Are farmer producer organizations a boon to farmers?
the evidence from Bihar, India

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Abstract This paper uses data from a field survey in Bihar to examine the impact of membership of farmers in farmer producer organizations (FPOs) on the adoption of technologies and Good Agricultural Practices. Membership in FPOs influences both the outcome variables positively and significantly, but poor access to capital and the absence of a proper monitoring and evaluation mechanism are among the most important challenges.

Keywords Farmer producer organization (FPO), adoption of technologies, good agricultural practices, Bihar

JEL classification L14, O33, Q13

1 Introduction

The wave of globalization and market liberalization that began in the 1980s has exposed small-scale farmers to many challenges and opportunities. Small-scale farmers are subject to the vagaries of weak and volatile markets; and state support against risks is limited. Farmers – especially smallholders, forced to produce without access to reliable and affordable inputs, credit, transport facilities or markets – find themselves competing against large commercial companies. Even if they can access markets, their weak bargaining position leaves them constrained in negotiations with big buyers (Penrose-Buckley 2007).

Collective action is an acclaimed strategy to deal with these challenges that small-scale producers face. Specifically, farmer organizations – such as cooperatives; associations; unions, groups; and federations with different organizational structures – have been identified to play a key role in enhancing farmers' access to markets (Chirwa et al. 2005; Hellin et al. 2007; Stockbridge et al. 2003 a). Most definitions of farmer organization stress the importance of membership in the organization.

The most important function of the organization is to provide its members with services and access to these services is among the most important incentives to become a member (Stockbridge et al. 2003b). Achieving economies of scale in transactions with input suppliers and buyers and improving one's bargaining power are other benefits that accrue to members. The benefits of collective action through producer organizations are widely acknowledged, and policymakers and development agencies often devote uncritical attention and resources to support smallholders in associating and collaborating to form farmer producer organizations (FPO). The politically (or even developmentally) motivated zeal for creating greater numbers of these organizations must, however, be weighed against the costs and problems associated with organizing large numbers of people (Stockbridge et al. 2003 a) and considerations about their viability.

What rules should these producer organizations be based on? How should the internal governance be structured? How should compliance be monitored? Whether the producer organization would favourably or unfavourably alter transaction costs incurred by individual farmers? Have the smallholders been trained in managerial and entrepreneurial skills, without which the management of the organization may be sub-

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optimal? These are critical factors that determine the viability or non-viability and the success or failure of any FPO.

In India, agriculture is dominated by smallholders; marginal and small farmers own nearly 86.2% of all operational landholdings and operate 47.3% of the total area (Agriculture Census 2015-16). This paper focuses on Bihar, where about 97% of the landholdings and 76% of the area is operated by marginal and small farmers. Small land sizes are associated with small marketable surpluses and limited access to critical agricultural inputs.

Poor transport and communication networks restrict farmers from accessing remunerative markets, thereby creating rent-seeking opportunities for informal buyers, that is, local traders and middlemen (Negi et al. 2018). Inadequate local markets and costlier transport for small quantities force farmers to sell their produce to local traders at low prices (Hegde 2010). Faced with limited production quantities, and lack of adequate access to input supplies, extension services, credit facilities and output markets, smallholders have lower rates of technology adoption and market efficiency, which in turn result in in lower levels of income. Greater vulnerability to climate and market risks pushes cost of cultivation upward and further reduces profits. In absence of large marketable surpluses, small farmers have low bargaining power in input procurement as also in the sale of output (Kirsten & Sartorious 2002).

By utilizing economies of scale, collectivization provides a self-sustaining solution to these problems; FPOs considerably reduce the role of intermediaries (Fafchamps & Hill 2005) and create opportunities for small and marginal farmers to participate in markets more effectively (Stockbridge et al. 2003 a). Access to markets is directly related with poverty reduction. Emran and Hou (2013) provide robust evidence from China that better access to markets benefits rural households substantially and the benefits of improved access to domestic markets are significantly larger. Enhancing the bargaining power of small and marginal farmers also reduces the entry barrier to markets for them (Kherallah et al. 2002; Thorp et al. 2005).

Besides, farmer organizations lower information cost for better market timings, clues and access to technologies. Farmer producer organizations have the potential to enhance smallholders' market outreach,

improve their bargaining power, and also achieve higher food safety standards by providing them with access to agricultural inputs, credit facilities, post-harvest agricultural logistics (including transport facilities), and a platform for aggregating their produce, as a collective. All these are likely to positively impact their incomes.

The Government of India (GoI) has set itself the target of doubling farmers' incomes by 2022, signalling a shift in its orientation from production and productivity toward agri-food policy (Chand 2017). Several schemes have been initiated in pursuance of this objective; the promotion of FPOs is one of them. The GoI supports FPOs vigorously; it even declared 2014 the 'Year of Farmer Producer Organisations'. Even before this reorientation of policy, however, there have been various forms of collective efforts among farmers in the form of primary agricultural cooperative societies and dairy and sugar cooperatives; FPOs are collectives comprising primarily marginal and small farmers. Including farmer producer companies, FPOs in India formed through various initiatives now number over 5,000; about 64% are registered as producer companies and the rest as cooperatives and societies (GoI 2018).

