Tractorisation and Agricultural Development in India

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1. Introduction:

With the growth of population and commercialization, the need for technological development in agriculture has become need of the hour in India. There has been evidences of increased in the use of farm machinery in the country's agriculture as it contributed to the increased in output due to timeliness of operations and increasing precision in input application (Singh, 2005). In reality, the importance of technology in the field of agriculture was realised from the early sixties with the inception of "green revolution" in the country (Verma, 2005). The process enhances the degree of "mechanization" in the agricultural farms, that strives to reduce drudgery in agriculture, increase employment, increase production as a result of increased productivity per unit area (Rijk, 1989). Further, the need for mechanization of agricultural operations in the country was felt and intensified when the country was facing acute food shortages till eighties (Singh, 2005).

As per Neo-classical growth model, long term development in the economy is an imaginary process without the growth of technology. The same holds true for the development of agriculture as well, it can not speed up without modernisation and mechanisation. Farm mechanization is regarded as *sine-qua-non* to reduce the human drudgery and enhances agricultural productivity. During the post-green revolution

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period, the impact of farm mechanization on agricultural production and productivity has been well recognised in India, and has witnessed three to four fold increases (Verma, 2005). In the process, tractorisation is the prime component, and tractor farms give more yield than non-tractor farms in the country (Singh and Singh, 1972). Having identified these facts, the present study tries to explore a causal relationship between tractorisation/mechanisation and the share of agriculture to country's Gross Domestic Product (GDP). How does the tractorisation (mechanisation) contribute to the agricultural sector is also discussed.

2. Methodology:

With the inception of India's Green Revolution in the sixties, mechanisation, especially the use tractor in agriculture has become one of the most important processes of the revolution. During the eighties, though inventions were restricted mostly to tractors, the usage of seeders, tractors and sprayers were still significant till the end of 1990s. From the 2000s, the pattern of mechanisation was diversified slightly from the tractorisation to other implements like, irrigation, fertilizer, harvester, energy and others in Indian agriculture (Manchikanti and Sengupta, 2011). In contrary, Vishal, *et al*. (2008) found that since 2003, tractorisation process started significantly in the country at an increasing of 12.7 percent in 2003–04, 30.1 percent in 2004–05 and so on. In totality, the past studies showed that the scenario of mechanisation/tractorisation in Indian agriculture had different picture from and after 2000s. Therefore, it is worth to study the periods separately- as pre and post-2000s.

With this background, the present study tries to analyse the impact of tractorisation in Indian agriculture from 1961 to 2003 (first phase of tractorisation). For the purpose, time series data on agricultural GDP and growth of tractorisation for the period of 43 years (1961-2003) were collected from the RBI (2011) and WDI (2012) respectively (refer to Table 4). The collected data were tested for stationarity by employing Unit Root Test. Further, a comparatively simple method called Augmented Engle-Granger (AEG) test based on estimated residuals from the co-integration regression, was used for the short run equilibrium analysis between the variables (Gujarati, *et al*., 2011).

3. Farm Tractorisation in India:

Technological innovations have had profound effect on the agriculture sector in the post-Green Revolution in India. The tractorisation is considered as backbone of

farm mechanization, and has played a pivotal role in making the Green Revolution a grand success in the country (Vishal, *et al*., 2008). In India, tractors were being used for tillage of 22.78% of total area and sowing 21.30% of total area in 2005, as the contribution of different power sources to the total power changed with time (Kulkarni, 2005; Singh, 2005). As an effect of mechanisation, Kulkarni (2005) found that the share of agricultural workers continuously declined since 1981 and expected to be only 5.09 per cent by 2011-12 and that of draught animal power from 27.23 per cent to 6.37 per cent in same period. The increase in power agriculture in India has been mainly through introduction of tractors, whose contribution has increased from 7.5 per cent in 1971 to 51.08 per cent in 2011-12.

