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Impact of contract farming of paddy seed on smallholder farm profits: evidence from Nepal

Anjani Kumar[a]*, Devesh Roy[a], P K Joshi[a], Gaurav Tripathi[a] and Rajendra P Adhikari[b]

[a]International Food Policy Research Institute, South Asia Office, New Delhi-110012, India
[b]University of Tasmania, Life Sciences Building, Sandy Bay Campus, Hobart TAS 7001, Australia

Abstract The paper identifies determinants of farmers' participation in contract farming of paddy seed and its impact on farm income using survey data from 502 farmers engaged in paddy seed production in Nepal. The results show that contract farming enhances profits for paddy seed cultivators and participation in it is influenced by farm size and main occupation of the cultivators. The empirical evidence on benefits from contract farming suggest the need for conducive policies for promotion and upscaling of contract farming for augmenting seed production.

Keywords Contract farming, Paddy seed, Impact, Nepal

JEL classification Q12, Q13, Q17, Q18

1 Introduction

Agriculture is the mainstay of Nepal's economy contributing about 32% to the country's gross domestic product (GDP) and employing two-third of the population. Agricultural productivity, however, is low, and is attributed to several factors such as low public and private investment, poor access to institutional credit and inadequate use of quality inputs (Sharma 2009; Pokhrel 2012). Use of quality inputs is, thus, crucial for accelerating agricultural growth. Among agricultural inputs, improved seed is the most important determinant of realizing the potential of agriculture (Maredia and Howard 1998; Awotide and Tontsa 2011). In fact, cultivating better-quality seeds alone may increase crop yields by 20–30% (Upadhyaya 1999a, 1999b; Sah et al. 2015).

Paddy is the most important crop in Nepal, accounting for 35% of gross cropped area (GCA) and 42% of the value of output of the crop sector (Thapa et al. 2017). Yet only about 15% of farmers use improved seed (CBS 2011). Several factors are attributed for the low adoption of improved paddy seed, including a significant gap in supply and demand. In 2010–11, there was a supply of 6,770 tons of paddy seed vis-à-vis a demand of 77,800 tons (Paudel et al. 2013). Despite the prevalence of favourable agroclimatic conditions for seed cultivation, existing seed replacement rate (SRR) for cereals is far lower than the recommended rate of 25% (MoAD 2014).

The Government of Nepal has been conscious about the prevalent situation and has taken several initiatives to enhance availability of certified/improved seeds by encouraging participation of the farming community, non-governmental organisations (NGOs), and private sector in seed production. The Seed Board of Nepal has allowed 20 private companies and cooperatives to produce foundation seeds availing the breeder seed from the Nepal Agriculture Research Council (NARC). The National Seed Company Limited (NSCL), NGOs, and private companies (MoAD 2012) use foundation seeds to produce certified/improved seeds.

In 1999, the District Self Sufficiency Seed Programme (DISSPRO) was initiated by the Crop Development

*Corresponding author: anjani.kumar@cgiar.org

Directorate of Nepal's Department of Agriculture. It is a community-based programme involving farmers' groups and cooperatives in seed production through contract farming (Pokhrel 2012). The programme has been implemented in various districts by the District Agriculture Development Offices (DADO) and is now the largest contributor to the formal seed production system.

The effect of contract farming (CF) on the well-being of smallholders in developing countries depicts a mixed picture, with both positive and negative outcomes (Little & Watts 1994; Opondo 2000; Morvaridi 1995; Baumann 2000; Key & Rusten, 1999; Glover & Kusterer 1990; Goldsmith 1985; Glover 1984; Simmons et al. 2005; Porter & Howard, 1997). Several researchers have studied the impact of CF on income and employment and found that CF helps improve the income of farmers and generate employment for the rural poor (Wainaina, Okello & Nzuma 2012; Kalamkar 2012; Ramaswami Birthal & Joshi 2006; Tripathi, Singh & Singh 2005; Birthal, Joshi & Gulati 2005; Singh 2002; Warning & Key 2002; Glover & Kusterer 1990; Key & Rusten 1999; Goldsmith 1985; Glover 1984; Leung, Sethboonsarng & Stefan 2008; Bellemare 2012; Michelson 2013; Miyata, Minot & Hu 2009; Xu & Wang 2009; Zhu 2007; Simmons, Winters & Patrick 2005). On the other hand, a number of researchers have also pointed out towards the negative impact of CF on the environment, and also welfare of farmers (*see* Singh 2002; Opondo 2000; Key & Runsten 1999; Morvaridi 1995; Little & Watts 1994). For instance, Little and Watts (1994) dispute the positive impact of CF on the income of beneficiaries. Singh (2002) highlights the exploitative nature of CF-monopsonistic power of the firms involved in it. Similarly, Key and Runsten (1999) attribute inequalities in rural income to be a negative outcome of CF.

In this study, we analyse an improved paddy seed production contract between co-operatives and farmers with an objective to determine whether farmers who participated in this contract are better off because of the contract and to understand the factors that motivate farmers to participate in the contract.