Since the 1990s, with the advent of liberalization, policymakers and cooperative sector leaders started to rethink about how to reorganize FPOs and infuse professionalism in the sector. With this objective, the GoI in 1999 formed a high-powered committee under the chairmanship of Dr. Y.K. Alagh for recommending guidelines for the formation and conversion of cooperative businesses into companies. The committee noted the need to transform the cooperative structure, especially its dependence on government support and its engagement with bureaucracy. To promote organizations with minimum government interference which offered space for farmer organizations to evolve, the committee suggested a new organizational structure: the farmer producer company (FPC). The Department of Agriculture and Cooperation, Ministry of Agriculture, identified FPOs registered under the special provisions of the Companies Act, 1956 as the appropriate institutional form around which to mobilize farmers and build their capacity to collectively leverage their production and marketing strengths. Farmer producer companies work on mutual assistance principles: voluntary membership; voting right independent of shareholding; elected board from

among members; limited return on share capital; and distribution of surplus on patronage basis.

With this background, we conduct a study on FPOs in Bihar to assess their performance in terms of adoption of technologies and Good Agricultural Practices (GAPs). In Bihar, all FPOs are either promoted by the government or supported by nongovernmental organizations (NGOs) or some other institution such as the National Bank for Agricultural and Rural Development (NABARD), Small Farmers' Agri-business Consortium or JEEViKA. Funding support for promoted FPOs lasts for limited periods of time, and many wind up at the end of the funding cycle. The emphasis on numbers has led membership to become non-serious and ineffective. The size and composition of FPOs is important for success, a factor that has not been internalized in the promotion of FPOs. The sub-par performance in terms of outcomes and life span is partly reflected in being a function of negative selection at different levels. Most FPOs have not delivered in terms of product differentiation that can give market power to farmers and reduce their risks. We focus on farmer outcomes as markers of performance in terms of adoption of technology, access to credit, access to market, risk mitigation and Good Agricultural Practices GAPs. We address the following research questions in this study:

1. What are the factors determining membership in FPOs? What is the impact of membership on adoption of technology and GAPs?

2. To what extent has membership in FPOs improved the ease of access to credit?

3. To what extent has membership in FPOs mitigated the risks of farmers (subjectively assessed)?

To address these questions, we conducted a survey of FPO members and non-members in Bihar. The survey collected data for 274 farmers who were FPO members and another 276 farmers who were not members of any FPO.

2 Survey design, data and descriptive statistics

We conducted a survey in Bihar of 550 farmers; 274 of them were members of some FPO; the other 276 farmers were not members of any FPO. The survey was conducted at the sub-regional level, that is, districts in the state of Bihar (figure 1). For the survey, we randomly selected districts from all four zones in Bihar: four districts from Zone 1 (Gopalganj, Muzaffarpur, Purba Champaran and Vaishali); two districts from Zone 2 (Khagaria and Purnia); one district (Jamui) from Zone 3; and four districts from Zone 4 (Bhojpur, Buxar, Jehanabad and Nalanda) (figure 1). For selecting FPOs,

Figure 1. Surveyed districts in Bihar

Table 1. Zone-wise distribution of the sample of FPOs selected for the survey and the total number of FPOs in Bihar

Zone	Total no. of FPOs	Sample of FPOs
Zone 1	50	10
Zone 2	18	03
Zone 3	06	01
Zone 4	30	06
Total	104	20

we used a random number generator in each zone in proportion to the total number of FPOs located in that zone and selected 20 out of a total of 104 FPOs in Bihar (table 1).

Of our sampled FPOs, some were sponsored by NGOs such as the Aga Khan Foundation, the Kaushalya Foundation, Farm and Farm or the Kshitize Foundation; some were affiliated with NABARD; and others were sponsored by quasi-government organizations such as the Bihar Rural Livelihoods Promotion Society – JEEViKA. We then selected 14 farmers randomly from each of the selected FPOs in all the 20 villages. To see the difference between being an FPO member and not being an FPO member, we sampled an equal number of non-members from each village. We used a structured questionnaire to interview the randomly selected farmers to collect information on household characteristics and agricultural practices.

2.1 Descriptive statistics

Table 2 presents the descriptive statistics for the complete sample and for the sub-sample of treated (FPO members) and non-treated (non-FPO members) farmers separately for comparison. On average, FPO members earn about Rs. 2,200 more per month than

