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Jatin Samarath
Department of Agri-Business and
Rural Management, College of
Agriculture, IGKV, Raipur,
Chhattisgarh, India

Hulas Pathak
Professor and Head, Department
of Agri-Business and Rural
Management, College of
Agriculture, IGKV, Raipur,
Chhattisgarh, India

Corresponding Author:
Jatin Samarath
Department of Agri-Business and
Rural Management, College of
Agriculture, IGKV, Raipur,
Chhattisgarh, India

Factors influencing the demand for farm machinery in Bastar district of Chhattisgarh

Jatin Samarath and Hulas Pathak

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Abstract

Farm mechanization has become central to Indian agriculture as rural wages rise and the farm workforce shrinks, yet the factors that generate machinery demand in tribal, rainfed and paddy-dominant districts remain thinly documented. This study examined the drivers of farm machinery demand among mechanized cultivators of Bastar district, Chhattisgarh. Primary data were collected through personal interviews from 139 respondents, comprising 127 farmers, 9 dealers and 3 retailers, across the Jagdalpur and Tokapal blocks, selected through a multi-stage random sampling procedure. The analysis of demand drivers was confined to the 112 mechanized farmers with a Machinery Demand Score on a 0–10 count scale treated as the dependent variable and fourteen demand-generating factors coded in binary form as explanatory variables. The data were analysed using correlation and ordinary least squares multiple regression, supported by analysis of variance and variance inflation diagnostics. All fourteen factors were positively correlated with the demand score, the strongest being field operational efficiency ($r = +0.481$), high cost of agricultural labour ($r = +0.390$), agricultural extension support ($r = +0.377$) and reduction in human drudgery ($r = +0.374$), increase in farm income was the only non-significant correlate ($r = +0.141$). The regression model explained a large share of the variation in demand ($R^2 = 0.834$, adjusted $R^2 = 0.810$, $F(14, 97) = 34.76$, $p < 0.001$) and every predictor carried a positive and significant coefficient. High cost of agricultural labour made the strongest standardized contribution ($\beta = +0.289$), followed by reduction in cost of cultivation ($\beta = +0.272$) and field operational efficiency ($\beta = +0.262$). The findings indicated that machinery demand in Bastar was driven mainly by labour economics, operational advantage and institutional support rather than by subsidy alone, which points to labour-linked and service-based interventions as the more effective levers for extending mechanization.

Keywords: Farm mechanization, machinery demand, mechanized farmers, demand drivers

Introduction

Farm mechanization eases labour drudgery, relieves seasonal labour shortages and improves the timeliness of field operations and it is now treated as a central lever in transforming agrifood systems across the developing world. In India, rising rural wages, a shrinking agricultural workforce and the need to complete time-bound operations within narrow weather windows have turned mechanization from a convenience into a necessity for many cultivators. Successive policy measures, including the Sub-Mission on Agricultural Mechanization and the promotion of Custom Hiring Centres have sought to widen machinery access for small and marginal farmers, particularly in regions where ownership is uneconomic.

Chhattisgarh remains well below the national average in farm power per hectare and its southern tribal districts lag further behind the more developed central plains. Bastar is a paddy-dominant, rainfed district in which cultivation has long rested on animal draught power and hand tools with tractor penetration historically described as negligible. Fragmented holdings, seasonal labour scarcity and limited local access to dealers and repair services have constrained the ability of farmers to complete operations on time. As government schemes extend subsidies, credit and hiring services into such districts, the question of what actually generates machinery demand at the farm level becomes important for the targeting of these interventions.

Most Indian evidence on the determinants of mechanization comes from irrigated and commercially developed belts and district-level evidence for tribal, rainfed tracts is limited. Where a district differs so sharply from the state average in landholding, cropping and

infrastructure, the drivers of demand cannot be read off from state-level studies. This paper therefore examined the factors responsible for generating farm machinery demand among mechanized farmers in Bastar district, so that the relative weight of labour, cost, productivity and institutional factors could be established for a setting that has received little dedicated research attention.