For this study, we surveyed about 500 paddy seed producing households from the major paddy seed producing areas of Nepal. Chitwan, Rupandehi, Dang, Banke and Kailali are the main districts where the contract farming in paddy seed is widespread. We use this data to examine how contracting has affected farmers' profits as well as the use of inputs in paddy seed production. Cooperatives also guide farmers on seed production methods and technology. The cooperatives have limited provision for providing fertilizers, micronutrients, pesticides, and loans to the farmers.

2 Data and methodology

2.1 Data

This study is based on a survey of households cultivating paddy seed in Nepal. Using a structured questionnaire, we gathered data on farmers' characteristics, cropping pattern, economics of cultivation, marketing channels and good agricultural practices. The survey was conducted during February-March 2015 in the districts of Chitwan, Rupandehi and Dang, located in the central, western, and mid-western regions of Nepal, respectively. We selected these districts due to high prevalence of paddy seed CF and presence of farmer-producer companies-cum-cooperatives undertaking formal contracts with farmers for paddy seed production.

Our survey comprised of 303 contract farmers and 199 noncontract farmers chosen randomly from 26 wards under 7 village development councils (VDCs) from three sample districts. The sample was selected from the three districts in proportion to the number of contract farmers in the respective district. Hence, the number of farmers selected from Chitwan, Rupandehi, and Dang districts were 165, 246, and 91, respectively. The VDCs within the district were selected based on the presence of paddy seed contract farmers. The sample households were classified into three groups based on farm size—marginal (<0.5 ha), small (0.5–<1 ha), and medium (≥1 ha).

2.2 Methodology

We used the survey data to estimate and compare profits for contract and noncontract paddy seed growers. With information on different inputs and their prices from respondents, we estimated cultivation and production costs and carried out a partial budget analysis to estimate the costs and returns for both contract and noncontract farmers. The cost of cultivation includes

expenditure on inputs (seed and manure), services, labour (own and hired), and land taxes. We calculate profit as the difference between cost incurred and revenue generated.

We also attempt to identify the factors that motivate farmers to enter a contractual arrangement with the buyers and assess the impacts of contract farming on the farmer's economic welfare. The empirical literature on these two aspects of CF is extensive. Several researchers have estimated the probability of a farmer's decision to contract as the first step in a two-step econometric process to analyse the impact of CF on farmers' welfare (for example, Katchova & Miranda 2004; Simmons Winters & Patrick 2005; Miyata, Minot & Hu 2009; Wang, Zhang & Wu 2011; Bellemare 2012; Gupta & Roy 2012; Ito, Bao & Sun 2012). Others focus exclusively on the decision to participate in contract farming (Birthal, Joshi & Gulati 2005; Guo 2005; Masakure & Henson 2005; Zhu & Wang 2007; Fischer & Qaim 2012; Kumar, Shinoj & Shivjee 2013).

Employing a logit model to examine farmers' willingness to opt for contract farming, we identified several sociodemographic and economic characteristics that influence their decision. These include age, education, gender, gender of household-head, family size, farm size, migration, caste, education, primary occupation, and remittance. Since the dependent variable is a binary variable (farmer's participation in contract farming = 1, otherwise = 0), and the independent variables were a mix of qualitative and quantitative factors, the logistic regression was used:

$$Y = \ln[p/(1-p)] = \beta_o + \sum \beta_i X_i \quad \ldots(1)$$

where, p represents the probability that a farmer will participate in CF and β_is are the regression coefficients estimated by the maximum likelihood method. The X_is are the explanatory variables.

For assessing the impact of contract farming on farmers' income, a profit regression is estimated:

$$\pi_i = \alpha + \delta d_i + \gamma X_i + \varepsilon_i \quad \ldots(2)$$

where, π_i is the net profit (per kg) received by a farm household from paddy seed cultivation, d_i is a dummy variable that equals 1 if a farmer is under contract and 0 if not under contract, X_i is a vector of farmer characteristics and ε_i is the error-term.

An ordinary least square (OLS) estimation of Eq.(2) may lead to biased results, as farmer participation in a contract is not decided randomly. Farmers are either selected for a contract by the buyers or they self-select to participate in CF.

Hence, different observed and unobserved factors could guide farmers' entry into CF. Thus, the variable representing a farmer's participation in contract farming can be endogenous, and thus correlated with error-term ε_i. The use of an OLS regression for determining the contribution of CF to farmers' welfare may produce biased estimates.

Therefore, we use 2-Stage Least Squares (2SLS) model with instrumental variables to minimize the bias due to unobserved and omitted variables. An ideal instrumental variable should not correlate with the dependent variable in Eq.(1). It should, however, correlate with d_i, the variable representing participation in contract farming. It should not be a variable from the vector of a farmer's characteristics, X_i.

We identified three instrumental variables: (1) 'demand' as motivation factor for adopting paddy seed cultivation, (2) 'demand' and 'price' as motivating factors for adopting paddy seed cultivation, irrespective of year of adoption, and (3) proportion of contract farmers by caste group in each ward.

