \text{MP} + \beta_5 \text{EXTN} + \beta_6 \text{SMP} + \varepsilon_i \quad (3)$$

The marginal effects associated with the continuous explanatory variables X_k on the probability $P(Y_{i=1} \mid X)$, holding the other variables constant is derived as follows:

$$\frac{\partial P_i}{\partial x_{ik}} = \Phi(x_i'\beta)\ \beta_k$$

where ϕ represents the probability density function of a standard normal variable.

The marginal effects of dummy variables are derived differently from continuous variables (Gujarati, 2004; Johnston, 1972). Discrete changes in the predicted probabilities constitute an alternative to the marginal effect when evaluating the influence of a dummy variable. Such an effect is derived from:

$$\Delta = \Phi(\bar{x}\beta, d = 1) - \Phi(\bar{x}\beta, d = 0)$$

Table 1: Description of the variables used in the study

Variable	Variable Name	Variable type	Variable measurement
SMPD	SMs Participation Decision	Dummy	1 if farmer participated in SM transaction, 0 otherwise
PROP	Proportion of marketable surplus transacted through SMs	Continuous	Percentage of marketable surplus transacted through SMs
LH	Size of land holding	Continuous	Number of acres of land cultivated under tomatoes
EDU	Education status of the sample farmer	Dummy	1 if farmer with education >10th class, 0 otherwise
OFFEMP	Off-Farm Employment	Dummy	1 if farmer enjoy off-farm employment, 0 otherwise

MP	Market prices of tomatoes in SMs	Continuous	Rs/100 kilos
EXTN	Interactions with Local Agricultural Extension Officers (market-led extension)	Dummy	1 if farmer interacted with local Agricultural Extension Officers, 0 otherwise
SMP	Interactions with personnel of SMs at collection centers	Dummy	1 if there are frequent interactions with the personnel at collection centers, 0 otherwise
PRED	Predicted values of SMPD	Continuous	Predicted values of SMPD from Probit Regression
OM	Organic Manures	Continuous	Cost incurred (Rs)
DRIP	Drip Irrigation cost incurred (excluding subsidy from the Government)	Continuous	Cost incurred (Rs)
MN	Micro nutrients	Continuous	Cost incurred (Rs)
NR	Net Returns	Continuous	Net Returns realized (Rs)

Source: Authors' definitions

3.2. Tobit model:

To analyze the extent of the participation of tomato farmers through SMs, Tobit regression was employed (Balsevich, 2005; Bellemare & Barret, 2006). The sample data discovered that 374 farmers enjoy market linkages with SM outlets. So, the PROP is used as a dependent variable and the explanatory variables of Equation 3 are again considered in Equation 4:

$$PROP = \beta_0 + \beta_1 LH + \beta_2 EDU + \beta_3 OFFEMP + \beta_4 MP + \beta_5 EXTN + \beta_6 SMP + \varepsilon_i \quad (4)$$

3.3. Seemingly Unrelated Regression (SUR) model

This study also used the SUR model to analyze the impact of the SMs participation of tomato farmers (n = 500) on their adoption of modern production technologies viz., use of organic manures, drip irrigation, micronutrients, and the realization of net returns. Hence, this model involves the estimation of the four aforementioned dependent variables by allowing for different estimator matrices in each equation and accounting for contemporaneous correlation (Chandrasekhara et al. 2018; Hung Anh & Bokelmann, 2019). Let us consider here a model comprised of 'M' multiple regression equations of the form:

$$y_{ti} = \sum_{j=0}^{n} x_{tij}\beta_{ij} + \varepsilon_{ti}, \quad t = 1, 2, \ldots, T;\ i = 1, 2, \ldots, M;\ j = 1, 2, \ldots, k_i \quad (5)$$

where y_{ti} is the t^{th} observation on the i^{th} dependent variable to be explained by the i^{th} regression equation, x_{tij} is the t_{th} observation on j_{th} explanatory variable appearing in the i_{th} equation, β_{ij} is the coefficient associated with x_{tij} at each observation and ε_{ti} is the t^{th} value of the random error component associated with the i^{th} equation of the model. Thus, these 'M' equations can be compactly expressed as:

$$y_i = X_i\beta_i + \varepsilon_i,\ i = 1, 2, \ldots..,\ M \qquad (6)$$

The explanatory variables considered in the Probit model (Equation 3), along with the predicted values from the Probit regression (SMPD), are considered as X_i in Equation 6. This model involves the application of the Generalized Least Squares (GLS) approach and the unknown residual covariance matrix is estimated from the data (Cadaves & Henningsen, 2011).