Table 2. Demographic and socio-economic profile of the sampled farmers

	FPO member	Non-FPO member	Combined	Difference
Age of respondent (years)	45.58	46.77	46.18	-1.19
Household size	7.29	7.10	7.19	0.19
Female-headed households (%)	12.32	8.13	10.24	4.19
Average monthly income (Rs)	18,555.11	16,353.44	17,450.00	2,201.67**
Average monthly expenditure (Rs)	11,361.68	10,145.65	10,751.45	1,216.03**
Years of experience in farming	21.30	22.92	22.12	-1.62
Percentage of respondents belonging to				
Scheduled caste/scheduled tribe	9.85	13.04	11.45	-3.19
OBC	56.93	55.08	56.00	1.85
General	33.21	31.88	32.55	1.33
Educational status of respondents (%)				
No school	18.98	32.97	26.00	-13.99***
Primary school	22.63	21.38	22.00	1.25***
Middle school	27.01	18.48	22.73	8.53***
High school	16.42	14.86	15.64	1.56****
Intermediate level	12.41	10.14	11.27	2.27***
Bachelors and above	2.55	2.17	2.34	0.38***
Percentage of respondents who have				
Soil health card	2.58	1.09	1.83	1.49
Ration card	64.1	63.41	63.75	0.69
Aadhar card	97.81	97.82	97.81	-0.01
Bank account	97.45	98.19	97.82	-0.74
Primary occupation of respondents (%)				
Agricultural and allied activities	76.28	63.77	70.00	12.51***
Wage labour	10.95	20.65	15.82	-9.7***
Trade and business	6.93	7.61	7.27	-0.68***

Note: ** and *** indicate statistical significance at the 5% and 1% level, respectively.

non-members – although their average monthly expenditure is also significantly higher. The higher incomes of members vis-à-vis non-members is despite their relatively fewer years of farming experience. This could possibly be a result of better access that FPO members have to information about new technologies and market prices.

About 33% of farmers in the overall sample belong to the general caste, 56% belong to Other Backward Classes (OBC), and 11% belong to the Scheduled Castes (SC) and Scheduled Tribes (ST). In our sub-sample of farmers who are FPO members, the largest numbers belong to the OBC category, followed by the general caste, and very few belong to the SC/ST category. Better-educated farmers were present in greater proportions in the sub-sample of members compared to the sub-sample of non-members, indicating that better-educated members are possibly more aware of the benefits of FPOs. However, within the sub-sample of FPO members, those with only primary and middle school education were present in greater proportion than those with higher levels of education (high school and above).

Among FPO members, 76% were engaged in agriculture and allied activities as their primary occupation, 11% were primarily wage labourers, and 7% were traders or businesspersons. Among the sub-sample of non-members, 64% were involved in agricultural and allied activities, 21% were engaged in wage labour, and 8% were traders or businesspersons. The differences in primary occupation between FPO members and non-members were also found to be statistically significant.

3 Conceptual framework and estimation strategy

Adopting a new technology or a package of new technologies or a set of GAPs can involve significant risks and may even result in losses. In deciding whether to adopt a new technology or a GAP, farmers compare benefits and risks associated with the respective technology or practice. If farmers can be assured by some agency that losses incurred due to such adoption will be covered, farmers are likely to adopt. Conceptually, the impact of membership of farmers in FPOs on the number of technologies adopted and GAPs practised could be estimated using the following framework:

$$Y_{ki} = \beta_0 + \beta_1\,\mathrm{FPO}_i + \beta_2 X_i + \mu_i \qquad (1)$$

where, Y_k represents the outcome variable ($k = 1, 2$; 1 = number of technologies adopted by farmer i; 2 = GAPs practised by farmer i); FPO_i represents whether farmer i is associated with any FPO or not; X_i is a vector of explanatory variables; and μ_i is the error term.

However, the survey data might have the self-selection problem: the decision of a farmer to enrol as an FPO member (an explanatory variable in equation 1) may be affected by certain unobserved characteristics that also impact the number of technologies and GAPs adopted (the dependent or outcome variable in our analysis). Since such characteristics have not been controlled for, they might lead to self-selection and endogeneity biases and cause this estimation method to be inconsistent. The error terms of the choice equation (the choice of becoming an FPO member as modelled in equation 2) and the outcome equation (adoption of technologies and GAPs, in this study) are both affected by some uncontrolled-for factors, resulting in correlation between the two error terms and an endogeneity bias.

To address this issue, researchers have used the two-stage regression predictor substitution (2SPS), where the predicted values of the endogenous variable are replaced by first-stage predictors. The two-stage residual inclusion (2SRI) method is consistent and more useful than the 2SPS method (Terza et al. 2008). When the conditional expectation is nonlinear, 2SPS is generally an inconsistent procedure, while 2SRI allows the estimates of structural equation parameters to be consistent (Wooldridge 2010; Terza et al. 2008). The 2SRI method has been employed in other studies too (Shea et al. 2007; Shin & Moon 2007; Lindrooth & Weisbrod 2007). In case of full parametric assumptions, the 2SRI approach involves separate maximum likelihood estimation of both first- and second-stage equations. The econometric specification that allows us to model farmer behaviour in a proposed 2SRI process is the count data model. Specifically, we estimate the factors affecting farmers' membership in FPOs. The choice of a farmer to enrol or not enrol as an FPO member can be affected by farmers' characteristics and other regional and local factors. Therefore, this decision can be modelled using the following specification:

$$\mathrm{FPO}_i = \beta_0 + \beta_1\,F_{ij} + \beta_2 R_j + \mu_{ij} \qquad (2)$$

