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Efficiency and imperfections of tilling machinery rental markets in the Brahmaputra Valley of eastern India

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Abstract In rural India, farm capital goods rental markets enable small and marginal farmers to mechanize their operations. Imperfections can arise in these important factor markets because most suppliers are user-suppliers and only a few pure suppliers. User-suppliers hire out capital goods only after they have tilled their farms, and hiring-in users may not have access at the most opportune times. The market power of suppliers does not significantly impact or distort the markets by controlling the rental rates. Farming outcomes were better for owner-users than hiring-in users on average; the difference was statistically insignificant, however.

Keywords Rental market, farm capital goods, imperfections, farming outcomes

JEL codes Q12

In India, the pressure of the population on agricultural land is increasing, succession within farm families is fragmenting land ownership, and landholdings are becoming smaller. The small size of landholdings is held to impede mechanization and the implementation of several productivity-increasing practices; to promote mechanization and improve productivity, the consolidation of holdings was taken up after independence. Although land consolidation has been implemented in only a few parts of the country, mechanized tilling, irrigation use, and the adoption of high-yielding varieties of seeds have spread to large, medium, small, and marginal farms. Rental markets of farm capital goods—tractors, power tillers, and irrigation pump sets—have facilitated this spread, and these markets have made lumpy capital goods almost perfectly divisible for utilization in the quantities required for a farmer's landholding size (Das and Bezbaruah 2017). These emerging factor markets have positively impacted the diffusion of farm mechanization and other good farming practices, but their efficiency and equity implications hinge upon the absence of major imperfections. Imperfections have two a priori sources.

One is the probable presence of market power or monopoly elements, because the suppliers in these markets are usually large landholders who have influence and status in the rural economy and, hence, may exert their influence to secure higher rental rates. The other is that most suppliers are user-suppliers—they both use the tilling machinery and supply it to rental markets—and only a few are pure suppliers, who hire out tilling machinery but do not use it; user-suppliers, understandably, hire out their machinery only after completing their own farm operations. Hiring-in users will conceivably have to wait for the machinery to become available, and it may not be available for their use at the most opportune times for cultivation, since it depends on weather and season.

To study the probability of such imperfections, we conducted a farm-level field investigation in the Brahmaputra Valley of eastern India from November 2013 to January 2014. In the Valley, 86% of the