However, the estimation of all four dependent variables of the aforementioned SUR model can also be fitted individually through the Ordinary Least Squares (OLS) method. But, by doing this, researchers can encounter the problem of not using all the information in the system of equations and the possibility of neglecting the correlation between error terms across different equations (Maddala, 1977). As a result, the application of the SUR model outweighs the OLS method on these issues and further, in the former, the computation is done as a single equation using GLS, thereby making the results more efficient asymptotically than OLS.

4. Results and discussion

4.1. Characteristics of Sample Respondents

The demographic summary of the sample respondents (Table 2) revealed that 89% are male and only 11% are female. Tradeoff between household works and income earning opportunities, market linkages, distance of SMs from the villages, etc., influence the women farmers' SMs participation for transacting tomatoes. The majority of the farmers (51%) are between the ages of 36 – 50 years, followed by 30.5% between the ages of 21 - 35, 10% are over 50 years of age and around 9% are less than 20 years. Educational attainment was classified into four categories: illiterate (15.5%), high school (61.5%), graduates (20%), and post-graduates (3%). That is, for around 77% of the respondents, the dominant level of education is up to high school only.

Table 2. Socio-economic and demographic characteristics of sample farmers (n = 500)

Characteristics	Frequency	%
Gender:		
Male	443	88.6
Female	57	11.4
Age:		
Under 20	44	8.9
21 – 35	153	30.5
36 - 50	255	51.0
> 50	48	9.6
Educational Background:		
Illiterate	78	15.5
High school	307	61.5
Graduate	100	20.0
Post-graduate	15	3.0
Off-farm employment:		
Yes	135	27.0
No	365	73.0
Annual Income (Rs):		
< 75,000 (< US$1,013)	71	14.2
75,001 to 150,000 (> US$1,013 to US$2,027)	180	36.0
150,001 to 225,000 (> US$2,027 to US$3,041)	224	44.8
>225,00 (>US$3,041)	25	5.0
Household size:		
<2	70	14.0
3-4	240	48.0
5-6	155	31.0
>6	35	7.0
Land holding Size:		
< 1 ha	52	10.4
1-2 ha	369	73.8
>2 ha	79	15.8

Source: Sample survey from the selected respondents

Around 45% of the total respondents reported an annual income between Rs.151,001 to Rs.225,000 (> US$2,027 to US$3,041) and around 36% reported an annual income range between Rs.75,001 to Rs.150,000 (> US$1,013 to US$2,027). The most common household size is 3-6 people, seen among 79% of sample respondents, implying that the sample is a homogeneous pool. The per capita size of landholding is 1.22 ha and 84% of the sample respondents are marginal and small farmers. Subsequently, linking this majority to SMs on a group basis will definitely ensure assured marketing for their low marketable surplus and to mitigate both production and marketing risks in transacting tomatoes.

4.2. Determinants of SMPD of tomato farmers

The findings of the Probit model revealed that all the selected factors have exerted a positive and significant (1% level) influence on the probability of SMPD of tomato farmers, with the exception of LH and OFFEMP (Table 3). The statistically significant coefficient suggests that the likelihood of farmers' participation in SMs will increase or decrease as the response of the explanatory variable increases or decreases. The likelihood ratio statistic is significant ($P < 0.0000$), indicating that all the model parameters are jointly significant in explaining the SMPD (Chandrasekhara et al., 2018).