where FPO_i is a dummy for the type of farmer that takes the value 1 if the farmer is an FPO member and 0 otherwise; F_{ij} is a vector of farmer characteristics; R_j is a vector representing regional characteristics; and μ_{ij} is the error term. Equation (2) is estimated using a generalized linear model. Because of the discrete nature of the response variables, a count model (Cameron & Trivedi 2005) is necessary to assess the impact of FPO membership on number of technologies adopted and GAPs practised in the second stage. We first estimate the determinants of farmers' membership in FPOs using equation (2). In the second stage, we estimate the outcome equation:

$$Y_{ki} = \alpha_0 + \beta_1 FPO_i + \gamma X_i + \delta FS\mu_i + \zeta_i$$

$$k = 1, 2; i = 1, \dots..n \tag{3}$$

where Y_k represents the outcome variable ($k = 1, 2$; 1 = number of technologies adopted by farmer i; 2 = GAPs practised by farmer i); X_i is a vector of explanatory variables, $FS\mu_i$ are the residuals obtained from equation (2); FPO_i represents whether farmer i is associated with any FPO or not; α_0, β_1 and γ are unknown parameters to be estimated; and ζ_i is the error term. The *t*-statistic for the estimate of δ is an asymptotically efficient test for the exogeneity of FPO_i with outcome variable Y_k in the outcome equations (Smith & Blundell 1986); if δ is not statistically significant, then farmers' membership in FPOs is exogenous.

4 Results

Figure 2 depicts technologies that have been adopted by both FPO farmers and non-FPO farmers. Crop management poses several questions: which crop variety should be grown when? how can crop production be maximized given scarce resources? how should land be prepared? how should soil be managed? and so on.

In our field survey, almost 78% of FPO farmers but only about 6% of non-FPO farmers reported to have adopted crop management techniques over the previous year, and nearly 17% of FPO farmers whereas only 3% of non-FPO farmers had adopted improved techniques of insecticide and pesticide application. It can be inferred from Figure 2 that FPO members were more likely than non-FPO members to adopt new technologies. It is crucial to examine what led farmers to become members of FPOs in the first place. The reasons can be a good reflection of how well FPOs have done the job that they are mandated to.

4.1 Factors affecting membership in FPOs

Table 3 presents the estimates of parameters for the factors determining FPO membership. A probit fixed effects model was used to estimate the determinants of membership in FPOs. We control for block-level fixed effects to account for block-level characteristics influencing membership in FPOs. Robust standard errors clustered at the block level are reported correcting for any heteroscedasticity.

Education is one of the main determinants of FPO membership. The educational status of the household head positively and significantly affects their decision to enrol as an FPO member. Those with high-school
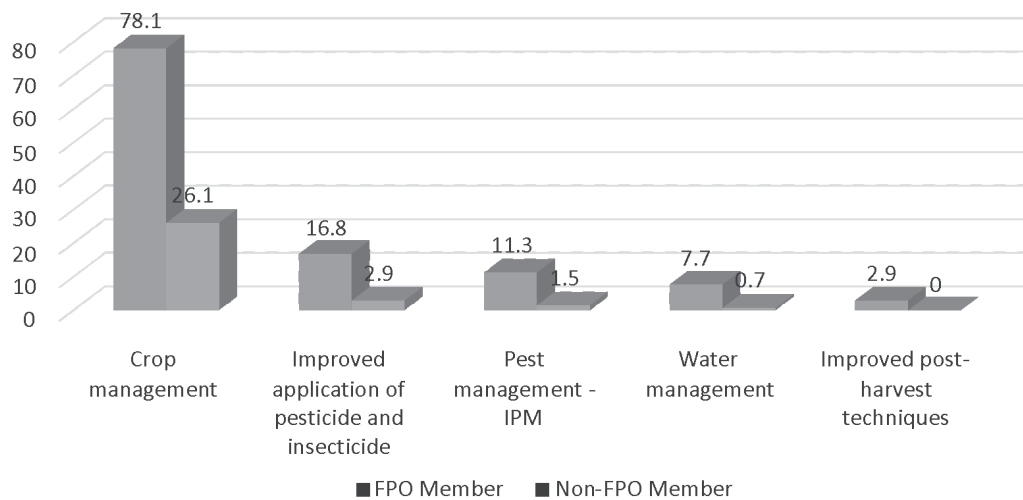

Figure 2. Technology adoption by FPO and non-FPO farmers

Table 3. Determinants of membership of FPOs

Variables	FPO member (1=yes, 0=otherwise) Marginal effects (dy/dx)
Gender (1=male; 0=female)	-0.226*
	(0.121)
Social group (base: SC/ST)	
OBC	-0.010
	(0.086)
General	-0.080
	(0.140)
Education (base: no school)	
Middle school	0.209***
	(0.053)
High school	0.298***
	(0.076)
Intermediate	0.213***
	(0.081)
Bachelor and above	0.210*
	(0.113)
Farming primary occupation	0.153***
(1=yes; 0=otherwise)	(0.055)
Monthly food expenditure (log) (Rs)	0.085
	(0.064)
Experience in farming (log) (years)	0.021
	(0.040)
Household size (log)	-0.019
	(0.056)
Access to internet (1=yes; 0=otherwise)	0.108
	(0.124)
Ration card holder (1=yes; 0=otherwise)	0.055
	(0.060)
Total area (acre)	0.009
	(0.012)
Have taken loans in the last 3 years	0.134**
(1=yes; 0=otherwise)	(0.065)
Sources of information about new technologies	
Friends/relatives	0.087
	(0.058)
Fellow villagers/neighbours	0.033
	(0.053)
KVK/ATMA/ICAR/government extension officials	0.170***
	(0.055)
Input/seed dealer	0.066
	(0.068)
Mass-media/social network	-0.121
	(0.077)
Perception about risks	
Increase in input prices	-0.077
	(0.060)

Contd...

