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Insights on ownership pattern and demand for machinery in Indian agriculture

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ABSTRACT

As the wage rate for labour escalates in agriculture, farmers opt for other power alternatives. Mechanization of farms provides an opportunity to overcome the issue of labour scarcity and rising cost of production besides facilitating timely farm operations thereby increasing yield and farmer's income. An examination of existing level of mechanization across the states in different crops is computed during 2018 using mechanization index for 2001–02 and 2013–14. The study concludes that the extent of mechanization is not uniform across crops and states. Wheat is the most mechanized crop and Punjab shows highest level of mechanization in the farms. The factor demand elasticity estimates confirm that change in market prices of inputs significantly affect the machinery usage in paddy and wheat. Substitution elasticities also indicate substitution between machine labour and human labour in major crops during 1996–2013.

Keywords: Factor substitution, Mechanization index, SURE, Translog cost function

Agricultural sector has seen significant growth after introduction of technological revolution in the mid-sixties and quadrupled in food grain production, especially in wheat and rice crops. With the adoption of high yielding varieties, the input requirement also increased resulting in rapid increase in the cost of production. In the recent past, the problem of labour scarcity and rising farm wages has further contributed to the higher cost of production. According to NSSO data on employment and unemployment, there has been consistent decrease in percentage of agricultural employment from 60% in 1999–00 to 49% in 2011–12 and a net reduction of 30.57 million labors from the agricultural sector during the period 2004-05 and 2011-12. Further, Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), has led to labour scarcity in agriculture and thereby higher farm wages which is affecting farm profitability adversely (FICCI report 2015). The promptly growing food demand has also brought the need for building efficiency in agriculture to the forefront.

Farm mechanization is emerging as one of the key areas of intervention to compensate the labour scarcity and also reducing the costs of farming. It facilitates timely, precise and scientific farm operations which lead to increase in farm input and labor use efficiency, cropping intensity etc. Though farm mechanization offers wide range of opportunities but various constraints also exist which are preventing farmer to take its benefit. The major constraints involved with mechanization are small and fragmented land holdings, poor financial status of farmer, and lack of repair and maintenance facilities in remote areas besides seasonality in crops (Singh 2015). To address key barriers in adoption of mechanization, suitable programs to support the farmers, especially for small and marginal landholders need to be formulated for providing them suitable machineries matching with their requirement. For formulation of consistent policies and programmes for promotion of farm mechanization, it is highly important to understand the pattern and structure of mechanization prevailing in Indian farms as well as the demand for the machinery input and its substitution with other farm inputs for different crops.

MATERIALS AND METHODS

Mechanization Index (MI): Mechanization index has been used for assessing the use of machineries in comparison with the other power sources such as human labour and animal labour. A mechanization index can be formulated in either on the basis of distribution of power source/energy or on basis of the distribution of cost in different power sources. By keeping in view the importance of economic factor in farming, this study uses the mechanization index based on distribution of cost among different power sources. The mechanization index (MI) is estimated as a ratio of

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cost of use of machine labour (ML) to the sum of cost of use of total animate energy inputs and machine labour (Singh 2006).

State or national level weighted average (MI_{aij}) can be calculated as:

$$MI_{aij} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} MI_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij}}$$

where, A_{ij}, area under i^{th} crop in j^{th} state; n=number of selected crops, m= number of selected states. For analyzing the pattern of mechanization at different farm categories, the use of owned or hired machinery (hr per ha) has been explored for major crops in different states.

Translog cost function approach: To estimate input demand and input substitution elasticities with special reference to mechanization, a translog cost function approach has been used following the methodology used by Srivastava *et al.* (2017). Using Shepherd's lemma, the derived demand equations were estimated.

The elasticities of substitution are given by

$$\sigma_{ii} = (a_{ii} + S^2_i - S_i)/S^2_i \text{ and } \sigma_{ij} = (a_{ij} + S_i - S_j)/ S_i S_j$$

Data sources: The present study was carried out during 2018 to analyze the pattern of mechanization in terms of use of hired and owned machinery (including irrigation machinery) on hour basis at different farm groups, viz. marginal, small, semi-medium, medium and large farms using the plot level data of CACP for the year 2000–01 and 2013–14. The data for estimation of mechanization index and translog elasticities is obtained from CACP. The data has been collected for cost of human labour, machine labour, fertilizer and crop yield. The input demand and substitution elasticity is estimated for rice and wheat crop using Translog cost function for the period 1996–2013. The nominal input and output prices were converted into constant prices by using real prices indices at 2004–05 base year. The shares of inputs were obtained by dividing real expenditure of respective inputs to the real cost of production. Seemingly Unrelated Regression (SURE) has been used to obtain the parameter estimates of the translog cost function (Bezlepkina *et al.* 2005, Mukherjee *et al*. 2016, Wijetunga 2016).