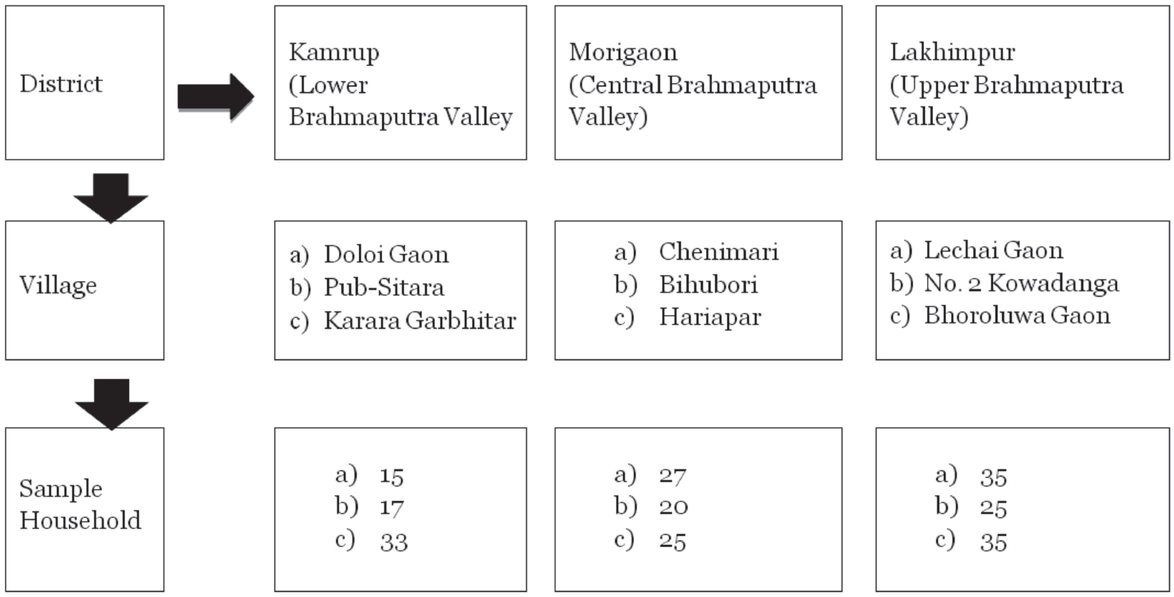

Figure 1 Sampling procedure

operational holdings and 49% of the operated area is small and marginal, and the average size of operational holdings is 1.10 hectares, according to the Report on Agricultural Census 2010–11 (Government of Assam 2011), and rental markets play a crucial role. Tilling machinery make up the most rented capital goods in the study area. The investigation attempted to find out the determinants of the rental rates of tilling machinery and whether the market power of suppliers affects their determination. It aimed also to examine the determinants of land productivity and evaluate whether the productivity of hiring-in users of farm capital goods lag behind that of owner-users.

Materials, methods, and models

The data

We selected 232 farms in three districts from the lower, central, and upper parts of the Brahmaputra Valley of Assam and conducted a sample survey there from November 2013 to January 2014. The contentions of this paper are based primarily on our analysis of the inputs of this survey. We extracted the secondary data from the Report of Agricultural Census (Government of Assam 2011). The data provided the background information for nesting the analysis of the sample survey inputs. We conducted the sampling through a multistage process in which farm households constituted the ultimate sampling units.

In the second stage, we selected three villages from each of the three districts. In the final stage, 12% of the households were selected randomly from the lists of all the farm households of the chosen villages. Most sample farmers (78.45%) use tilling machinery in their farm operations (Table 1). Most of the users were hiring-users who could not have mechanized their tilling operations had the rental markets of such machinery been not functioning. Hiring-users constitute the dominant proportion of marginal and small farmers.

Modeling of market power and its impact on rental rate

We measure market power as the supply-demand ratio of the relevant agricultural capital good. Fewer the number of suppliers in relation to demanders, greater can be their bargaining strength, giving them a say in determining the rental rate. The rental markets of tilling machinery, especially of power tillers, are confined to the village.[1] Therefore, to calculate market power, we counted suppliers and demanders within the village.

[1] Around 94% of the sample farmers hire power tillers from suppliers in the village. Leasing, too, is mostly confined to the village, because it is difficult to move a power tiller— unlike a tractor—over a long distance.

Table 1 Sample farmers: distribution by use status of tilling machinery

Size class (hectare)	Sample farmers (number)	Users of tilling machinery		
		Total users (%)	Owner users (%)	Hiring-in users (%)
<1	101	81 (80.20)	3 (2.97)	78 (77.23)
1–2	92	67 (72.83)	16 (17.39)	51 (55.43)
2–3	24	19 (79.17)	5 (20.83)	14 (58.33)
3–4	6	6 (100.00)	5 (83.33)	1 (16.67)
4–5	6	6 (100.00)	1 (16.67)	5 (83.33)
5 ≥	3	3 (100.00)	2 (66.67)	1 (33.33)
All size classes	232	182 (78.45)	32 (13.79)	150 (64.66)

Source Authors' field survey
Note Hiring-in users hire tilling machinery. Owner-users use their own tilling machinery; in some cases, they hire equipment in addition to using their own. Figures in parentheses are percentages to the sample farmers in the respective categories.

We examined the impact of market power on the rental rate by regressing the rental rates paid by hiring sample farmers on market power and a few control variables. The dependent variable rental rate (R) is defined and calculated as

$$R = \frac{\text{Total amount paid by a farmer for hiring the tilling machinery}}{\text{Gross area tilled with hired machinery}} \quad \ldots(1)$$

The main independent variable on which R is regressed is market power (MP). The control variables are sources of hiring, personal relation of hirers with lenders, membership of hiring farmer in a group lending farm machinery, and locational dummies.