Pest attacks	-0.053
	(0.071)
Collapse in market price	0.052
	(0.049)
Block fixed effects	yes
Log pseudolikelihood	-335.151
Pseudo R^2	0.097
Correctly classified	51.084
# of observations	536

Note: Values in parentheses are robust standard errors; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

education are almost 30% more likely than those with no schooling to be an FPO member. The magnitude of the effect of education on FPO membership is smaller for those with lower levels of education (primary and middle school) than for those with high-school education possibly because they are relatively less aware than their high-school educated counterparts. But the magnitude of impact is also lower for those with higher than high-school education (intermediate and above). This seems counterintuitive at first glance, but it might be that higher education erodes trust and belief in rural institutions such as farmer organizations and leads farmers to perceive FPO membership to yield few benefits, if any.

Households headed by females are over 22% more likely to have membership in FPOs. This is unsurprising because women tend to be more open to receiving new knowledge and information as also trying new things that they might perceive to be beneficial. Households for which farming is their primary occupation are 15% more likely to become FPO members as farmer organizations would have most of their activities, trainings, services and potential benefits around the broad theme of farming. A person who engages in wage labour as his primary occupation will have little motivation to join an FPO, unless there is someone else in her/his household who is involved in farming activities and could potentially benefit from such membership.

Having access to loans is another important determinant of membership in FPOs – those who had taken loans over the previous three years were 13% more likely to be FPO members. People who have access to loans are likely to, as FPO members, expect to get access to better and cheaper inputs and higher prices for their

produce. The lure of prospective benefits of higher profits and incomes entice indebted farmers to enrol as FPO members.

Lastly, among the various sources of information about new technologies, those who received information from Krishi Vigyan Kendras (KVK), the Agricultural Technology Management Agency (ATMA), the Indian Council of Agricultural Research (ICAR) or other government extension officials were more likely to join FPOs. It is possible that farmers perceive encouragement from officials of these agencies to join FPOs as more credible and lacking in any ulterior motive.

4.2 Impact of FPO membership on adoption of technologies and GAPs

We use the 2SRI method to assess the impact of FPO membership on adoption of technologies and GAPs in Bihar. The results obtained from our empirical model are presented in table 4. Employing the exogeneity test for a simultaneous equation tobit model (Smith & Blundell 1986), we see that the *t*-statistic for the residual term in the residual inclusion specification is statistically significant at the 10% level of significance for the number of technologies adopted and at the 1% level of significance for GAPs. These results reject the null hypothesis of exogeneity of FPO membership in explaining variation in adoption of technologies and GAPs across FPO members and non-members in Bihar. We have controlled for block-level fixed effects in the regression to account for unobserved block-level characteristics that might impact adoption of technologies and GAPs, and standard errors are clustered at the village level.

The first stage of 2SRI determines the drivers of membership in FPOs (table A1) and the second stage shows the impact of FPO membership on the number of technologies adopted. The results suggest that FPO membership has a statistically significant and positive impact on the number of technologies adopted by farmers – on an average, FPO members adopted 1.5 times greater number of technologies than non-members (Table 4). Those belonging to the general caste and OBCs adopted fewer new technologies (by almost 26% and 32%, respectively) compared to farmers belonging to the SCs and STs. This implies that association with FPOs is more effective in

enhancing the adoption of improved technologies for the weaker and relatively more disadvantaged sections of farmers.

Households with farming as their primary occupation adopted significantly greater number of technologies compared to those for whom farming and allied activities did not comprise their primary occupation. A 1% increase in the cultivable land size also increased the number of new technologies adopted by 2.3%.

In terms of sources of information, those who received information about new technologies from fellow villagers and neighbours adopted more new technologies (by almost 21%) than others. Farmers who perceive pest attacks and collapse in market prices as important sources of risks, adopt almost 36% and 25% greater number of new technologies, respectively. This corresponds with the perception of benefits that farmers could achieve from being an FPO member.

Membership in FPOs has a statistically significant and positive impact on the adoption of GAPs – a member farmer adopts 30% more GAPs than a non-member farmer on an average. This is a substantial difference and points to the benefits that can be achieved from being an FPO member. Farmers from households with female heads practice GAPs by almost 58% more than those belonging to male-headed households. Interestingly, the greater the number of years of experience in farming, the lesser the number of GAPs practised. This might seem counter-intuitive at first glance. However, it is likely that farmers who have been in the business of farming for long have hardened beliefs in conventional knowledge and practices and are more likely to be reluctant in adopting new practices that counter their long-held beliefs. An increase in the size of cultivable land by 1% also increases the number of GAPs practised by about 4%.