RESULTS AND DISCUSSION

Extent of mechanization in different crops of India: The mechanization index for different crop groups for the year 2000–01 and 2013–14 at all India level is shown in Fig 1. It is clearly seen that mechanization index has been increased from 2000-01 to 2013–14 in all the crops in India which indicates increasing mechanization in the country. However, the level of mechanization is not uniform across the crops/ crop groups. Among the cereals highest mechanization is found in wheat crop in both the time periods and lowest in sorghum. Though paddy crop occupies the largest area under cultivation, the level of mechanization is only 18.32% in 2013–14. The low level of mechanization in paddy may be due to intense use of labour in transplanting activity on a large scale in the country. Besides this, the eastern and southern states which are the major paddy growing states are hardly mechanized. Gram and soybean have highest level of mechanization under pulses and oilseed group respectively. The cash crops, viz. cotton and sugarcane show low level of mechanization as farmers follow labour intensive method of cultivation. Thus, these crops show higher scope for mechanization which can increase the productivity. Though the mechanization is low (less than 20%) for most of the crops, many crops show significant increase in mechanization from 2000–01 to 2013–14. This increase in mechanization index has not only came from increase in use of machinery but also due to increase in area under cultivation of crop or/and reduced human and animal labour expenditure. Singh (2006) also examined the mechanization level of crops using mechanization index and he found that level of mechanization was only 8% for paddy and of about 29% for wheat in 1996-97.

Extent of farm mechanization of major states: The extent

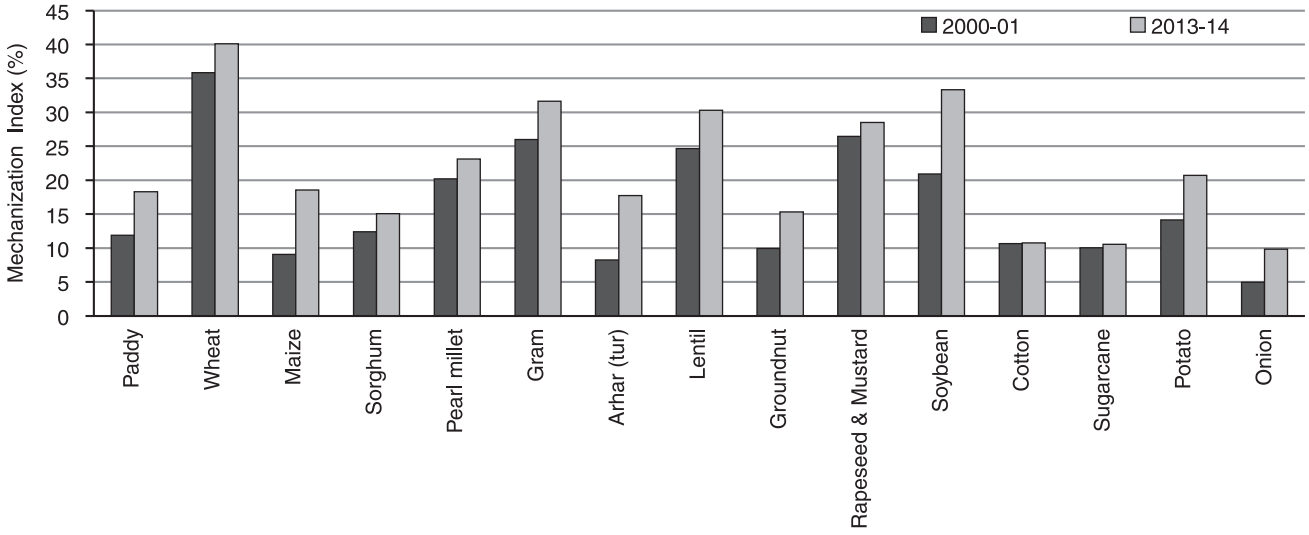

Fig 1 Mechanization Index for major crops of India (2000–01 and 2013–14).