We asked farmers about the year of adoption of paddy seed cultivation and the motivations behind their decision to adopt. Around 67% farmers in the sample had adopted commercial paddy seed cultivation prior to 2010 while all had adopted it by 2014 i.e. before the year of survey (2015). Note that with complete adoption, there still is extant difference in terms of contracting. Contract farming is likely for those farmers who are commercially oriented at least in a relative sense. Commercial orientation is reflected in expectation of higher demand and price as motivation for adoption of paddy seed cultivation. Indeed, we do find more commercially oriented farmers more likely to be getting into contract. Moreover, these motivations are related to adoption of paddy seed cultivation prior to contract; hence satisfy the exclusion condition for an instrument.

In our sample 53% farmers had identified 'high demand for seeds in the market' as a motivating factor while 41% had selected 'remunerative price for seed' as the

reason behind their decision to go for seed production. With the decisions predating the joining of the contract, the motivations for adopting commercial cultivation of paddy seed are not related with current profit (dependent variable). The other instrument i.e. 'proportion of contract farmers by caste group in each ward' involves division of the number of contract farmers of a particular caste group in a ward (while excluding the respective household with respect to each record) with the total number of farmers in that ward. This is done with respect to each household. This gives share or proportion of contract farmers of a caste group in a ward (excluding respective household). Similarly, the proportion of contract farmers belonging to different caste groups is determined for all the households from different wards.

We expect that farmers belonging to same caste have strong network relations among them. Hence, we have taken 'proportion of contract farmers by caste group in each ward' as an instrument as farmers' social network relations influence their decisions pertaining to participation in contract farming; and this instrument does not directly affect profits and does so only through the decision to contract. The survey data also indicates strong correlation between farmers' participation in contract farming and network instrument while it is not related with the dependent variable i.e. profit.

We used these variables as instruments, as they are likely to be exogenous to the dependent variable in Eq. (1) and are not correlated with it. They are, however, strongly correlated with d_i (i.e. the probability of participation in CF), and therefore meet the condition of an ideal instrument variable.

Further, we use propensity score matching (PSM) to gauge impact of contract farming on unit profit. This also helps check robustness of the results based on OLS and IV. The matching approach is used to find a large group of control households that are similar to the treatment households in all relevant pre-treatment characteristics X. Then, the differences between the outcomes of the control group and of the treatment group can be attributed to the treatment. Since conditioning on all relevant covariates is limited in the case of a high-dimensional vector X, Rosenbaum and Rubin (1983a) suggest the use of balancing scores b(X), that is, functions of the relevant observed covariants X such that the conditional distribution of X given b(X) is independent of assignment into treatment, also known as the conditional independence assumption (CIA). One possible balancing score is the propensity score, that is, the probability of participating in a treatment given observed characteristics X. The matching procedures based on this balancing score are known as propensity score matching.

Besides CIA, a second assumption of matching requires that treatment observations have comparison observations "nearby" in the propensity score distribution. This common support or overlap condition ensures that persons with the same X values have a positive probability of being both control and treatment households (Heckman, LaLonde & Smith 1999). The common support, thus, represents the area where there are enough of both control and treatment observations. The common support region allows effective comparisons of outcomes between the treatment and control groups.

Assuming the CIA holds and that there is overlap between both the groups, the average treatment effect can then be estimated. One ideally wants to estimate $\Delta = Y_t^1 - Y_t^0$, which is the difference of the outcome variable of interest at time t between two groups, denoted by the superscripts 1 and 0. However, we are unable to estimate Δ in this way because a household cannot simultaneously be in the treatment and the control groups. Therefore, we measure the average treatment effect (ATE). We estimate the average treatment effect on the treated households (ATT), given a vector household characteristic, X (Birol et al., 2011):

$$ATT = E(\Delta|X,T=1) = E(Y_t^1 - Y_t^0|X,T=1) = E(Y_t^1|X,T=1) - E(Y_t^0|X,T=0)$$

To estimate potential effects of a participation in contract farming, propensity scores are used to match households with similar observable characteristics. Propensity score matching entails forming matched sets of treated and untreated subjects who share a similar value of the propensity score (Rosenbaum & Rubin 1983a, 1985). Propensity score matching allows one to estimate the ATT (Imbens 2004). We use nearest neighbor matching to select best control matches for each subject in the treatment group. We match 1, 3 and 5 control subjects to each treated subject using nearest neighbor matching besides kernel based matching with bootstrap standard errors.

3 Results and discussion

3.1 Characteristics of contract and noncontract farmers

Table 1 reveals significant differences in some of the characteristics and not in others. For example, contract and noncontract farmers differ in terms of operational holding size, gross cultivated area, cropping intensity and caste. The average operational holding size is much higher for contract farmers (1.0 ha) than noncontract farmers (0.6 ha). Similarly, the gross cultivated area is much larger for contract farmers (2.07 ha) than for noncontract farmers (1.26 ha). Cropping intensity for contract farmers (207%) is slightly lower than for noncontract farmers (217%).