The three types of tilling machinery used in the study locations are power tillers, tilling tractors, and tilling-cum-levelling tractors. These types perform distinct activities and have different technical specifications, such as horsepower, and they cannot be aggregated into one homogeneous category, and their rental fees are also not comparable. Power tillers are the most extensively used tilling machinery in the study areas—61% of the sample farmers used it—and we limit the regression analysis to the rental for hiring power tillers only. The basic rental rate function has been formulated as

$$R_{pt} = F\,(SOH, PR, MP, MEM, L_1, L_2) \quad \ldots(2)$$

Table 2 Summary of explanatory variables included in regression equation on determinants of rental rate

Variable	Notation	Definition	Expected impact
Independent variables			
Market power	MP	The ratio of demanders to suppliers in the village	+
Control variables			
Sources of hiring	SOH	1 if the source is within the village and 0 if hiring is from outside village sources	-
Personal relation of hirers with lenders	PR	1 if hired from friend/relative and 0 if hired from open market	-
Membership of the hiring farmer in a group lending farm machinery	MEM	1 if group members and 0 if non-members	-
2 dummies for capturing local effect of the 3 locations	L_1 & L_2	L_1=1 for Morigaon, 0 otherwise and L_2=1 for Kamrup, 0 otherwise assuming Lakhimpur as the reference location	+/-

The value of the dependent variable cannot be negative; hence, the exponential specification of the above function is considered more appropriate than a linear specification. Thus, we have

$$R_{pti} = exp\ (\beta_0 + \beta_1 SOH_i + \beta_2 PR_i + \beta_3 MP_i + \beta_4 MEM_i + \beta_5 L_{1i} + \beta_6 L_{2i} + U_i) \quad \ldots(3)$$

where, U_i is the usual disturbance.

Further, taking the logarithm on both sides, the estimable regression equation obtained is

$$\text{Ln}\ R_{pti} = \beta_0 + \beta_1 SOH_i + \beta_2 PR_i + \beta_3 MP_i + \beta_4 MEM_i + \beta_5 L_{1i} + \beta_6 L_{2i} + U_i \quad \ldots(4)$$

Models for comparing farming outcomes of owner-users and hiring-in users of capital goods

Farm mechanization has a significant and positive impact on agricultural production and productivity (Agarwal 1984; G Singh 2006; J Singh 2006; Verma 2006). Compared to hiring-in users, owner-users have better and more timely access to machinery; therefore, the intensity of their use of machinery in farm operations can be expected to be higher, and their adoption of better practices, such as multiple cropping, should be greater. Also, they can be expected to diversify their cropping pattern more and realize better yields of individual crops. We compared the farming outcomes of tilling machinery for hiring-in and owner-users and examined the intensity of mechanization of tilling (IMT):

$$\text{IMT} = \frac{\text{Gross mechanically tilled area}}{\text{Gross cropped area}} \times 100 \quad \ldots(5)$$

We used the one-tailed Fisher's *t*-test to determine whether there is any statistically significant difference in the IMT between owner-users and hiring-users based on these hypotheses: there is no difference in the IMT between owner-users and hiring-users (H_0); and the IMT is higher for owner-users than for hiring-users (H_A). We used regression analysis to investigate whether the hiring-users lag behind the owner-users with respect to cropping intensity, crop diversification, and in the realization of yield of paddy, the principal crop.

Cropping intensity (CI) is defined as the ratio of gross cropped area to net sown area and it is expressed as a percentage. Crop diversification (CD) is measured by the Herfindahl Index:

$$\text{CD} = 1 - \sum_{i=1}^{n} S_i^2 \quad \ldots(6)$$

where, s_i is the share of the *ith* crop in the gross cropped area of a farm household. Larger the value of CD, greater the diversification.

Yield (Y) is defined as paddy harvested during the reference year in kilogram per hectare of acreage.

User's type (UT) is the independent variable in all three regressions, which is defined as UT = 1 for owner users and 0 for hiring-in users.