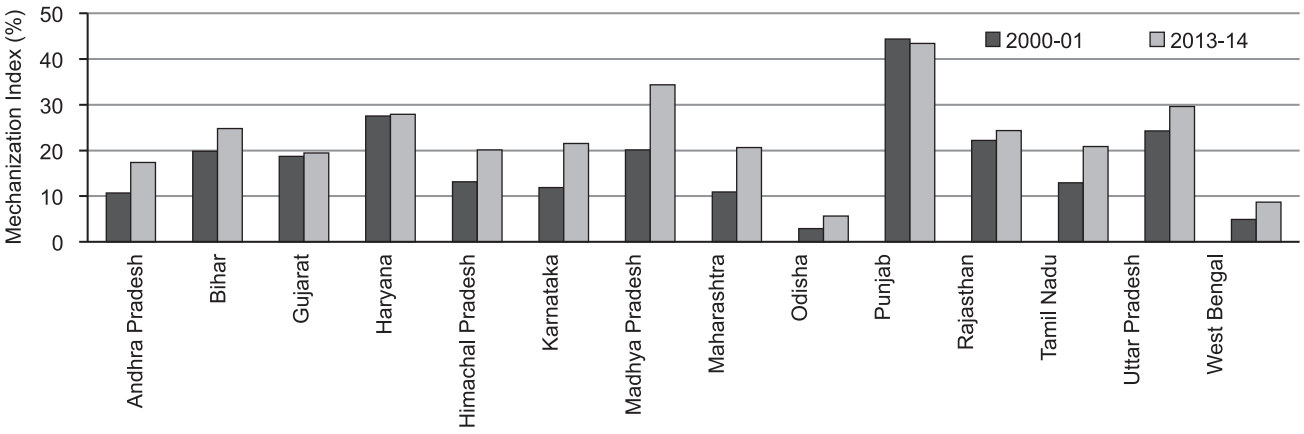

Fig 2 Mechanization Index for Major States (2000–01 and 2013–14).

of mechanization in major states for the year 2000–01 and 2013–14 is depicted in Fig 2. Among these states, highest mechanization is seen in Punjab (43%), whereas lowest level of mechanization is seen in Odisha (5.66%) and West Bengal (8.72%). The high level of mechanization is mainly due to due to high tractor density which is resulted due to comparatively large landholding size of farmers of these states. There has been a significant increase in mechanization in Madhya Pradesh, Tamil Nadu, Maharashtra, Andhra Pradesh and Karnataka whereas states like Punjab, Haryana, Gujarat, Rajasthan and Uttar Pradesh do not show any significant change in mechanization between 2000–01 and 2013–14. Singh (2006) reported that the major factor influencing the level of mechanisation is the size of holding, income level, credit facilities and land topography.

This necessitates the need to explore the farm level study of mechanization status as well as the pattern of machinery use/ownership in different crops to identify gaps in mechanization across the different farm categories. Similarly, the pattern of labour use as well as mechanization in paddy and wheat across the states was also estimated by comparing two periods, viz. 2000–01 and 2013–14. The use of labour (h/ha) was found to be decreasing for both paddy and wheat from 2000–01 to 2013–14 in the selected states which possibly can be the consequence of the problem of labour scarcity. For paddy, except Punjab there has been increase in machine use (h/ha) in all selected states from 2000–01 to 2013–14 especially the use of hired machines (h/ha) have been increased. However, for wheat, the use of hired machinery have been increased in only Haryana and Rajasthan while owned machine use has been increased in some farm categories in Bihar, Rajasthan, UP and MP. In Punjab, where the mechanization index is highest, there has been decreased use of hired as well as owned machine (h/ha) in both paddy and wheat from 2000–01 to 2013–14. For both the crops, the use of owned machine hours is lowest in marginal farms and it increases as the farm size is increasing. Therefore, it evident that marginal and small farms are mainly opting for hired machines for performing farm operations in both the crops in the two time periods.

Input demand and substitution elasticities: The estimates of the seemingly unrelated regression model of translog cost function for paddy and wheat in India for the period 1996–2013 are presented in Tables 1 and 2 respectively. The estimates of own price elasticity for all inputs for paddy and wheat crop were negative which is consistent with the economic theory that as price of input increases the demand for that input will decrease. The own price demand elasticity was found to be inelastic for human labour (-0.2964) and elastic for machine labor (-1.0116) and fertilizer (-1.0027) for paddy. However in wheat crop, own price elasticities of input demand for all the inputs, viz. human labour (-0.3171), machine labour (-0.5946) and fertilizer (-0.2120) were found to be inelastic. The estimates of the own price elasticities of input reveal that farmers are more sensitive to the price of machinery than the human labour. It provides the scope of increasing the use of machineries in these crops by providing the low cost custom hiring facilities to the farmers.