Apprehension about promoting CF in developing countries stems from the fear of excluding smallholders. Critics of CF argue that firms, to reduce their transaction costs, prefer to engage a few large farmers rather than dealing with large numbers of smallholders. However, our results show that there is reasonable presence of smallholders in the contractual arrangements, yet the distribution of contract and noncontract farmers differ significantly by farm size

Table 1. Characteristics of contract and noncontract paddy seed cultivators in Nepal

Characteristics	Contract	Noncontract farmers	Difference	*t*-test of difference
Age of respondent (years)	45.4	44.9	0.5	0.3945
Number of years of education (highest educated household member)	12.3	12.3	0.0	0.0127
% households having education				
Primary	0.7	1.5	-0.8	(Pr = 0.567)
Middle	9.6	9.5	0.1	
Secondary	53.8	48.7	5.1	
Graduate & above	36.0	40.2	-4.2	
Household size (No.)	6.6	6.3	0.3	0.8189
Size of operational land (ha)	1.00	0.58	0.42	5.9547***
% distribution by farm size				
Marginal (<0.5 ha)	24.8	53.8	-29.0	***(Pr = 0.000)
Small (0.5 - <1 ha)	40.3	31.2	9.1	
Medium (≥1 ha)	35.0	15.1	19.9	
Gross cultivated area (ha)	2.07	1.26	0.81	5.8038***
Cropping intensity (%)	207	217	-10	-1.7225*
Irrigated area (%of total cropped area)	75.4	81.2	-5.8	-0.4823
Households having farming as primary occupation (%)	97.4	99.0	-1.6	-1.2822
Migration for employment (number per household)	0.35	0.41	-0.06	-1.0175
Monthly remittance (NPR)	6,397	6,488	-91	-0.0765
Experience in farming (years)	26.4	26.5	-0.1	-0.1196
Number of plots per household	2.7	2.4	0.3	1.8618
% distribution by caste				
General castes	45.9	44.2	1.7	***(Pr = 0.035)
Dalit	3.0	5.5	-2.5	
Tribal	38.9	44.7	-5.8	
Other backward castes	12.2	5.5	6.7	

Source: Authors' calculations based on field survey (2015).
Note: ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. NPR = Nepalese rupees.

(table 1). Only 25% of the contract farmers belong to the marginal farm size class as compared to 54% of the noncontract farmers. Low participation of smallholders may be voluntary as well as involuntary. Delayed payments based on highest annual price by cooperatives can be a disincentive for smallholders to participate in CF, as they require immediate payment to meet their cash needs. Further, the distribution of sample households based on caste group also differ significantly among contract and noncontract farmers. The share of general and other backward caste households is higher among contract farmers (58.1%) than noncontract farmers (49.7%). The share of dalit and tribal households (socioeconomically weaker sections) is lower among contract farmers (41.9%) relative to that among noncontract farmers (50.2%). However, there is no significant difference in education level between contract and noncontract farmers.

3.2 Economics of paddy seed production

Table 2 presents data on yield, production cost, output prices, and profits for contract and noncontract farmers. The average paddy seed yield is significantly higher for contract growers (43.5 q/ha) than noncontract producers (41.7 q/ha). Additionally, the average price realised by contract farmers (NPR 2,561/q) is significantly higher vis-à-vis noncontract farmers (NPR 2,364/q). The cost of paddy seed cultivation is slightly higher for contract farmers (NPR 55,961/ha) than for noncontract farmers (NPR 55,535/ha). The higher yields and better prices achieved by contract farmers makes paddy seed cultivation more profitable. On average, paddy seed contract farmers' profit is about 23.4% higher than those of noncontract growers. Furthermore, the higher profit realization is observed across farm categories (appendix table A1). It is notable that marginal farmers seem to fetch the highest benefit from contract farming. The unit profit for marginal contract farmers is 40% more than that for their counterpart noncontract farmers. Several studies have reported substantial positive impact of contract farming on gross margins, crop income or total household income.These include studies on Kenya (Wainaina, Okello & Nzuma 2012), India (Singh 2002; Birthal, Joshi & Gulati 2005; Tripathi, Singh & Singh 2005; Ramaswami, Birthal & Joshi 2006; Kalamkar 2012), Senegal (Warning & Key 2002), Laos (Leung, Sethboonsarng & Stefan 2008), Madagascar (Bellemare 2012), Nicaragua (Michelson 2013), China (Zhu 2007; Miyata, Minot, & Hu 2009; Xu & Wang 2009), and Indonesia (Simmons, Winters, & Patrick 2005).

Table 2. Economics of paddy seed cultivation for contract and noncontract farmers in Nepal, 2015

Economics of cultivation	Contract	Noncontract farmers	Difference	Difference (%)	t-test of difference
Yield (q/ha)	43.5 (12.6)	41.7 (13.3)	1.8	4.3	3.7052***
Price (NPR/q)	2,561 (168)	2,364 (209)	196.8	8.3	14.2884***
VOP (NPR/ha)	111,361 (32,538)	98,580 (34,228)	12781.3	13.0	6.7902***
Cost of cultivation (NPR/ha)	55,961 (17,415)	55,535 (14,473)	425.6	0.8	2.0265**
Cost of production (NPR/q)	1,287 (439)	1,332 (495)	-44.9	-3.4	2.7469***
Profit (NPR/ha)	55,401 (30,457)	43,045 (30,951)	12,355.8	28.7	6.2797***
Profit (NPR/q)	1,274 (451)	1,032 (518)	241.7	23.4	8.1895***

Source: Authors' calculations based on field survey (2015).
Notes: ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. Figures in brackets are standard deviation. NPR = Nepalese rupees; q = Quintals; ha = Hectare.