Internet access increases the number of GAPs practised by over 33%; so does the use of mass media and social networks as sources of information (by almost 48%). Even farmers who obtain information from KVK, ATMA, ICAR or government extension officials practise 36% more GAPs than those who do not utilize these sources of information.

As far as perception of risks is concerned, those who perceive pest attacks as a potentially important source of risk bring into practice 28% more GAPs than others.

Table 4. Impact of FPO membership on adoption of technologies and GAPs

Variables	2SRI	
	1	2
	Number of technologies adopted	GAPs
FPO member (1=yes; 0=otherwise)	1.459***	0.295**
	(0.167)	(0.133)
Gender (1=male; 0=female)	-0.201	-0.575**
	(0.163)	(0.266)
Social group (base: SC/ST)		
OBC	-0.321***	0.128
	(0.103)	(0.260)
General	-0.261**	-0.233
	(0.131)	(0.271)
Education (base: no school)		
Middle school	-0.002	0.104
	(0.104)	(0.188)
High school	-0.084	0.142
	(0.114)	(0.221)
Intermediate	-0.079	-0.008
	(0.139)	(0.212)
Bachelor and above	-0.023	0.165
	(0.128)	(0.197)
Farming primary occupation (1=yes; 0=otherwise)	0.310**	-0.163
	(0.136)	(0.175)
Monthly food expenditure (log) (Rs)	0.067	0.001
	(0.083)	(0.142)
Experience in farming (log) (years)	-0.243	-1.023**
	(0.349)	(0.441)
Household size (log)	-0.751	-0.238*
	(0.507)	(0.132)
Square of experience in farming (log) (years)	0.032	0.177**
	(0.064)	(0.086)
Access to internet (1=yes; 0=otherwise)	-0.118	0.334**
	(0.118)	(0.170)
Ration card holder (1=yes; 0=otherwise)	-0.125	-0.198
	(0.092)	(0.166)
Total area (acre)	0.023*	0.038**
	(0.012)	(0.019)
Have taken loans in the last 3 years (1=yes; 0=otherwise)	-0.032	-0.124
	(0.073)	(0.113)
Sources of information about new technologies		
Friends/relatives	-0.084	-0.005
	(0.084)	(0.121)
Fellow villagers/neighbours	0.214***	0.083
	(0.076)	(0.126)
KVK/ATMA/ICAR/government extension officials	0.143	0.359*
	(0.091)	(0.193)
Input/seed dealer	0.157*	-0.252
	(0.082)	(0.155)
Mass-media/social network	0.020	0.479***
	(0.098)	(0.121)
		Contd...

Perception about risks		
Increase in input prices	0.030	0.022
	(0.079)	(0.164)
Pest attacks	0.359***	0.277**
	(0.068)	(0.123)
Collapse in market price	0.252***	-0.232
	(0.077)	(0.146)
First-stage residuals	-1.890*	-6.357***
	(1.032)	(2.222)
Constant	-0.495	2.744
	(1.420)	(1.963)
Block fixed effects	Yes	Yes
Log pseudolikelihood	-467.938	-665.403
Akaike's Information Criteria (AIC)	1.883	2.599
Bayesian Information Criteria (BIC)	-2977.268	-2797.404
Number of observations	549	549

Note: Values is parentheses are robust standard errors; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Farmers cultivating fruits and vegetables often consider pest attacks as a potent threat to their crops and hence an important source of risk, and are, therefore, more likely to practise greater numbers of GAPs than those who grow pest-resistant varieties of more resilient crops.

4.3 Constraints to technology adoption

Figure 3 depicts the constraints that inhibit the adoption of technologies by farmers. The lack of access to adequate and formal sources of credit is one of the most important factors stymieing adoption of greater number of technologies – nearly 60% of FPO members and 68% of non-members attributed non-adoption to lack of credit facilities. The high cost of technologies, which is exacerbated in the absence of adequate credit, was another important factor that wedged technology adoption in greater numbers. The other constraints that became known were adverse weather conditions and waiting to see the impact of adoption of such new technologies by others before adopting them themselves.

One of the founding principles of FPOs as also one of its most crucial functions is to provide farmers access to capital and credit. However, the picture that emerges from our field study in this respect is not very
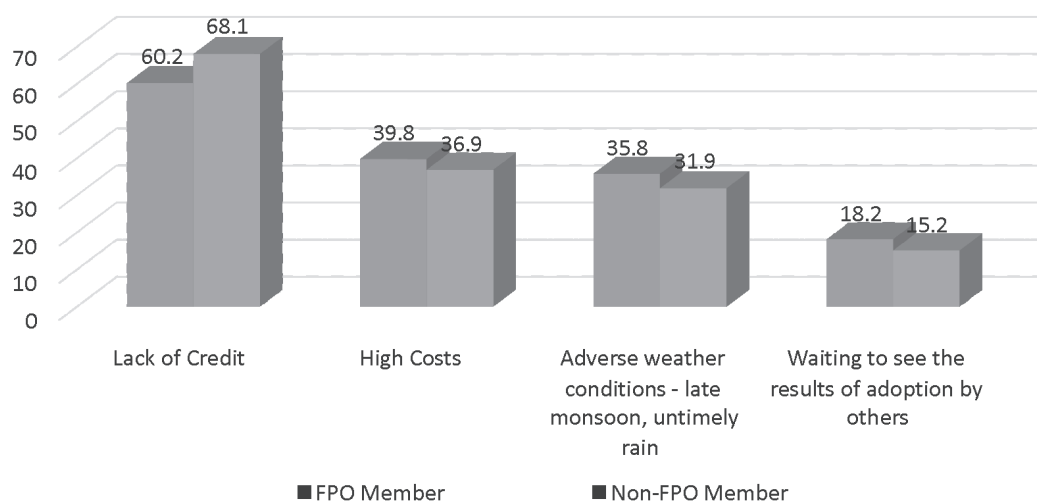