Materials and Methods

Study area

The study was conducted in Bastar district in southern Chhattisgarh with its headquarters at Jagdalpur. The district is predominantly rural and tribal and its economy rests mainly on rainfed kharif paddy grown on fragmented, largely marginal and small holdings. Farm power per hectare in Chhattisgarh falls well below the national average, and Bastar sits at the lower end of the state's mechanization spectrum, which made it a suitable setting for studying machinery demand and its barriers.

Sampling procedure and sample size

A multi-stage random sampling procedure was used. Bastar district was purposively selected and the Jagdalpur and Tokapal blocks were chosen within it. About 6 to 7 per cent of villages in each block were selected, giving 8 villages in Jagdalpur and 9 in Tokapal with a fixed number of farmers drawn from each. This yielded 127 farmer respondents distributed almost evenly between the blocks. Interviews with 9 machinery dealers and 3 retailers brought the total to 139. The present analysis was confined to the 112 farmers who had adopted mechanization.

Variables and measurement

The dependent variable was a Machinery Demand Score, constructed as the sum of demand indicators expressed by each mechanized farmer and specified on a 0–10 count scale. Fourteen demand generating factors were treated as explanatory variables, each coded in binary form (1 = present, 0 = absent). These covered labour factors, namely high cost and shortage of agricultural labour; economic factors, namely reduction in cost of cultivation and increase in farm income; operational factors, namely timely operations, field efficiency, crop productivity, drudgery reduction and quality of operations and institutional factors, namely subsidy, CHC services, credit, extension support

and repair services.

Analytical tools

The relationship between each factor and the Machinery Demand Score was first examined through correlation analysis with the coefficient, its significance and its rank recorded for every factor because the factors were binary, these are point-biserial correlations. An ordinary least squares multiple regression was then fitted with the Machinery Demand Score as the dependent variable and all fourteen factors as predictors of the form $Y = a + b_1X_1 + b_2X_2 + \dots + b_{14}X_{14} + e$. Because the dependent variable is a bounded count, the linear model is interpreted as an approximation to the underlying relationship. The overall fit was assessed through the coefficient of determination and an analysis of variance, the individual contributions through the unstandardized and standardized coefficients and their significance and multicollinearity through variance inflation factors. All computations were carried out in Microsoft Excel.

Results and Discussion

Variable specification

The model was specified with demand-generating factors as independent variables and Machinery Demand Score as dependent variable.

Table 1 presented the variable specification for the demonstration model. It comprised one dependent variable and fourteen independent variables. Machinery Demand Score, the dependent variable, summed the demand indicators on a 0–10 count scale with the fourteen explanatory variables coded as 1/0 for presence or absence.

The explanatory variables covered several demand-related factors. The first group comprised High Labour Cost, Labour Shortage, Cost Reduction and Farm Income Increase, capturing labour and income conditions. Timely Operations, Operational Efficiency, Crop Productivity, Human Drudgery Reduction and Quality Operations captured the operational and productivity benefits associated with machinery use in farming.

The model also included institutional and support-related factors. These comprised Government Subsidy, CHC Availability, Institutional Credit, Extension Support and Repair Maintenance. All fourteen explanatory variables were coded as 1/0 and specified as independent variables.

Table 1: Specification and coding of variables used in the analysis

Variable	Description	Coding	Role
Machinery Demand Score	Sum of demand indicators (dependent)	0–10 count	Dependent (Y)
High Labour Cost	High cost of agricultural labour	1/0	Independent
Labour Shortage	Shortage of agricultural labour	1/0	Independent
Cost Reduction	Reduction in cost of cultivation	1/0	Independent
Farm Income Increase	Increase in farm income	1/0	Independent
Timely Operations	Timely completion of farm operations	1/0	Independent
Operational Efficiency	Improvement in field operational efficiency	1/0	Independent
Crop Productivity	Increase in crop productivity	1/0	Independent
Human Drudgery Reduction	Reduction in human drudgery	1/0	Independent
Quality Operations	Improvement in quality of agricultural operations	1/0	Independent
Government Subsidy	Government subsidy on farm machinery	1/0	Independent
CHC Availability	Availability of Custom Hiring Centre services	1/0	Independent
Institutional Credit	Institutional credit for machinery purchase	1/0	Independent
Extension Support	Agricultural extension support	1/0	Independent
Repair Maintenance	Repair and maintenance services	1/0	Independent

Correlation analysis

Table 2 presented the correlation between the selected factors and Machinery Demand Score. The correlation coefficients were positive for all the factors and ranged from +0.141 to +0.481,

indicating positive associations of varying magnitude.