3.3 Determinants for farmers' participation in contract farming

The results of the logit model for determinants of farmers' participation in contract farming of paddy seed are presented in table 3 The explanatory variables include a variety of sociodemographic and economic characteristics such as age, gender, household size, farm size, educational level, social caste, farming experience, out-migration, and remittance to household. Choice of explanatory variables included in this analysis is guided by the previous empirical literature on the subject (for example, Miyata, Minot, & Hu 2007; Roy &Thorat 2008; Bellemare 2012; Fisher & Qaim 2012; Kumar, Shinoj, & Shivjee 2013). Regression results show farm size and main occupation as the significant determinants of farmers' participation in CF. Farm size has a positive effect on participation in CF, and 'farming' as the main occupation has a negative influence.

The contracting cooperatives do not make immediate payments to the farmers supplying paddy seed and make them wait to provide the highest market price achieved during the year. The contract farmers sometimes have to wait even for a year to get the optimum value for the paddy seed sold to the contracting cooperatives. This create disincentives particularly for marginal farmers who exclusively depend on agriculture. Hence, farmers having relatively large farm size and non-farm occupation as primary source of income tend to participate more in CF. Farmer's age, household size, gender, farming experience, remittances, and social caste have no effect on households' participation in CF.

Table 3. Determinants for farmers' participation in contract farming of paddy seed cultivation in Nepal

Dependent variable: Participation in contract farming (Yes = 1; No = 0)

Variable	Coefficients	S.E.	Marginal effect	S.E.
Socio-demographic variables				
ln (age in years)	0.0981	(0.347)	0.0231	(0.0823)
ln (household size in number)	-0.0498	(0.0810)	-0.0117	(0.0191)
Gender (male=1, otherwise=0)	0.118	(0.180)	0.0278	(0.0419)
ln (land size in ha)	1.036***	(0.233)	0.2441***	(0.0467)
Migration (yes=1, otherwise=0)	0.211	(1.401)	0.0497	(0.3285)
Social caste				
General (yes=1, otherwise=0)	0.510	(0.750)	0.1202	(0.1788)
OBC (yes=1, otherwise=0)	0.832	(1.017)	0.1961	(0.2453)
Tribal (yes=1, otherwise=0)	0.294	(0.443)	0.0692	(0.1048)
Educational level (highest in the family)				
Primary (5 years of schooling)	-0.368	(1.024)	-0.0867	(0.2408)
Middle (8 years of schooling)	0.468	(0.424)	0.1102	(0.0977)
Secondary (10 years of schooling)	0.330	(0.368)	0.0777	(0.0845)
Economic variables				
Main occupation (farming=1, otherwise=0)	-1.693**	(0.789)	-0.3992**	(0.1794)
ln (remittance in NPR)	-0.0285	(0.139)	-0.0067	(0.0326)
Constant	2.008	(1.887)		
Pseudo R^2	0.1049			
No. of observations	502			
log pseudo likelihood	-301.757			
District fixed effects	Yes	Yes	Yes	Yes

Source: Authors' calculations based on field survey (2015).

Note: ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. Standard errors are clustered at the VDC level.

3.4 Impact on farmer profits

We estimate the impact of contract farming in paddy seed cultivation using OLS and IV regressions, and the results are presented in table 4. We use three specifications with different combinations of instrumental variables: (i) 'demand' as motivation factor for adopting paddy seed cultivation, (ii) 'demand' and 'price' as motivation factors for adopting paddy seed cultivation, and (iii) proportion of contract farmers by caste in each ward. In table 4, the first column for each specification contains results of the first stage, which is similar to the coefficients given in table 3.

The second column shows the second stage results of IV regression, and all the specifications reveal that CF is a significant determinant of profit. Contract farmers earn higher profits than do the noncontract farmers. With OLS regression, the unit profit is higher by NPR 2.86 per kg vis-à-vis noncontract farmers. The contract farmers also benefit in terms of getting superior quality of source-seeds; guidance on methods and technology for seed production; and information and updates on government support programmes and inputs-markets. The Hausman test does not show endogeneity with respect to the first and second specifications of instrumental variables, indicating that OLS regression should be preferred over these two specifications of 2SLS regression. The Hausman test, however, indicates endogeneity with respect to the third specification of instrumental variable in 2SLS regression.