As a result of Green Revolution in the sixties, the total food grain production increased from a mere 50.8 million tonnes during 1950-51 to 217 million tonnes in 2006-07, and productivity increased from 522 kg/ha to more than 1,500 kg/ha. The increase in production of food grains was also possible as a result of adoption of quality seeds, higher dose of fertilizer and plant protection chemicals. Irrigation played a major role in increasing the productivity. Increased cropping intensity and higher quantity of inputs could no longer be effectively managed by animate power alone and, therefore, farmers adopted tractors, irrigation pumps, harvesters and power threshers extensively[4].

Table 1 gives a glance of agricultural implements used per 1000 hectare of net sown area of agriculture in India in the recent years. The agricultural tractor machinery per 1000 hectare of net sown area in the country is quite impressive and the level of technological up-gradation among the farmers in the country is also quite appreciable. However, though it is not shown in the Table, the state-wise share of these technological implements is quite asymmetrical in the country.

4. Empirical Findings

To understand mechanisation of farm, degrees of sophistication must be distinguished. For example, a simple locally made single-axle tractor without differential gears and gear box, a single axle tractor with gearbox and power-take-off, and a 70 KW tractor, are all mechanical power technology, but with a large difference

[4] Refer to Indo-Italian Chamber of Commerce and Industry (2008), Mumbai: "Overview of the Agricultural Machinery Sector in India"

in sophistication and capability (Rijk 1989). Nevertheless, the agricultural mechanisation or tractorisation here in this paper refers to the number of wheel and crawler tractors (excluding garden tractors) used in agriculture at the end of the calendar year specified or during the first quarter of the following year. It is considered as mechanisation or tractors used per 100 sq km of arable land.

4.1 Correlation of the Variable: There is positive correlationship between the mechanization/tractorisation and agricultural GDP and is reflected in the Table 2. The correlation coefficient value is found to be 0.972 and is significant at 1 percent level. This implies that the two variables are highly correlated between the mechanization and agriculture GDP. Further to measure stationarity of the variables, unit root test is employed.

4.2 Unit Root Tests: Table 3 shows that the variables are not found to be stationary at the level. However, using Augmented Dickey- Fuller (ADF) and Phillips-Perron (P-P) unit root test, both the variables are found to be stationary at the 1 percent in the first difference with the constant and trend level. This process helps further to proceed for the co-integration test of the model, and it enable us to test short run relationship between the two variables.

4.3 Testing of Co-integration: To understand the short run and long run relationship between agriculture's share to country's GDP and mechanization or tractorisation in Indian agriculture, co-integration test is done. In order to test the co-integration between the variables were taken natural log and classical log-log regression is run, e.g. mechanization (*LnMech*) and agricultural share of GDP (*LnAGDP*).

The relationship of the variables is expressed in the following regression form:

$$\text{LnAGDP}_t = \beta_1 + \beta_2 \ln\text{Mech}_t + U_t \quad \ldots (1)$$

Where, 'Ln' before the variables denotes logarithms of the variables, β_2 is the elasticity of agricultural share of GDP (*LnAGDP*) with respect to Mechanisation (*LnMech*).

The equation (1) can be written as:

$$U_t = LnAGDP_t - (\beta_1 + \beta_2 lnMech_t) \quad \ldots (2)$$

From equation (2), $\boldsymbol{u_t}$ is calculated and is tested for stationarity of the variables. If u_t is stationary then this cancels out the presence of stochastic trend in the two series. In this case, we say that the two variables are said to be co-integrated. If u_t is not stationary, then the two variables are again modeled as follows:

$$LnAGDP_t = \beta_1 + \beta_2 T + \beta_3 lnMech_t + U_t \quad \ldots (3)$$

Further, equation (3) can be written as:

$$U_t = LnAGDP_t - (\beta_1 + \beta_2 T + \beta_3 lnMech_t) \quad \ldots (4)$$

Now, we conduct unit root test for u_t . If u_t is stationary then we can infer that u_t is I (0) series that is they are stationary round a determinant trend.