Table 3: Determinants of SMPD of sample farmers

Variables	Coefficients	Marginal effects	SE	Z	P(Z)
LH	0.0002	0.00004	0.0001	1.300	0.193
EDU	0.460***	0.141	0.154	2.980	0.003
OFFEMP	0.180	0.052	0.151	1.200	0.231
MP	0.095***	0.026	0.023	4.180	0.000
EXTN	0.395***	0.121	0.154	2.570	0.011
SMP	0.454***	0.137	0.149	3.040	0.002
Constant	-1.568	--	0.397	-3.950	0.000
Observations	500				
Pseudo R^2	0.201				
Log likelihood	-225.490				
LR χ^2	113.54***				
Prob> χ^2	0				

Note: ***p<0.01

The sign and coefficient of the estimate, EDU (+0.460***), imply that if a farmer receives an 'education', the probability of their making a decision to participate in the SMs increases. The marginal effect of EDU (0.141) indicates that imparting education would increase the probability of farmers' participation in SMs by 14.1%. Therefore, the improvement of education among the farmers will act as a trigger mechanism for availing better market linkages. It is thus vital to impart capacity building to farmers through promoting contracts with farmers' associations and strengthen market-led extensions in the study area.

Interactions with SMs personnel (SMP) at the collection centers had a positive and significant effect on the SMPD of the farmers (+0.454***) and its marginal effect revealed an increasing probability of transacting produce through the SMs by 13.7%. This is because the SMs personnel guide the farmers in the right direction both in the production and marketing of tomatoes, provide requisite support on behalf of the corporate firms, and also make arrangements to procure the farmers' produce at the farm gate. They further guide the farmers to grade the tomatoes before transporting the same produce to retail outlets. The informal discussions held with the officials from SMs and SMs personnel revealed that the sorting and grading of tomatoes is generally done manually with the following specifications: small (< 100 grams; medium (100-255 grams) and large (>255 grams). Grading further helps to develop greater confidence between buyers and farmers, increase marketing efficiency, facilitate easy transportation, and increase both farmer and SM profits. Consequently, a long-term association between the farmers and the SM personnel will decrease the probability of distress sales of produce in the local market and increase their access to retail market outlets. However, the grades and standards followed by the SMs have lagged behind the official standards prescribed by the Directorate of Marketing & Inspection (DMI), Government of India. Put simply, the SMs usually buy based on their own private standards and this highlights the significance of third-party certification. So, in the future, standards that are a mix of private and Government standards are likely to be used, as is being done by TOPS SMs in Thailand (Andrew, 2004)

As expected, 'EXTN' showed a positive and significant impact (+0.395***) on SMPD because the extension agents guide the farmers and link them to the SMs. However, the real challenge is linking the farmers on a group basis to SMs, as linking each and every farmer to the

market is rather difficult in transacting tomatoes. The marginal effect revealed that this variable has increased the SMPD of farmers by 12.1%.

The realization of higher 'MP' from SMs (+0.095) is *sine qua non* for SMPD of sample farmers. With a 1% increase in the prices of tomatoes, the probability of SMPD will increase significantly by 2.6%. Once again, this proved that farmers are price conscious and the lucrative prices offered by SMs will check the distress sales of their produce in the local markets.

However, the variables 'LH' and 'OFFEMP' had no significant influence on the SMPD of farmers. This implies that the benefits from this market linkage are scale neutral, i.e., they will benefit all the size categories of farmers alike. Further, the justification for the non-significance of 'OFFEMP' implies a lack of alternative employment opportunities for the farmers in the study area.

4.3. Determinants for degree of participation of tomato farmers in SMs

Results of the Tobit model (Table 4) revealed that MP, SMP, and EXTN are the priority variables to influence PROP at the significant level. The marginal effects of these variables indicate an increase in PROP by 37.2, 25.6, and 2.7, percent respectively. It is interesting that, as in the Probit regression earlier, LH is found to have a non-significant (albeit positive) influence on PROP, implying that the extent of produce transacted through SMs is mainly influenced by the quality rather than quantity of tomatoes produced. In some studies, irrigation facilities played a significant role in increasing the PROP through SMs retail outlets (Balsevich, 2005; Hernandez et al. 2007; Neven et al., 2009; Rao, 2017). However, the 'OFFEMP' had an unexpected negative sign in the relationship with the PROP, but was found to be statistically insignificant and this indirectly indicates a lack of adequate alternative employment opportunities in the study area.