Operational efficiency emerged as the factor most closely associated with Machinery Demand Score and was therefore ranked first with a correlation coefficient of $r = +0.481$ ($p <$

0.001) that reflected a positive and moderate association, significant at the 1 per cent level. High cost of agricultural labour followed in second place at $r = +0.390$ ($p < 0.001$), its positive coefficient again pointing to a moderate association that was significant at the 1 per cent level. Agricultural extension support took the third rank with $r = +0.377$ ($p < 0.001$), and reduction in human drudgery came fourth at $r = +0.374$ ($p < 0.001$) both showed positive, moderate associations with Machinery Demand Score that held statistical significance at the 1 per cent level.

The middle band of factors carried on this pattern of moderate, highly significant associations. Government subsidy on machinery ranked fifth at $r = +0.340$ ($p = 0.0002$), availability of CHC services sixth at $r = +0.336$ ($p = 0.0003$), timely completion of operations seventh at $r = +0.333$ ($p = 0.0003$), and repair and maintenance services eighth at $r = +0.316$ ($p =$

0.0007), each recording a positive association of moderate magnitude that was significant at the 1 per cent level. Institutional credit was placed ninth at $r = +0.300$ ($p = 0.0013$), reduction in cost of cultivation tenth at $r = +0.290$ ($p = 0.0019$) and increase in crop productivity eleventh at $r = +0.266$ ($p = 0.0046$), with all three continuing to show positive associations significant at the 1 per cent level.

The lower-ranked factors showed a gradual decline in their association with Machinery Demand Score. Shortage of agricultural labour ranked twelfth with $r = +0.247$ ($p = 0.0086$), indicating a significant positive relationship at the 1 per cent level. Improvement in quality of operations ranked thirteenth with $r = +0.198$ ($p = 0.0365$), significant at the 5 per cent level. Increase in farm income ranked fourteenth with $r = +0.141$ ($p = 0.1368$) and was not statistically significant.

Table 2: Correlation between factors and Machinery Demand Score

Factor	r	p-value	Direction	Sig.	Rank
Operational efficiency	+0.481	<0.001	Positive	**	1
High cost of agricultural labour	+0.390	<0.001	Positive	**	2
Agricultural extension support	+0.377	<0.001	Positive	**	3
Reduction in human drudgery	+0.374	<0.001	Positive	**	4
Government subsidy on machinery	+0.340	0.0002	Positive	**	5
Availability of CHC services	+0.336	0.0003	Positive	**	6
Timely completion of operations	+0.333	0.0003	Positive	**	7
Repair and maintenance services	+0.316	0.0007	Positive	**	8
Institutional credit	+0.300	0.0013	Positive	**	9
Reduction in cost of cultivation	+0.290	0.0019	Positive	**	10
Increase in crop productivity	+0.266	0.0046	Positive	**	11
Shortage of agricultural labour	+0.247	0.0086	Positive	**	12
Improvement in quality of operations	+0.198	0.0365	Positive	*	13
Increase in farm income	+0.141	0.1368	Positive	ns	14