Table 1 Estimates of input demand and substitution elasticity for paddy (1996–97 to 2013–14)

Input demand/Input price	Human labour	Machine labour	Fertilizer
Human labour	-0.2964*	0.1433*	0.1531*
	(0.0199)	(0.0132)	(0.0098)
Machine labour	0.7822*	-1.0116*	0.2294*
	(0.1057)	(0.1032)	(0.0766)
Fertilizer	0.7833*	0.2193*	-1.0027*
	(0.0211)	(0.0205)	(0.0211)
Substitution elasticities	Human labour	Machine labour	Fertilizer
Human labour	-0.1985*	1.0812*	1.0804*
	(0.0177)	(0.093)	(0.0186)
Machine labour		-0.1240	2.8933*
		(0.7283)	(0.1446)
Fertilizer			-0.1333
			(0.03957)

*Significant at 95% confidence interval. The values in the parenthesis indicate standard errors.

Table 2 Estimates of input demand and substitution elasticity for wheat (1996–97 to 2013–14)

Input demand/Input price	Human labour	Machine labour	Fertilizer
Human labour	-0.3171*	0.3088*	0.0082
	(.0483)	(.0497)	(.0305)
Machine labour	0.4248*	-0.5946*	0.1698*
	(.0652)	(.1052)	(.0634)
Fertilizer	-0.0146	0.2267*	-0.2120*
	(.0538)	(.0852)	(.0658)
Substitution elasticities	Human labour	Machine labour	Fertilizer
Human labour	-0.1360	0.9579*	-0.0236
	(.1157)	(.1521)	(.1271)
Machine labour		-0.1881	0.6840*
		(.3248)	(.2637)
Fertilizer			-0.0597
			(.2838)

*Significant at 95% confidence interval. The values in the parenthesis indicate standard errors.

The cross price elasticities of demand between machine labour and other two inputs were found to positive for both rice and wheat crops denoting that the inputs are substitutes. The cross price elasticity of machine labour for human labour price is found to be higher in paddy (0.7822) than in wheat (0.4248) revealing that in paddy crop machine labour use is more sensitive to any change in human labour prices. The estimates of Allen's partial elasticities of substitution between human labour and machine labour were found to be positive which indicates substitutive relationship consistent with the economic theory. This is also in conformity with the results of translog cost estimates of Kumar *et al.* (2010) indicating substitutive relationship between human labour and machine labour in paddy. The elasticity of substitution between human labour and machine labour is found to be elastic for paddy (1.0812) and nearly elastic for wheat (0.9579). This high rate of substitution between human labour and machine labour is due to increase in human labour cost or wages in India due to labour scarcity and rising farm and non-farm wages under MGNREGA. Khalil (2005) also revealed substitutive relationship between capital-labor, capital-materials, and labor-materials and the substitution elasticity for labor-materials is found to be higher than that of capital-labor. In addition, price of bullock labour is also one of the major factor that influences the demand for machinery rather than a change in the wage rate of labour (Rasouli *et al*. 2009, Meena *et al*. 2010, Mehta *et al.* 2014).

The mechanization index reveals mechanization scenario is not uniform in all crops and states. Crops like wheat, gram and soybean are more mechanized in comparison with paddy, cotton and sugarcane. The extent of mechanization has increased from 2000-01 to 2013-14 across the crops and regions, the level of mechanization is still lower than many developed countries. The low level of mechanization in Indian farms may be due to use of conventional farming practices in many states, farm size constraint, lack of technical knowledge and financial resources for adoption of machinery. The substitution elasticities between human labour and machine labour prove that as labor becomes more expensive, alternative is more machine labour use to keep cost of cultivation low. Further, the results confirm that the farmers are sensitive to the price of machine labour in paddy and wheat crops. This creates space for making available machinery based on ergonomic principles according to matching requirements of farmers. Models of custom hiring in group action and farm machinery banks in public-private mode could be possible institutional and policy responses to address the barriers of farm mechanization besides enhancing income and livelihood security of resource scarce smallholders.

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