Table 4: Determinants of PROP - Tobit model

Variables	Coefficient	Marginal Effects	SE	Z	P(Z)
LH	0.401	0.310	1.437	0.280	0.781
EDU	0.143	0.197	0.487	0.290	0.778
OFFEMP	-0.452	-0.373	1.407	-0.320	0.748
MP	0.903**	0.372	0.783	2.430	0.015
EXTN	0.079**	0.027	0.001	2.950	0.003
SMP	0.759***	0.256	0.592	2.970	0.003
Constant	90.298		3.294	27.410	0.000

Observations	374				
Pseudo R^2	0.005				
Log likelihood	-1340.268				
LR χ^2	14.220				
Prob> χ^2	0.027				

Note: ***p<0.01, **p<0.05

Consequently, the findings revealed that MP is the crucial factor that influenced the PROP, as it is the driving force for the farmers to transact their produce through SMs. Thus, MP incentivize the farmers to transact more PROP through SMs. The role of SMP is equally important to strengthen this modern value chain in offering benefits to tomato farmers with respect to both quality production and assured marketing. In the study area, it is expected that EXTN facilitated the market linkages to SMs to realize higher MP for the farmers. Though EDU unexpectedly recorded a non-significant influence, it will influence the educated farmers to enjoy market networking and facilitate trading opportunities at lower transaction costs. The earlier studies concluded that market experience background also helped farmers to overcome selected fixed transaction costs in South Africa (Makhura, 2001; Matungul et al. 2001).

4.4. Determinants of technology adoption and net returns from tomatoes transacted through SMs

As discussed in Table 2, there are variations in the characteristics of the sample farmers selling tomatoes through SMs and these might influence the adoption of modern production technologies (organic manures, drip irrigation, micronutrients) and the realization of net returns. Accordingly, the same have been analyzed through the SUR model and the findings are illustrated in Table 5.

Table 5: Results of SUR estimates

Variables	Organic manures	Drip Irrigation	Micronutrients	Net Returns
LH	0.013**	0.016*** (0.005)	0.013**	0.015***
	(0.006)		(0.006)	(0.005)
EDU	0.019**	0.021	0.008	-0.007
	(0.008)	(0.026)	(0.028)	(0.024)

OFFEMP	-0.001 (0.001)	-0.001 (0.001)	0.001 (0.001)	-0.002 (0.001)
MP	0.053** (0.024)	-0.048 (0.033)	0.036** (0.016)	0.031*** (0.012)
EXTN	0.034*** (0.012)	0.088 (0.069)	0.020 (0.018)	0.015*** (0.005)
SMP	0.016*** (0.005)	0.013*** (0.004)	0.023** (0.0108)	0.012** (0.005)
Predicted values from Probit regression (SMPD)	0.421*** (0.092)	0.299*** (0.109)	0.219*** (0.079)	0.532*** (0.101)
Intercept	9.812 (0.108)	10.446 (0.127)	11.956 (0.139)	11.879 (0.118)
Observations	500	500	500	500
Adj R^2	0.491	0.317	0.442	0.532

Note: ***p<0.01, **p<0.05. Figures in parentheses indicate SEs.

It is interesting that the predicted values of SMPD have exerted a positive and significant influence on the adoption of modern production technologies and the realization of net returns by the farmers from tomato cultivation. Selling the produce through SMs increased the net returns by 53.2% compared to transactions made in the local market. This is mainly because farmers meet both the quantity and quality requirements prescribed by the corporate firms. The other determinants, LH and SMP, also exerted a positive and significant influence on all the selected dependent variables. The use of modern inputs and the realization of higher net returns with an increase in LH is an indicative for the scope of the formation of farmers' cooperatives and linking them with SMs in a group approach in the future. Linkages with SMP have enabled the farmers to use modern inputs and realize higher net returns through improving both product quality and marketability. These findings further indicate that the realization of higher net returns by tomato farmers through linkages with SMs serve as a 'push' factor for the increased use of modern inputs in production programmes.