** significant at 1%, * significant at 5%, ns = not significant.

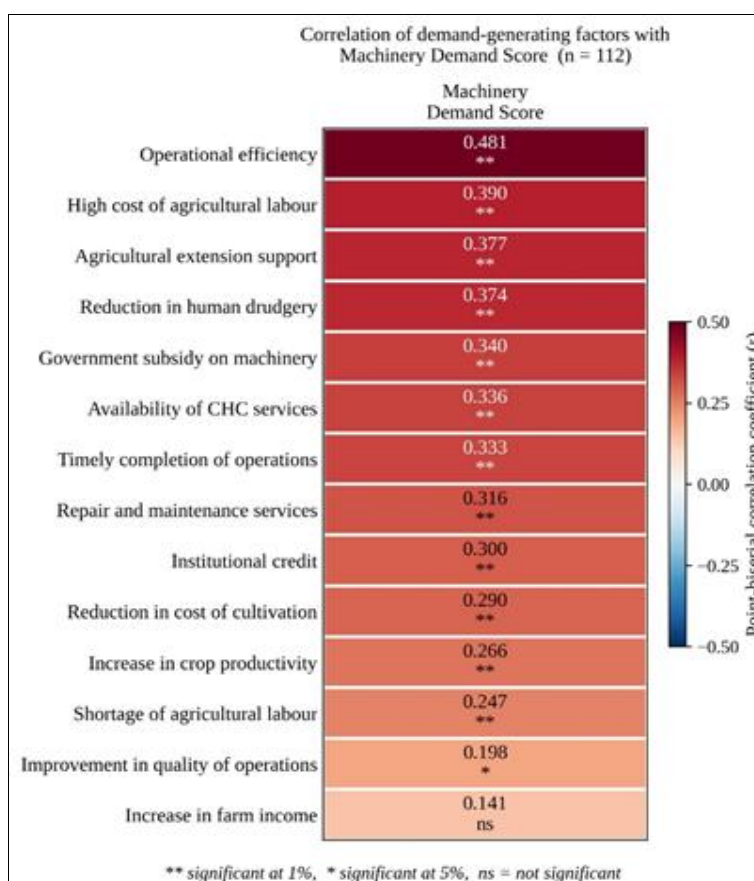


Fig 1: Heat Map of Correlation of Demand Generating Factors with Machinery Demand Score

Multiple linear regression analysis

An ordinary least squares regression was fitted with Machinery Demand Score as the dependent variable and all fourteen factors as predictors. Since the dependent variable is a bounded count, a Poisson or negative-binomial model would be stricter. The model is expressed as:

$$Y = a + b_1X_1 + b_2X_2 + \dots + b_{14}X_{14} + e$$

Table 3 presented the model summary of the regression examining the combined relationship between the independent variables and Machinery Demand Score.

The analysis was based on 112 observations. The multiple correlation coefficient (R) was 0.913, indicating a strong positive relationship between observed and predicted Machinery Demand Score. The coefficient of determination (R^2) was 0.834, showing that 83.4 per cent of the variation was explained, the remaining 16.6 per cent lying outside the model. The adjusted R^2 was 0.810 and the standard error of the estimate 0.944 score units.

Table 3: Fitness of multiple regression model

R	R ²	Adjusted R ²	Std. error of estimate	Observations
0.913	0.834	0.810	0.944	112

Analysis of variance of the regression model

Table 4 presented the analysis of variance of the regression model. The total sum of squares was 520.00 with 111 degrees of freedom, partitioned into regression and residual components.

The total sum of squares was 520.00 with 111 df. The regression component accounted for 433.58 with 14 df and the residual for 86.42 with 97 df. The regression mean square was 30.970 and the residual mean square 0.891. The model produced an F-value of 34.76 with $p < 0.001$, so it was statistically significant and the null hypothesis was rejected at the 1 per cent level. The set of independent variables together had a significant relationship with the score, with explained variation substantially exceeding unexplained variation, supporting the adequacy of the model. Individual coefficients were assessed separately.

Table 4: Analysis of variance of the regression model

Source	Sum of squares	df	Mean square	F	p-value
Regression	433.58	14	30.970	34.76	<0.001
Residual	86.42	97	0.891		
Total	520.00	111			

Regression coefficients Analysis

Table 5 presented the regression coefficients of the fourteen

Table 5: Regression coefficients explaining Machinery Demand Score

Independent variable	B	SE	Beta	t	p	VIF	Sig.
High cost of agricultural labour	+1.245	0.192	+0.289	6.48	<0.001	1.16	**
Shortage of agricultural labour	+0.846	0.195	+0.191	4.35	<0.001	1.13	**
Reduction in cost of cultivation	+1.173	0.186	+0.272	6.31	<0.001	1.08	**
Increase in farm income	+0.590	0.185	+0.136	3.19	0.002	1.07	**
Timely completion of operations	+0.753	0.190	+0.174	3.95	<0.001	1.13	**
Field operational efficiency	+1.130	0.198	+0.262	5.71	<0.001	1.23	**
Increase in crop productivity	+0.409	0.189	+0.095	2.16	0.033	1.12	*
Reduction in human drudgery	+0.790	0.194	+0.183	4.07	<0.001	1.18	**
Improvement in quality of operations	+0.501	0.193	+0.112	2.60	0.011	1.08	*
Government subsidy on machinery	+0.625	0.198	+0.145	3.16	0.002	1.23	**
Availability of CHC services	+0.677	0.189	+0.155	3.59	0.001	1.09	**
Institutional credit	+0.683	0.187	+0.158	3.65	<0.001	1.09	**
Agricultural extension support	+0.934	0.197	+0.215	4.74	<0.001	1.20	**
Repair and maintenance services	+0.639	0.197	+0.148	3.25	0.002	1.21	**