Figure 3. Major constraints inhibiting adoption of new technologies among FPO members and non-members
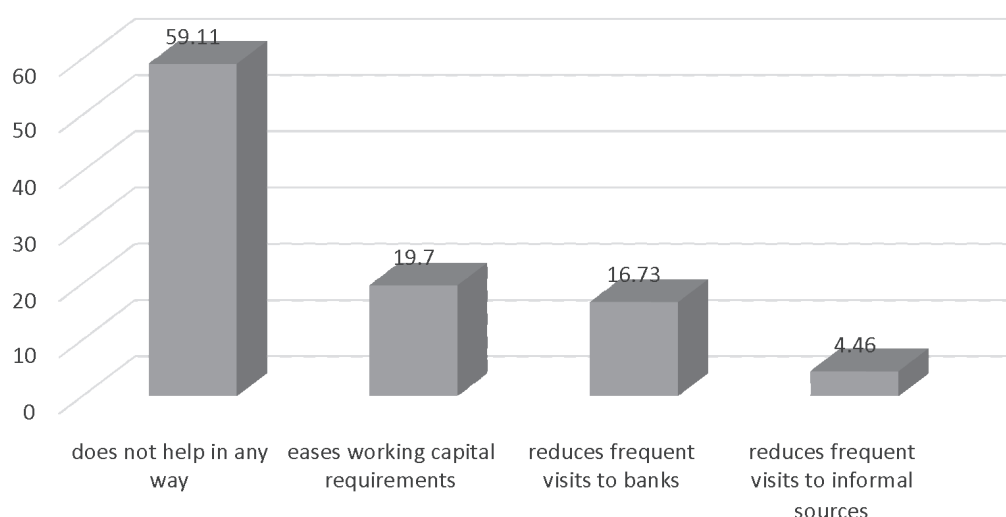
Figure 4. How does membership in FPOs ease the credit constraint?

encouraging. The lack of access to capital and credit is one of the most important constraints to adoption of new technologies in greater numbers (figure 3). Figure 4 shows how access to credit and capital has eased (or not) with membership in FPOs. This aspect of FPOs in Bihar also turns out to be in a rather dismal state. Nearly 59% of FPO members believed that their membership in FPOs did not help them in any way to get access to credit. Only about 20% thought that it had eased working capital requirements; 17% were of the view that it reduced their need to frequently visit the bank; and just about 4% reported that it had reduced their frequent visits to informal sources of credit.

5 Conclusion and policy implications

The results of the Bihar survey suggest that as an institution for collective action the FPO has been successful on many fronts. The success in getting new information on crop management, technology, and seeds; inputs such as fertilizers, pesticides, and insecticides at cheaper prices; and higher prices and new markets for their produce have resulted in significant benefits to FPO members in the form of enhancement of their incomes. The sudden decline or collapse in market price was the biggest fear of farmers, but as FPO members, now they can deal with these situations better.

Several challenges remain, however. One of the biggest challenges – farmers' inability to access capital – is undermining the foundation of the FPO. One of the motives behind the formation of an FPO is to provide

farmers access to capital. But most of the member farmers in our survey reported that their FPO does not help them in getting access to capital in any way. This emerged as a great barrier in providing many services such as infrastructure for value addition. The other challenges are lack of proper monitoring and evaluation, no record of farmer members, no penalties for wrongdoers and no incentive for farmers doing well.

The lack of proper monitoring and evaluation is one of the biggest impediments in the growth of FPOs as a robust institution. The FPOs do not maintain records of their members; often, farmers also do not know whether they are members of any such organization. In this scenario, there is little hope for FPOs to thrive. The focus in Bihar seemed to be not on strengthening the FPOs as an institution but simply on increasing their membership, without a selection mechanism. This is a serious challenge for FPOs to deal with if they must meaningfully serve the purpose they were created for.

Our FPO study in Bihar has several policy implications.