In assessing the impact of UT on CI, CD, and Y, we need to control for the interference of other factors, such as the extent of tenancy and irrigation, farm size, fertilizer application, access to credit and extension services, and the area under high-yield variety (HYV) seeds. The tenure status of farmers influences cropping intensity, crop diversification, and yield realization (Goswami 2012; Junankar 1976). Especially, sharecroppers under certain situations may lack the incentive for fuller exploitation of these farming practices and outcomes. Irrigation positively influences cropping intensity (Dhawan and Datta 1992; Karunakaran and Palanisami 1998), crop diversification (Goswami 2012), and yield realization (Dayal 1984). Farm size is a determinant of cropping intensity (Agarwal 1984) and yield (Hossain and Hussain 1977; Khan 1979; Rao and Chotigeat 1981; Dorward 1999; Toufique 2005). Fertilizer consumption contributes positively to land productivity (Khan 1979). Conceivably, access to finance and extension services can positively influence cropping intensity, crop diversification, and yield realization.

The HYV seeds take less time to mature, and they are more productive than the traditional seed varieties; hence, it can be expected that larger acreage under HYV seeds enhances cropping intensity by releasing land early enough for accomodating more crops in the farmers' crop schedule. Compared to farmers who also practise nonfarm occupations, a full-time farmer is more motivated to adopt production-enhancing farming practices. We introduced a dummy variable, TC, into the analysis to distinguish between the outcomes of the two categories of farmers. To capture the variation in the adoption of better farm practices due to location-specific conditions, we used two location dummies and assumed Lakimpur as the reference location.

Table 3 Summary of variables in the regressions for utilization of land productivity

Variable	Notation	Definition	Expected impact		
			CI	CD	Yield
Independent variables					
User's type	UT	1 for owner user and 0 for hiring user	+	+	+
Control variables					
Extent of tenancy	ET	The proportion of lease in an area to the area of the total operational holding	-	-	-
Farm size	FS	The operated area in the hectare	+/-	+/-	+/-
Extent of irrigation	ERR	The ratio of gross irrigated area to gross cropped area	+	+	+
Access to finance	ATF	1 for borrowers and 0 for nonborrowers	+	+	+
Access to extension services	ATE	1 if consulted with extension workers, 0 otherwise	+	+	+
The area under HYV seeds	AHYV	Percentage of area under boro paddy to the total paddy acreage	+	NA	+
Types of cultivator	TC	1 for the pure cultivators and 0 for mixed income earners	+	+	NA
Fertilizer consumption	FER	Application of NPK (in kg) per hectare of paddy	NA	NA	+
Location dummies	L_1 & L_2	L_1=1 for Morigaon, 0 otherwise and L_2=1 for Kamrup, 0 otherwise assuming Lakhimpur as the reference location	+/-	+/-	+/-

Note NA- Not Applicable

To examine the impact of the different types of users on cropping intensity, we formulated the basic function as

$$CI = F\,(UT, ET, FS, ERR, ATF, ATE, AHYV, TC, L_1, L_2) \quad \ldots(7)$$

The minimum value of cropping intensity being 100, we have a cluster of observations at the lower end; hence, a left-censored tobit regression is considered more suitable than a simple linear regression. Accordingly, the tobit has been formulated in terms of the latent variable CI_i^* as:

$$CI_i^* = \beta_0 + \beta_1 UT_i + \beta_2 ET_i + \beta_3 FS_i + \beta_4 ERR_i + \beta_5 ATF_i + \beta_6 ATE_i + \beta_7 AHYV_i + \beta_8 TC_i + \beta_9 L_{1i} + \beta_{10} L_{2i} + U_i \quad \ldots(8)$$

where, $CI_i = \begin{cases} 100, \text{ for } CI_i^* < 100 \\ CI_i^*, \text{for } CI_i^* \geq 100 \end{cases}$, and U_i is the usual disturbance.

We examined the impact of the different types of users on crop diversification (CD) using the following functional form:

$$CD = F\,(UT, ET, FS, ERR, ATF, ATE, TC, L_1, L_2) \quad \ldots(9)$$

The value of crop diversification index ranges from 0 to 1, and there is a cluster of observations at the lower end in our data set. Hence, a left-censored tobit regression has been formulated as:

$$CD_i^* = \beta_0 + \beta_1 UT_i + \beta_2 ET_i + \beta_3 FS_i + \beta_4 ERR_i + \beta_5 ATF_i + \beta_6 ATE_i + \beta_7 TC_i + \beta_8 L_{1i} + \beta_9 L_{2i} + U_i \quad \ldots(10)$$

where, $CI_i = \begin{cases} 0, \text{ for } CD_i^* < 0 \\ CD_i^*, \text{for } 0 \leq CI_i^* \leq 1 \end{cases}$, and U_i is the usual disturbance.