Let us now explore the relationship between *LnAGDP* and *LnMech* using Engle and Granger (1987) methodology, and the corresponding estimated result of equation (1) is as follows:

$$LnAGDP_t = \underset{(33221)}{11.575} + \underset{(25.64)}{0.261}\ lnMech_t \quad \ldots (5)$$

$R^2 = 0.941 \qquad DW = 0.733$

Since *LnAGDP* and *LnMech* are individually I (1), there is possibility that the regression is spurious. Now using equation (2) we estimated $\boldsymbol{u_t}$ as:

$$U_t = LnAGDP_t - (11.575 + 0.261\ lnMech_t) \quad \ldots (6)$$

We perform unit root test on this residual $\boldsymbol{u_t}$ and then we obtained the following results,

$$\Delta U_t = \underset{(-2.26)}{-0.403}\, U_{t-1} \quad \ldots (7)$$

$R^2 = 0.215 \qquad DW = 2.343$

As the critical values of Engle-Granger asymptotic for 5 percent and 1 percent are -2.935 and -3.600 respectively, the residual from the regression are not stationary at 5 percent level. Therefore, we estimate equation (3) in which a deterministic trend is

included to see whether the residuals from this equation are stationary. The estimated result of equation (3) is presented below.

$$\underset{}{LnAGDP_t} = \underset{(293.00)}{11.876} + \underset{(8.64)}{0.038}\,T - \underset{(-2.44)}{0.104}\ lnMech_t \qquad \ldots (8)$$

$R^2 = 0.979$ DW=1.910

Further, u_t is estimated using equation (4) as:

$$U_t = LnAGDP_t - (11.876 + 0.038\,T - 0.104\,lnMech_t) \qquad \ldots (9)$$

The estimated u_t obtained from the equation (9) is further tested for stationarity, and the result is presented below:

$$\Delta U_t = \underset{(-6.34)}{-0.9809}\,U_{t-1} \qquad \ldots (10)$$

R^2=0.50 DW=2.016

In this stage, the Engle-Granger asymptotic critical values for 5 percent and 1 percent are found to be -2.933 and -3.5966 respectively. Therefore, the residual from the regression is stationary at 1 percent level. Thus, the residual u_t obtained from equation (3) is I (0), and it is stationary around a deterministic time trend being linear. That is the residuals are I (0) plus a linear trend. This result confirmed that the two variables— *LnAGDP* and *LnMech* are co-integrated**.**

4.4 Co-integration and ECM: Now, we have already shown that the variables *LnAGDP* and *LnMech* are co-integrated. This indicates that the two variables have long run or equilibrium relationship. But, in the short run there may be disequilibrium. Therefore, the error term obtained from equation (9), is used as the *Error Correction Term* (ECT) so that it can tie the short run behavior of ***AGD***P to its long run value. Granger representation theorem states that if two variables— X and Y are co-integrated, the relationship between the variables can be represented as ECM (Engle and Granger, 1987).

Now, to see the short run behavior of *LnAGDP* and *LnMech*, we use the following model:

$$\Delta LnAGDP_t = \alpha_0 + \alpha_1\,\Delta ln\ Mech_t + \alpha_2\,ECT_{t-1} + \varepsilon_t \qquad \ldots (11)$$

Table 1: Availability of Agricultural Equipments in India (Up to May, 2007)

Type of Equipment	Availability in Numbers/Per 1000 Ha Net Area Sown
Manual Seed Drill/Seed Cum Fertilizer Drill	153.2
Animal Drawn Seed Cum Fertilizer Drill	36.1
Tractor Drawn Seed Cum Fertilizer Drill	7.2
Animal Drawn Leveler	84.8
Tractor Operated Levelers	6.2
Manually Operated Plant Protection Equipment	28.5
Power Operated Plant Protection Equipment	4.3
Drip & Sprinkler Equipments	8.3
Horticultural Tools (Power Operated)	8.9
Tractors	16.7
Power Tillers	2.0
Tractor Operated Disc Harrow	6.6
Tractor Operated Cultivator	12.5
Tractor Operated Rotavator	0.9
Potato Digger	2.1
Straw Reaper	18.8
Forage Harvester	18.2