In addition to participation in CF, farm size has a significant positive effect on profit from paddy seed production. OLS regression shows that a 10% increase

Table 4. Determinants of profit for paddy seed cultivators in Nepal

Dependent variable: Unit profit in paddy seed production (NPR/kg)

Variable	OLS	2SLS					
		Specification 1		Specification 2		Specification 3	
		First stage	Second stage	First stage	Second stage	First stage	Second stage
Contract farming	2.855***		6.341***		5.180**		7.138***
	(0.670)		(2.010)		(2.212)		(2.490)
Socio-demographic variables							
ln (age in years)	0.122	-0.0024	0.0600	0.0016	0.0806	0.0246	0.0459
	(0.672)	(0.0704)	(0.737)	(0.067)	(0.677)	(0.0753)	(0.794)
ln (household size in n umber)	-1.085*	0.0077	-1.050**	0.0128	-1.061**	-0.0148	-1.041**
	(0.475)	(0.049)	(0.464)	(0.0464)	(0.455)	(0.0117)	(0.463)
Gender (male=1, otherwise=0)	1.424*	0.0054	1.325**	-0.0049	1.358**	0.0111	1.303**
	(0.626)	(0.0527)	(0.578)	(0.0515)	(0.569)	(0.0392)	(0.633)
ln (land size in ha)	1.376**	0.1857***	0.637	0.1542***	0.883	0.2115***	0.468
	(0.407)	(0.0281)	(0.645)	(0.029)	(0.660)	(0.0336)	(0.622)
Out-migration (yes=1, otherwise=0)	2.665	0.0289	2.596	-0.0052	2.619	0.0571	2.580
	(1.525)	(0.2585)	(1.795)	(0.2353)	(1.629)	(0.1738)	(1.960)
Social caste							
Other backward castes		0.0607	1.099***	0.0977	1.206***	0.0753	1.026**
(Yes=1, otherwise=0)		(0.0761)	(0.244)	(0.0784)	(0.164)	(0.0829)	(0.425)
General castes	0.300	0.0431	1.576***	0.0734	1.623***	0.0002	1.543***
(Yes=1, otherwise=0)	(0.671)	(0.0656)	(0.510)	(0.0611)	(0.509)	(0.0473)	(0.541)
Dalits (Yes=1, otherwise=0)	1.455	-0.0292	3.088***	0.0198	3.016***	0.1199	3.137***
	(1.248)	(0.1287)	(1.094)	(0.1245)	(1.048)	(0.1006)	(1.033)
Tribals (Yes=1, otherwise=0)	-1.418**						
	(0.464)						

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Educational level (highest in the family)							
Primary (4 years of schooling)	-0.765	0.0301	-1.125	0.0509	-1.163	-0.0274	-1.100
	(1.264)	(0.2241)	(1.498)	(0.2033)	(1.454)	(0.1626)	(1.511)
Middle (8 years of schooling)		0.1325	-0.836	0.0878	-0.714	0.099	-0.919
		(0.0829)	(1.063)	(0.0806)	(1.131)	(0.0754)	(0.951)
Secondary (10 years of schooling)	1.038	0.063	0.298	0.0336	0.388	0.0942	0.237
	(1.228)	(0.0439)	(0.658)	(0.0432)	(0.657)	(0.0599)	(0.758)
Graduate	0.472						
	(1.305)						
Economic variables							
Main occupation	-2.555**	-0.3622***	-1.362*	-0.3381***	-1.759**	-0.3582***	-1.089
(Farming=1, otherwise=0)	(0.701)	(0.1237)	(0.750)	(0.118)	(0.805)	(0.1044)	(1.105)
ln (remittance in NPR)	-0.151	-0.0068	-0.139	-0.0065	-0.143	-0.0068	-0.136
	(0.125)	(0.0264)	(0.169)	(0.0237)	(0.149)	(0.0171)	(0.191)
Instrumental variables							
'Demand' as motivation factor for adopting paddy seed cultivation		0.2432***		0.2643***			
		(0.0444)		(0.0437)			
'Price' as motivation factors for adopting paddy seed cultivation				0.235***			
				(0.0465)			
Proportion contract farmers by caste in ward						0.6643***	
						(0.2051)	
Constant	10.21**	0.9087***	5.830	0.7479**	6.974	0.7194**	5.046
	(3.745)	(0.3207)	(4.524)	(0.3072)	(4.745)	(0.3514)	(3.889)
Observations (No.)	502	502	502	502	502	502	502
R^2	0.216	0.1859	0.118	0.2351	0.172	0.1706	0.068
District fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors' calculations based on field survey (2015).
Notes: Robust standard errors in parentheses; ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively; Standard errors are clustered at the VDC level. VDC = Village Development Council; OBC = Other Backward Caste; NPR = Nepali Rupees; kg = Kilogram.

in farm size increases profit by NPR 0.13/kg. Family size has a significant negative effect on unit profit. A 10 per cent increase in family size results in a NPR 0.10/kg decrease in profit. Households belonging to the tribal castes are likely to earn less profit than other caste groups.