Similarly, the basic model formulated to see the impact of the different types of users on yield (Y) is

$$Y = F\,(UT, ET, FS, ERR, ATF, ATE, AHYV, FER, L_1, L_2) \quad \ldots(11)$$

An exponential specification of Equation 11 has been adopted as the values of the dependent variable can be positive only.

$$Y_i = exp\,(\beta_0 + \beta_1 UT_i + \beta_2 ET_i + \beta_3 FS_i + \beta_4 ERR_i + \beta_5 ATF_i + \beta_6 ATE_i + \beta_7 AHYV_i + \beta_8 FER_i + \beta_9 L_{1i} + \beta_{10} L_{2i} + U_i \quad \ldots(12)$$

where, U_i is the usual disturbance.

Equation 12 has been made linear by taking logarithm on both the sides as:

$$lnY_i = \beta_0 + \beta_1 UT_i + \beta_2 ET_i + \beta_3 FS_i + \beta_4 ERR_i + \beta_5 ATF_i + \beta_6 ATE_i + \beta_7 AHYV_i + \beta_8 FER_i + \beta_9 L_{1i} + \beta_{10} L_{2i} + U_i \quad \ldots(13)$$

Results and discussion

Market power and rental rate

The rental rate of all the three types of tilling machinery—power tiller, tilling tractors, and tilling-cum-levelling tractors—varied across sample villages and households (Table 4). We designed the econometric model to examine whether market power impacts the variations in the rental rates and to identify their determinants.

The analysis shows that the coefficient of variable market power (MP) is statistically insignificant; market power played no significant role in determining the rental rate. The coefficient of the variable PR is negative and highly significant; often, a supplier offers a concession to a hirer if they share a personal relationship. The variable MEM is significant at 1% and it has a negative coefficient; if a farmer is a member of a group that hires out equipment, that farmer is offered a concession on the rental rate. The variable SOH is insignificant, implying that the rental rate is not influenced by the distance from hiring source to the land. The location dummy L_1 is significant with a positive coefficient; in relation to other factors, the

Table 4 Structure of rental rates (in INR) per bigha/round

Villages	Tilling cum levelling tractor			Tilling tractor			Power tiller		
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Lechai Gaon	NA	NA	NA	300	150	209.00	280	200	227.00
No. 2 Kowadanga	NA	NA	NA	250	150	200.00	250	200	236.67
Bhoroluwa Gaon	NA	NA	NA	220	220	220.00	280	220	240.00
Chenimari	300	300	300.00	300	140	200.00	300	150	284.00
Hariapar	250	250	250.00	250	250	250.00	300	200	242.11
Bihubori	400	300	333.33	300	150	250.00	300	220	238.18
Doloi Gaon	350	300	312.50	350	220	285.00	260	200	240.83
Pub-Sitara	350	200	294.44	300	200	275.00	300	200	258.00
Karara Garbhitar	350	300	311.36	240	130	178.33	250	150	223.00
Overall	400	200	297.66	350	130	222.06	300	150	246.32
Coefficient of variation (in per cent)	Across villages=9.33 Across households=13.86			Across villages=16.04 Across households=26.28			Across villages=7.46 Across households=13.47		

Source Authors' field survey
Note NA-Not Available, Max.-maximum, Min.-Minimum & Ave.-Average

Table 5 Descriptive statistics of explanatory variables for regression on determinants of rental rate

Non-categorical variable	Mean	S.D.	Min.	Max.
Market power (MP)	5.96	2.86	2.86	12
Categorical variable	Percentage			
Sources of hiring (SOH)	94			
Personal relation of hirers with lenders (PR)	08			
Membership of the hiring farmer in a group lending farm machinery (MEM)	05			
Lakhimpur (reference location)	30			
Morigaon (L_1)	43			
Kamrup (L_2)	27			

Source Authors' field survey
Note S.D.-Standard Deviation, Max.-maximum, Min.-Minimum

Table 6 Results of log-linear regression for determinants of rental rate of power tiller