Source: MoA (2012)

Where, ϵ_t , is a white noise error term and ECT_{t-1} is the lagged value of error term obtained from equation (9). Now, we estimate the equation (11) as:

$$\Delta LnAGDP_t = \underset{(1.522)}{0.0257} + \underset{(0.374)}{0.0052}\,\Delta \ln Mech_t - \underset{(-6.34)}{1.00}\,ECT_{t-1} + \varepsilon_t \quad \ldots (12)$$

$R^2=0.514$ DW=2.018

This implies that the error correction term (ECT_{t-1}) is statistically significant, as verified by 't' value (-6.34). It suggests that the *Agriculture GDP* adjusts to the

changes in *Mechanisation of Tractor* with a lag of about cent percent of the discrepancy between long term and short term *AGDP*. From the equation (8) we can infer that the long-run elasticity of mechanisation at 10.4 percent and with the help of equation (12), the short-run elasticity is found to be at 0.52 percent. It implies that there is a positive impact of mechanisation on short run changes in agriculture GDP as well.

Table 2: Correlations

Variables	Statistics	MECH	AGDP
MECH	Pearson Correlation Sig. (2-tailed) N	1 43	
AGDP	Pearson Correlation Sig. (2-tailed) N	.972 (.000)* 43	1 43

* Correlation is significant at the 0.01 level (2-tailed).

Table: 3: Unit Root Tests

Variable		**ADF**		**P-P**	
		Level	**1st Diff**	**Level**	**1st Diff**
Agriculture GDP	**c**	1.171 (0.997)	-11.208 (0.0000)*	2.291 (0.999)	-12.039 (0.0000)*
	ct	-2.066 (0.548)	-11.563 (0.0000)*	-2.852 (0.187)	-21.088 (0.0000)*
Mechanisation	**c**	13.0933 (1.0000)	-0.7925 (0.8104)	16.9053 (1.0000)	-1.2905 (0.6249)
	ct	3.4885 (1.0000)	-4.5258 (0.0042)*	5.6644 (1.0000)	-4.4833 (0.0048)*

* Significant at 1% level

Note: c = constant and ct = constant and trend

Table 4: Mechanisation and Agriculture GDP in India

Year	**Machinery***	**Agriculture GDP****
1961	1.99	149355
1962	2.23	146149
1963	2.54	148887
1964	2.79	164271

1965	3.03	142144
1966	3.41	138892
1967	4.13	162603
1968	4.87	162042
1969	5.62	173788
1970	6.23	186668
1971	8.96	181696
1972	10.59	171471
1973	11.41	185920
1974	12.53	180797
1975	13.97	206462
1976	15.37	193905
1977	18.03	218172
1978	20.42	222520
1979	23.17	192788
1980	23.50	220624
1981	25.65	231320
1982	28.29	230997
1983	30.89	255837
1984	33.90	259633
1985	37.24	260139
1986	39.75	259122
1987	42.72	254647
1988	46.12	297543
1989	56.78	298720
1990	60.70	311500
1991	65.48	304301
1992	70.15	325777
1993	73.75	336136
1994	77.64	352069
1995	83.76	348626
1996	93.00	384886
1997	102.16	373446
1998	111.25	400030
1999	120.74	409660
2000	128.51	407176
2001	139.62	433475
2002	149.12	398206
2003	158.44	441360

Source: WDI (2012); RBI (2011)

**1999-00 price (Constant), and Rs. in crore; *Agricultural Machinery Tractor per 100 sq km of arable land

5. Conclusion

Despite some discrepancies that the tractorisation displaces bullock, labour and retrenchment of manpower in the labour intensive nation like India, the usage of tractorisation or mechanisation has made significant contribution to Indian agriculture. It enhances the agricultural GDP both in the short and long run. Tractor farm gives more yield than the non-tractor firms in India, especially the commercial crops like, sugarcane and potato (Verma, 2005). However, the present paper concludes that both in long run and short run, the growth of mechanisation or tractorisation has been positive impact on the agriculture GDP of the country.

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