B = unstandardized coefficient; Beta = standardized coefficient; VIF = variance inflation factor. Intercept B = 1.685 ($p < 0.001$). ** 1%, * 5%.

independent variables explaining variation in Machinery Demand Score. All coefficients were positive, interpreted through B, SE, Beta, t, p and VIF values.

High cost of agricultural labour had a positive and significant effect ($B = +1.245$, $SE = 0.192$, $Beta = +0.289$, $t = 6.48$, $p < 0.001$) at the 1 per cent level, its presence raising the score by 1.245 units, other variables held constant. Shortage of agricultural labour recorded $B = +0.846$, $SE = 0.195$, $Beta = +0.191$, $t = 4.35$, $p < 0.001$, significant at 1 per cent, a 0.846-unit increase. Reduction in cost of cultivation gave $B = +1.173$, $SE = 0.186$, $Beta = +0.272$, $t = 6.31$, $p < 0.001$, raising the score by 1.173 units. Increase in farm income showed $B = +0.590$, $SE = 0.185$, $Beta = +0.136$, $t = 3.19$, $p = 0.002$, a 0.590-unit rise at the 1 per cent level. Timely completion of operations recorded $B = +0.753$, $SE = 0.190$, $Beta = +0.174$, $t = 3.95$, $p < 0.001$, a 0.753-unit increase. Field operational efficiency gave $B = +1.130$, $SE = 0.198$, $Beta = +0.262$, $t = 5.71$, $p < 0.001$, raising the score by 1.130 units. Increase in crop productivity recorded $B = +0.409$, $SE = 0.189$, $Beta = +0.095$, $t = 2.16$, $p = 0.033$, significant at the 5 per cent level, a 0.409-unit increase, after accounting for other variables.

Reduction in human drudgery showed $B = +0.790$, $SE = 0.194$, $Beta = +0.183$, $t = 4.07$, $p < 0.001$, significant at the 1 per cent level, a 0.790-unit increase. Improvement in quality of operations recorded $B = +0.501$, $SE = 0.193$, $Beta = +0.112$, $t = 2.60$, $p = 0.011$, significant at 5 per cent, a 0.501-unit rise. Government subsidy on machinery gave $B = +0.625$, $SE = 0.198$, $Beta = +0.145$, $t = 3.16$, $p = 0.002$, a 0.625-unit increase at the 1 per cent level. Availability of CHC services recorded $B = +0.677$, $SE = 0.189$, $Beta = +0.155$, $t = 3.59$, $p = 0.001$, a 0.677-unit rise. Institutional credit showed $B = +0.683$, $SE = 0.187$, $Beta = +0.158$, $t = 3.65$, $p < 0.001$, a 0.683-unit increase. Agricultural extension support recorded $B = +0.934$, $SE = 0.197$, $Beta = +0.215$, $t = 4.74$, $p < 0.001$, a 0.934-unit rise at the 1 per cent level. Repair and maintenance services recorded $B = +0.639$, $SE = 0.197$, $Beta = +0.148$, $t = 3.25$, $p = 0.002$, a 0.639-unit increase, each holding the remaining explanatory variables constant.

The intercept was $B = 1.685$ ($p < 0.001$), the estimated score when all variables were at their reference category. By standardized Beta, high cost of agricultural labour (+0.289) contributed most, followed by cost reduction (+0.272) and field efficiency (+0.262), then extension support (+0.215) and labour shortage (+0.191), while crop productivity was lowest (+0.095). VIF values ranged from 1.07 to 1.23, indicating no problematic multicollinearity.