Variables	Breusch-Pagan test Chi^2 (1) = 2.36 p = 0.1246 Average VIF=1.53 and Maximum VIF=2.19	
	Coefficients	SE
MP	0.01	0.01
PR	-0.16***	0.04
SOH	0.06	0.05
MEM	-0.19***	0.06
L_1	0.12***	0.03
L_2	0.01	0.04
Constant	5.38***	0.07
R^2	0.25	
F	6.07 (6,110)***	
n	117	

Source Authors' field survey
In ( ) degrees of freedom
*** represents significant at 1%

rental rate tends to be higher in Morigaon district (in the central part of the Brahmaputra Valley) than in Lakhimpur district (in the Upper Brahmaputra Valley).

Market imperfection and extent of utilization of land productivity

Agricultural outcome depends on biological and weather conditions, and productivity depends on the application of inputs and efforts in the apposite proportion and at the proper time. Hiring-in users may not be able to till their land at the most opportune times—because owner-users understandably make tilling machinery available in rental markets only after they have tilled their own fields—and they may experience lower yield and income. Market suppliers are not entirely distinct from equipment users, and we analyse how this element of imperfection in rental markets impairs hiring-in users' crop yield and use of productivity-enhancing practices.

Intensity of mechanized tilling

The IMT is 92.39% for owner-users in the sample but 88.46% for hiring-in users; owner-users can mechanize their tilling operation better than hiring-in users. For our analysis to be rigorous, however, we need to statistically check the significance of the difference in the IMT. Accordingly, we conduct Fisher's *t*-test to prove the null hypothesis of no difference in IMT between the two groups against the alternative hypothesis of owner-users having higher IMT. The null hypothesis cannot be rejected on the basis of a suitable one-tailed *t*-test, and we conclude that the apparent disadvantage of hiring-users in the fuller mechanization of tilling operation is statistically insignificant.

Table 7 Result of Fisher's t-test for no difference in IMT

	Levene's test for equality of variances	Fisher's t test
Calculated value of the statistic	F = 3.221	t = 0.929 (180)
p-value	0.074	0.177
Result	Equal variances	No difference

Source Authors' field survey
In ( ) degrees of freedom

Cropping intensity, crop diversification, and yield realization

Cropping intensity, crop diversification, and yield are higher for owner-users in the sample than hiring-in users. Cropping intensity is 116.32% for owner-users but 114.92% for hiring-users; crop diversification is 0.46 for owner-users and 0.45 for hiring-in users; and yield is 3,902.76 kg per hectare for owner-users but 3,488.86 kg per ha for hiring-in users. At first sight, therefore, hiring-in users appear disadvantaged, but we need to control for other factors influencing cropping intensity, crop diversification, and yield realization of the sample farms.

The results of the three regression analyses show that access to finance and extension services significantly enhances cropping intensity, crop diversification, and yield (Table 9). Farm size significantly but negatively impacts cropping intensity. Fertilizer application contributes positively to yield. The extent of irrigation contributes to cropping intensity and crop diversification. Locational characteristics have certain impacts on crop diversification. However, the coefficients of our prime independent variable, UT, are

Table 8 Descriptive statistics of explanatory variables for determination of CI, CD and Y

Non-categorical variables	Cropping intensity, n=182				Crop diversification, n=182				Yield, n=174			
	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Farm size in hectares (FS)	1.38	1.13	0.13	6.76	1.38	1.13	0.13	6.76	1.42	1.14	0.13	6.76
Extent of tenancy in proportion (ET)	0.32	0.37	0	1	0.32	0.37	0	1	0.32	0.37	0	1
Area under HYV in % (AHYV)	20.74	35.76	0	100	NA				21.70	36.29	0	100
Extent of irrigation in proportion (ERR)	0.30	0.37	0	1	0.30	0.37	0	1	0.27	0.40	0	1.00
Fertilizer consumption in kg/hectare (FER)	NA				NA				49.68	79.91	0	300.29

Categorical variables	Percentage	Percentage	Percentage
User's type (UT)	18	18	17
Types of cultivator (TC)	41	41	NA
Access to finance (ATF)	54	54	56
Access to extension services (ATE)	23	23	24
Lakhimpur (reference location)	30	30	30
Morigaon (L_1)	37	37	39
Kamrup (L_2)	33	33	31

Source Authrs' field survey
Note S.D.-Standard Deviation, Max.-maximum, Min.-Minimum, NA-Not Applicable

statistically insignificant in all three regression equations. Thus, controlling for other factors reduces to insignificance the apparent differences in cropping intensity, crop diversification, and rice yield realization between owner-users and hiring-in users of tilling machinery.