Table 5 shows impact of contract farming on unit profit in paddy seed cultivation using propensity score matching approach[2]. The outcomes of the nearest neighbour matching estimation with analytical standard errors as in Abadie and Imbens (2006) and kernel based matching with bootstrap standard errors are presented in table 5. The unit profit for contract farmers is significantly higher than that for noncontract farmers by NPR 2.55 per kilogram (kernel based matching) to NPR 2.61 per kilogram (nearest neighbor matching with number of matches = 5). Further, marginal farmers with farm size less than 0.5 ha are the real beneficiaries of CF (table 5). The contract farmers in marginal category earn significantly higher profit than their noncontract counterparts in the range of NPR 2.41 per kilogram (nearest neighbor matching with number of matches = 3) to NPR 2.85 per kilogram (kernel based matching). However, the small and medium contract farmers get significantly higher profit of NPR 2.08 per kilogram than their noncontract counterparts only with one nearest neighbor matching.

[2] List of variables used in satisfying the balancing property and common support of the propensity score include: Contract farming (treatment variable); ln (Age), ln (Household size), Gender of the household-head, ln (Operational land) Out migration, caste group, Education (highest in the family), Main occupation, and ln (Remittance)

Table 5. Impact of contract farming on profits of paddy seed cultivators in Nepal: Outcomes of the nearest neighbour matching and bootstrap standard errors (kernel-based matching)

Average Treatment Effects

Number of matches (m)	Unit profit in paddy seed production (NPR/kg)		
	All farmers	Marginal farmers (<0.5ha)	Small & medium (≥0.5 ha)
m = 1	2.602***	2.415***	2.075*
	(0.580)	(0.645)	(1.173)
m = 3	2.555***	2.409***	1.182
	(0.511)	(0.561)	(1.055)
m = 5	2.606***	2.654***	0.974
	(0.501)	(0.553)	(1.077)
Observations	502	366	136
Bootstrap standard errors (kernel-based matching)	2.554***	2.849***	-0.201
	(0.498)	(0.540)	(1.363)
Observations	502	366	132

Source: Authors' calculations based on field survey (2015).
Notes: Standard errors in parentheses; ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively; m=1, 3 and 5 indicating 1,3 and 5 neighbours respectively.

4 Conclusions

Using data collected in 2015, this study has assessed the effect of paddy seed contract farming on farm profits and identifies determinants of participation in CF. Farm size and main occupation of household are the key determinants of farmers' participation in paddy seed contract farming. Large farmers are more likely to join CF than do the small farmers. The unit profit for paddy seed cultivation also varies between contract and noncontract farmers. Contract farmers receive higher prices and have better yields than noncontract farmers.

Due to their high production potential, demand for improved quality seeds is soaring in Nepal. With the wider expansion of contract farming Nepal can achieve its "*Seed Vision*" goals and reduce its import of improved paddy seeds. CF will smooth the flow of seeds along the value chain. Given the increased policy focus of Nepal on food security, self-sufficiency, and agricultural exports, CF can play a key role in raising agricultural production. Results show that by expanding paddy seed production through CF, farmers gain greater access to improved seeds and realize higher gains in yield and profitability which will have a cascading effect on poverty alleviation and improvement in food security. CF in improved paddy seed cultivation will play a critical role in augmenting paddy production in the country.

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Table A1. Farm-size-wise economics of paddy seed cultivation in Nepal, 2015

Land-size category	Contract farmers	Noncontract farmers	Per Cent Difference	Difference	*t*-Test of difference
		Yield (q/ha)			
Marginal (<0.5 ha)	47.6	39.5	8.1	20.4***	3.3334
Small (0.5–1 ha)	42.9	41.5	1.4	3.3	1.4206
Medium (≥1 ha)	43.0	44.7	-1.7	-3.7	0.2978
All	43.5	41.7	1.8	4.3***	3.7052
		Price (NPR/q)			
Marginal (<0.5 ha)	2,606	2,350	256	10.9***	9.4119
Small (0.5–1 ha)	2,626	2,289	337	14.7***	10.7829
Medium (≥1 ha)	2,515	2,469	46	1.9**	2.3406
All	2,561	2,364	197	8.3***	14.2884
		Value of production (NPR/ha)			
Marginal (<0.5 ha)	124,113	92,953	31,160	33.5***	5.0091
Small (0.5–1 ha)	112,579	95,002	17,577	18.5***	4.2377
Medium (≥1 ha)	108,240	110,329	-2,088	-1.9	0.3339
All	111,361	98,580	12,781	13.0***	6.7902
		Cost of cultivation (NPR/ha)			
Marginal (<0.5 ha)	65,724	58,407	7,317	12.5***	3.3205
Small (0.5–1 ha)	61,630	55,544	6,086	10.9**	2.1920
Medium (≥1 ha)	50,966	51,880	-913	-1.8	0.9406
All	55,961	55,535	426	0.8**	2.0265
		Cost of production (NPR/q)			
Marginal (<0.5 ha)	1,380	1,477	-97	-6.5	1.6405
Small (0.5–1 ha)	1,438	1,338	99	7.4	0.0429
Medium (≥1 ha)	1,184	1,161	23	2.0	0.5122
All	1,287	1,332	-45	-3.4***	2.7469
		Profit (NPR/ha)			
Marginal (<0.5 ha)	58,389	34,546	23,843	69.0***	4.2592
Small (0.5–1 ha)	50,949	39,458	11,491	29.1***	3.2547
Medium (≥1 ha)	57,274	58,449	-1,175	-2.0	0.8995
All	55,401	43,045	12,356	28.7***	6.2797
		Profit (NPR/q)			
Marginal (<0.5 ha)	1,226	874	353	40.4***	4.9997
Small (0.5–1 ha)	1,189	951	238	25.0***	4.7976
Medium (≥1 ha)	1,331	1,308	23	1.8	1.3560
All	1,274	1,032	242	23.4***	8.1895

Source: Authors' calculations based on field survey (2015).
Notes: ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. NPR = Nepalese rupees; q = Quintal; ha = Hectare.