Multicollinearity diagnostics

Variance inflation factors ranged from 1.07 to 1.23 and tolerances stayed above 0.81, well within accepted limits ($VIF < 5$). Multicollinearity was therefore not a concern and each predictor retained an independent contribution after the others were held constant which Indicated in the table 5

Standardized coefficient plot

Figure 4.15 presented the standardized regression coefficients with their 95 per cent confidence intervals, ordered by magnitude. The confidence limits (derived as $Beta \pm t_{0.975} \times Beta/t$) lie entirely above the zero-reference line for every predictor, consistent with the significance pattern in Table 5

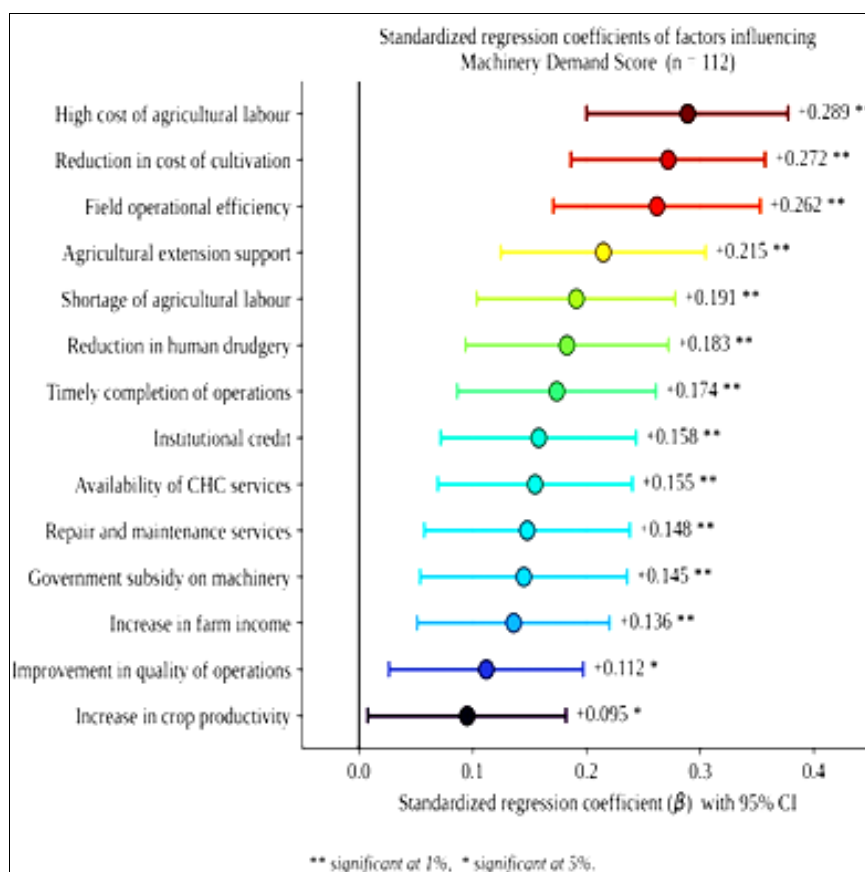


Fig 2: Standardized regression coefficients of factors influencing Machinery Demand Score

Conclusion and Implications

The study established that farm machinery demand among mechanized cultivators in Bastar district was generated by a combination of labour, operational and institutional factors, all positively associated with the Machinery Demand Score. High cost and short supply of agricultural labour, the operational efficiency and timeliness machinery offered and the support from extension, credit and Custom Hiring Centre services emerged as the leading drivers, while lower cultivation cost and productivity gains reinforced this demand. Government subsidy contributed positively but ranked below these factors and farm income mattered only alongside others. The regression model explained a large, significant share of the variation.

These findings carry several practical implications. Since labour cost and scarcity were the strongest drivers, machinery and hiring services that substitute for peak-season hired labour, especially in land preparation, threshing and eventually transplanting and harvesting are likely to meet the most pressing demand. The weight of Custom Hiring Centre availability and institutional credit suggests that stronger hiring networks and machinery finance would convert latent demand into use more effectively than subsidy alone, particularly for the small and marginal farmers who dominate the district. For dealers, demand concentrates on tractors and tillage and threshing equipment, while for policymakers, subsidy works best when paired with extension support and reliable service infrastructure.

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