Similarly, higher MPs offered by the SMs serve as a 'pull' factor for the tomato farmers to produce quality output. We found that this variable has exerted a positive and significant influence on the net returns realized by the farmers, i.e., a 1% increase in MP will increase net returns by 3.1%. Both EDU and EXTN exerted a positive and significant influence on boosting cost-effective

and quality output through the increased use of organic manure. However, the negative (non-significant) coefficient of OFFEMP corresponded to the lack of adequate alternate employment opportunities in the study area (Cadaves & Henningsen, 2011; Chandrasekhara et al., 2018; Hung Anh & Bokelmann, 2019). These findings imply that the SMs linkages of tomato farmers provide a direct sales agreement for a target market. This improves their net returns significantly by increasing sale volumes, quality output, and the realization of remunerative prices. The SMs secure the market and source tomato farmers to produce and supply aggregate volumes and control quality. They often support financing and technology and also logistics that significantly reduce risks for tomato farmers. So, cost-effective and quality production, reduced transaction costs, traceability in the supply chain, access to a more consistent market, consistent pricing, etc., contribute to farmers' higher net returns (Ferris et al., 2014).

The informal discussions held with the sample farmers revealed that they must meet variety and quality specifications and always be able to supply the agreed upon quantities of output to the SMs at all times. However, this linkage has still provided an assured market outlet to the tomato farmers, meets both financial and technical assistance from the corporates, and facilitates the procurement of produce at the farm gate (Reardon & Timmer, 2005). The personnel from the corporate firms conduct frequent on–farm monitoring and technical trainings to promote backward linkages in the study area. With tomatoes being a highly perishable produce, the need for the direct marketing of produce to retail outlets has gained momentum in the past five years.

To justify the use of the SUR model in this study, OLS regressions are computed separately for each dependent variable (Appendix 1). In comparing Table 5 and Appendix 1, it was interesting to note that the SEs of the estimates of four OLS regressions are consistently higher compared to the corresponding SEs of SUR estimates, indicating the superiority of the SUR model over the OLS model (Zellner,1962).

5. Summary and conclusions

Agricultural market reforms in India have become controversial due to the lack of evidence on the impact of such policy measures on the farmers. Opening up the markets for farmers, especially smallholders, to sell freely to contractual buyers is a key element of this reforms process. Nevertheless, several gaps exist to support reform measures. This study contributes to this debate by analyzing the willingness of farmers to participate in SMs, the degree of SMs participation, and

the impact of transacting tomatoes through SMs on the adoption of modern production technologies and the realization of higher net returns in the Ranga Reddy district of Telangana, India. A Probit model revealed that EDU, MP, EXTN, and SMP positively and significantly influenced the SMPD of tomato farmers. On the other hand, a Tobit model also concluded that MP, EXTN, and SMP positively and significantly influenced the PROP of tomato farmers. The findings of the SUR model revealed that predicted values of SMPD, SMP, LH, and MP are the predominant variables that contribute to the use of modern inputs and the realization of higher net returns due to market linkages with SMs for transacting tomatoes. The other benefits include: reduced transaction costs, mitigation of both production and marketing risks, enhanced commercial outlook of farmers. In this context, it is high time to meet the real challenges of grouping the majority of small and marginal tomato cultivating farmers and link them to SMs for assured marketing on the one hand and modernizing agri-business on the other.

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Appendix 1: Results of OLS estimates

Variables	Organic manures	Drip Irrigation	Micronutrients	Net Returns
LH	0.013**	0.016***	0.013**	0.015***
	(0.006)	(0.006)	(0.007)	(0.006)
EDU	0.019	0.021	0.009	-0.007
	(0.039)	(0.049)	(0.043)	(0.043)
OFFEMP	-0.001	-0.001	0.001	-0.002
	(0.003)	(0.005)	(0.003)	(0.002)
MP	0.053**	-0.062	0.036**	0.042***

	(0.029)	(0.042)	(0.022)	(0.013)
EXTN	0.034***	0.072	0.026	0.015***
	(0.015)	(0.070)	(0.021)	(0.005)
SMP	0.016***	0.013***	0.025**	0.032**
	(0.006)	(0.006)	(0.011)	(0.014)
Predicted values from Probit regression (participation in SMs)	0.421***	0.299***	0.219***	0.532***
	(0.108)	(0.117)	(0.079)	(0.129)
Intercept	10.182	10.446	12.089	11.879
	(0.193)	(0.142)	(0.169)	(0.143)
Observations	500	500	500	500
Adj R^2	0.491	0.317	0.442	0.532

Note: ***p<0.01, **p<0.05. Figures in parentheses indicate SEs.