Table A2. Economics of paddy seed cultivation by contract and noncontract farmers in Nepal, 2015

Particulars of cost of cultivation (NPR/ha)	Contract farmers	Noncontract farmers	Difference	*t*-Test of difference
Human labour	25,172	25,123	49	0.1895
Source seed	2,601	2,394	208	3.2517***
Seed treatment	2	47	-44	1.4145
Fertilizers	3,357	3,150	207	2.1840**
Micronutrients	11	11	0	0.9090
FYM (Farm yard manure)	8,172	7,637	534	2.6245***
Pesticides	101	133	-32	1.1704
Other inputs	692	123	569	5.1676***
Machine labour and rent for machineries (ploughing, harvesting, threshing and irrigation)	11,991	13,191	-1,201	0.1522
Interest on loan	18	6	12	0.9083
Rent for leased-in land	25,065	24,882	182	1.1005
Land revenue tax	343	390	-46	0.6890
Collection & packaging	2,026	2,341	-314	2.3092**
Transportation of produce	702	765	-64	1.9393*
Cost of cultivation total	55,961	55,535	426	2.0265**

Source: Authors' calculations based on field survey (2015).
Notes: ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. NPR = Nepalese rupees; ha = Hectare.

Table A3. Hausman's test for endogeneity in the profit equation for given specifications of instrumental variables
Dependent variable: Unit profit in paddy seed production (NPR/kg)

Variable	Specification 1 IV = 'demand' as motivation factor for adopting paddy seed cultivation	Specification 2 IVs = (i) 'demand' as motivation factor for adopting paddy seed cultivation; (ii) 'price' as motivation factors for adopting paddy seed cultivation	Specification 3 IV = Proportion of contract farmers by caste in ward
Contract farming	5.657**	4.846*	9.548***
	(2.171)	(2.113)	(2.447)
Socio-demographic variables			
ln (Age)	0.0509	0.0838	0.157
	(0.609)	(0.591)	(0.683)
ln (Household size)	-1.021*	-1.027*	-1.108*
	(0.511)	(0.492)	(0.505)
Gender	1.346*	1.344*	1.353*
	(0.610)	(0.603)	(0.620)
ln (Operational land)	1.329**	1.290**	1.418**
	(0.422)	(0.433)	(0.407)
Out-migration	2.703*	2.606	2.836*
	(1.391)	(1.449)	(1.453)

Contd...

Social- caste group			
General castes	0.411	0.355	0.180
	(0.670)	(0.694)	(0.579)
Dalits	1.653	1.608	2.311
	(1.171)	(1.168)	(1.276)
Tribal	-1.326**	-1.462**	-1.365***
	(0.400)	(0.463)	(0.131)
Educational level (highest in the family)			
Primary (4 years of schooling)	-0.671	-0.545	-0.749
	(1.190)	(1.310)	(1.280)
Secondary (10 years of schooling)	0.875	0.956	1.134
	(1.284)	(1.286)	(1.213)
Graduate	0.342	0.480	0.474
	(1.369)	(1.371)	(1.307)
Economic variables			
Main occupation	-2.710***	-2.655***	-2.697**
	(0.620)	(0.658)	(0.736)
ln (Remittance)	-0.164	-0.160	-0.167
	(0.114)	(0.122)	(0.120)
Ehat	-3.038	-2.311	-6.900**
	(1.877)	(1.846)	(2.650)
Constant	8.846*	9.173*	5.996*
	(4.172)	(4.180)	(3.015)
Observations (No.)	502	502	502
R^2	0.222	0.222	0.223
District fixed effect	Yes	Yes	Yes

Source: Authors' calculations based on field survey (2015).
Note: ***, ** and * represent significance at 1 per cent, 5 per cent and 10 per cent levels, respectively. IV = instrumental variable; NPR = Nepalese rupees; kg = Kilogram.

Table A4. Sargan's test for over-identification of instrumental variables in the 2SLS regression

Dependent variable: Profit (NPR/kg)
Instrumental variables: (i) Motivation for adopting paddy seed cultivation: Demand, (ii) Motivation for adopting paddy seed cultivation: Demand and Price
Tests of over-identifying restrictions:
Sargan (score) chi2(1) = 0.888924 (p = 0.3458)
Basmann chi2(1) = 0.85857 (p = 0.3541)
Instruments are valid