Conclusions

A key objective of this paper was to see if the market power of power tiller suppliers impacts rental rates. The results show that the suppliers have hardly any market power, despite being fewer in number than the hirers, because many farmers use traditional bullock-and-plough units. Also, if local rental rates are high, farmers can ask nearby suppliers for a better deal. In other words, the market power of suppliers is restrained by the contestability of local rental markets by owners and suppliers of substitute agricultural capital goods in nearby areas.

Although market power is not important in determining the rates of capital goods in rental markets, these markets are not entirely free of imperfections. Most suppliers of power tillers are users, too, and since hiring-in users cannot always hire the machinery at the most opportune times, their farming operations are adversely impacted, and their tilling operations are less mechanized. The use of production and productivity-enhancing practices is higher among owner-users, though the differences are not statistically significant.

Despite these imperfections, rental markets of tilling machinery contribute to mechanization and productivity-improving practices without any serious deficit in efficiency. We sense that in due course of time, ownership of these machinery will become more widespread, and even independent suppliers may emerge in larger numbers, eliminating this none-too-significant imperfection.

Table 9 Results of regression equation on the determinants of utilization of land productivity

	Cropping intensity Breusch-Pagan/ Cook-Weisberg test for heteroscedasticity Chi^2 (1) = 51.41 Prob > Chi^2 = 0.0000		Crop diversification Breusch-Pagan/ Cook-Weisberg test for heteroscedasticity Chi^2 (1) = 5.56 Prob > Chi^2 = 0.0183		Yield Breusch-Pagan/ Cook-Weisberg test for heteroscedasticity Chi^2 (1) = 0.14 Prob > Chi^2 = 0.7115	
Variable	Coefficient	Robust SE	Coefficient	Robust SE	Coefficient	SE
UT	5.49	10.59	-0.01	0.07	0.05	0.06
FS	-9.35*	4.85	0.02	0.02	-0.01	0.02
ET	-5.58	13.43	-0.07	0.09	-0.01	0.07
TC	13.48	8.89	0.05	0.05	NA	NA
ATF	17.71*	9.61	0.16***	0.06	0.10**	0.05
ATE	22.85*	12.12	0.13**	0.07	0.11*	0.06
AHYV	0.25	0.19	NA	NA	0.002	0.002
ERR	27.47*	16.73	0.26***	0.09	0.05	0.09
FER	NA	NA	NA	NA	0.002***	0.001
L_1	11.97	12.93	0.24***	0.07	-0.08	0.07
L_2	-9.66	11.37	0.06	0.08	-0.02	0.06
Constant	77.00***	12.43	-0.20***	0.08	7.98***	0.06
F	3.89 (10,172)***		6.22 (9,173)***		12.97 (10,163)***	
Pseudo R^2	0.0389		0.2113		—	
R^2	—		—		0.4431	

Source Authors' field survey
Note There is no serious problem of multicollinearity as the average VIFs corresponding to regression equations on cropping intensity, crop diversification and yield are 1.68, 1.36, and 2.60 respectively.
NA-Not Applicable
In ( ) degrees of freedom
***, **and * represents significant at 1%, 5% and 10% respectively

In this context, it may be instructive to comment on the role of custom hiring centres, which hire out farm machinery and other equipment and facilitate the servicing of old machinery. The government set up these centres to promote mechanization, especially on marginal, small, and medium-size farms. These centers contribute to the expansion of independent supply to the rental markets of farm capital goods. Farmers who use their services raise their income and profit (Chinnappa et al. 2018), but the custom hiring centres suffer losses, and their net social benefit is ambiguous. Their need depends on how well a farm capital goods rental market functions: if these are functioning effectively, custom hiring centres need to merely supplement or complement rental markets; if rental markets are weak or non-existent, for custom hiring centres can facilitate farm mechanization.

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