First, if FPOs are considered as a promising approach to ameliorate the condition of small and marginal farmers, there should be a proper mechanism for selecting members. While drafting rules and regulations for a selection mechanism, FPOs can consider selection based on cropping pattern or on region. It is always more convenient to monitor a small group of, say, 25-30 members than a larger group, and a record of each member in that group can be easily maintained. How can we make a group of 25–30 members? The answer

is based on cropping pattern. Different farmers grow different crops at the same time, so if we make a group for each crop the group size would be small. For example, there are farmers who grow vegetables, fruits, cereals, coarse cereals and pulses. If we have separate groups for each crop, it becomes very easy for the FPO to share crop-specific knowledge in a group. Even trainings organized by FPOs can be crop-specific so that only those concerned with that crop group need to attend. If selection based on cropping pattern is not possible, FPOs can select members based on region, that is, at the village level. On average 60–70 families reside in a village in India; a village-level group will have around 60-70 people, which is more manageable than larger groups. It would be wieldy for the FPO to conduct trainings and knowledge-based experiments for such groups at the village level.

Second, if FPOs want to maximize the price they receive for their produce, they need to come up with the idea of product differentiation. In our field survey, not a single FPO seemed to have this idea. For them, all tomatoes are the same, but if one thinks from a marketing perspective, this cannot be true. Tomatoes differ in, say, size – some are bigger, some are smaller and some are average in size. If tomatoes could be graded into different categories based on size, they could fetch prices accordingly and be sold for a higher collective value than if they were sold as a homogeneous commodity. FPOs should train farmers in such grading and sorting techniques. One can differentiate one's products by labelling – providing them with all relevant information such as freshness (plucked in the morning), organically produced (in villages they hardly use fertilizers for vegetables and fruits crops) and produced within a given radius from the market where it is being sold. In the USA, a successful campaign for fresh vegetables and fruits advertised that their food was coming from just within a 2-miles radius around the market. This marketing strategy was very successful and allowed farmers to earn premium on their products. Similar types of campaigns can be adopted by FPOs to help farmers earn extra bucks for their produce. One can also differentiate their products by packaging. Packaging not only keeps the food safe and free from dirt, dust and pollutants, it also plays an important role in visually appealing to buyers. If FPOs can encourage its member farmers to package their produce, they can earn much higher prices than they would by selling the same produce without packaging.

Finally, if FPOs want farmers to participate actively in a group, they need to give them incentives. For example, if a farmer is doing well in a group then she/he can be rewarded for the good work, say an extra 10% on profits. Similarly, if a farmer in a group is not doing well or not participating actively, some penalties could be imposed on her/him, say a 10% deduction from his/her profits. If FPOs adopt an incentive-based model, each farmer in a group will participate actively and it will reduce the problem of free-riding to some extent.

Adherence to these key founding principles of FPOs can play a determining role in its success in yielding the benefits it ought to, to farmers who choose to become members of such farmer organizations for collective action. It can go a long way in developing its capacity to survive and thrive in a self-sustaining manner in the long run.

Acknowledgement

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Table A1. First-stage estimates in evaluating the impact of FPO membership on adoption of technologies and GAPs

Variables	2SRI	
	(1) Number of technologies adopted	(2) GAPs
	1st stage FPO member = 1	1st stage FPO member = 1
Gender (1=male; 0=female)	-0.302*	-0.298
	(0.183)	(0.193)
Social group (base: SC/ST)		
OBC	-0.027	-0.042
	(0.132)	(0.131)
General	-0.151	-0.171
	(0.169)	(0.169)
Education (base: no school)		
Middle school	0.443***	0.442***
	(0.141)	(0.142)
High school	0.592***	0.599***
	(0.146)	(0.147)
Intermediate	0.446***	0.437***
	(0.168)	(0.170)
Bachelor and above	0.401**	0.390**
	(0.172)	(0.177)
Farming primary occupation (1=yes; 0=otherwise)	0.275**	0.261**
	(0.120)	(0.119)
Monthly food expenditure (log) (Rs)	0.182*	0.159*
	(0.095)	(0.096)
Experience in farming (log) (years)	0.753**	0.706**
	(0.368)	(0.356)
Household size (log)	0.905	0.023
	(0.814)	(0.103)
Square of experience in farming (log) (years)	-0.137*	-0.128*
	(0.070)	(0.068)
Access to internet (1=yes; 0=otherwise)	0.214	0.212
	(0.155)	(0.159)
Ration card holder (1=yes; 0=otherwise)	0.111	0.101
	(0.099)	(0.098)
Total area (acre)	0.012	0.014
	(0.014)	(0.014)
Have taken loans in the last 3 years (1=yes; 0=otherwise)	0.238***	0.237***
	(0.091)	(0.091)
Sources of information about new technologies		
Friends/relatives	0.140	0.109
	(0.101)	(0.099)
Fellow villagers/neighbours	0.072	0.046
	(0.101)	(0.100)
KVK/ATMA/ICAR/government extension officials	0.318***	0.288***
	(0.092)	(0.088)
		Contd...

Input/seed dealer	-0.007	-0.004
	(0.111)	(0.114)
Mass-media/social network	-0.267**	-0.283**
	(0.116)	(0.121)
Perception about risks		
Increase in input prices	-0.109	-0.115
	(0.109)	(0.110)
Pest attacks	-0.113	-0.105
	(0.119)	(0.122)
Collapse in market price	0.111	0.111
	(0.089)	(0.091)
Constant	-4.740***	-3.616***
	(1.397)	(0.973)
Block fixed effects	Yes	Yes
Number of observations	549	549

Note: Values is parentheses are robust standard errors; *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.