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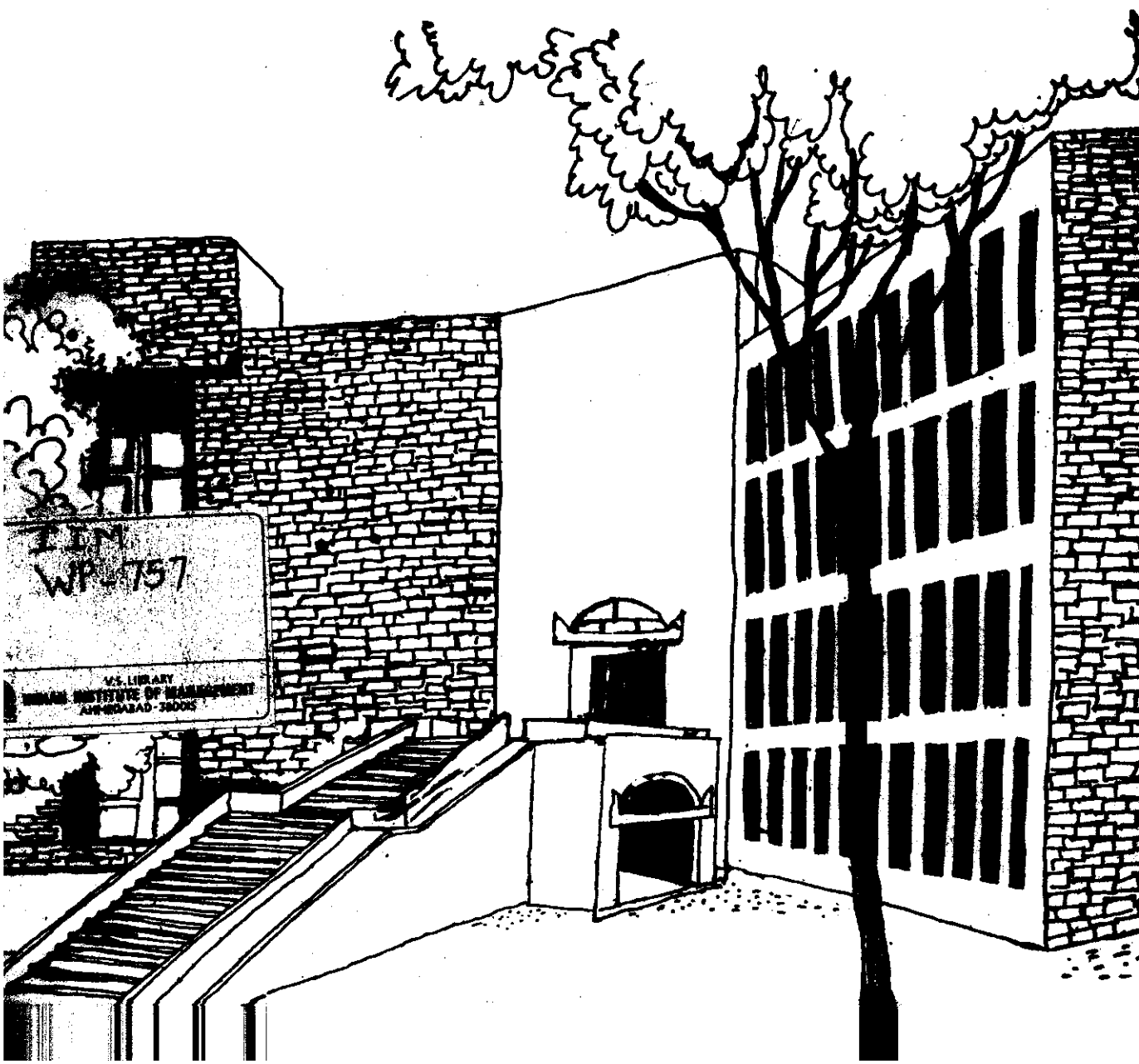

# GROWTH OF TRACTORS IN INDIA: PAST AND FUTURE

By

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# GROWTH OF TRACTORS IN INDIA : PAST AND FUTURE

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ABSTRACT

A causal, discrete, dynamic mathematical model to describe the growth of tractors in India has been proposed. It is able to describe the past pattern of growth quite closely, and yields results that are much better than possible from methods available in literature. Therefore, it has been used to outline scenarios till the year 2000. The model appears promising and needs to be tested further on independent set of data from individual states.

Determination of future demand for tractors is of interest to industry. Studies in this regard have been reported from time to time. Some of the studies have sought to indicate the 'ultimate' potential. Bergmann(1978) visualised that holdings with more than 20 ha size will require 2 tractors and those of 8 to 20 ha., one. On this basis he calculated the ultimate potential to be 4 million tractors in India. Yadav(1986) visualised that holdings of 10 ha and above will require one tractor. Accordingly he put the potential at 2 million. Singh et al(1986) refering to Punjab, considered holdings with more than 4 ha will have one tractor. Such holdings number nearly 300 thousands in Punjab. They expected this potential to be reached by year 2000.

Assessment of ultimate potential is useful. Of greater interest to industry, however, is the rate at which the potential will be approached. Balis(1968) and Bergmann(1978) who anticipated

rapid growth of mechanisation in India made some projections. On the basis of rising trend in tractor sales during mid 60's, Bergmann felt in 1966 that the annual production capacity should be increased to 100 thousand tractors by the end of fifth Plan i.e by 1979. The production in 1966 was around 11,000. Balis expected even more rapid rise in demand and felt that the production will reach a level of 90,000 per year by 1973. The basic view, held by Balis and Bergmann, of steady rise in mechanisation came true, though the pace has been slower than anticipated by them.

More systematic efforts at projection have also been made. NCAER(1974) estimated tractor demand from three linear regression models for the period 1973 to 1978. The models use combinations of four variables- agricultural production, relative price(tractor price index/foodgrain price index), cultivated area and irrigated area. As can be seen in Table(1) the estimates turned out to be uniformly higher than the actuals, with difference varying from 48% to 75%.

Mehta and Pahoja(1985) examined the production data from 1961 to 1984 and found that it fitted a quadratic equation. Since the fit was good they used the equation to project production for next six years(1985-90). The actual production for the first three years, of this period is now available. Their projections too turned out to be uniformly higher than the actuals.

Alam(1986) projected demand for 1984 as 92,000 and expected it to rise to 132,000 by 1989. Against these, the actual sales in 1984-85 was 80,000 and rose only to 86,000 by 1987-88. It appears

unlikely that it will reach 132,000 in the next two years. Here again, the projections proved to be over estimates.

Gupta et al(1987) projected tractor demand for India and several other states for 11 year period(1985-95) by extrapolating time series data of past sales. Yet again, the actuals in the first three years proved uniformly lower than the projections(table 1).

Clearly there is need to devise better methods of projection. The fact that past projections have invariably turned out higher than the actuals suggest that the cause and effect mechanisms needs to be identified more clearly. This paper proposes a mathematical model to describe the growth of tractors. The plausibility of the model is discussed. The likely future scenario derived from it is presented.

## MODEL

Change in the number of tractors in a given time occurs essentially in two ways. New tractors are purchased by the farmer adding to the existing stock. Some of the existing tractors reach the end of their working life and are dispensed with, reducing the stock. Those who dispense with the old tractor, may buy a replacement. If it is assumed that the tractors which have expended their working life are replaced necessarily and without delay, the net change in any given period will consist of those buying tractors for the first time, during that period.

The core of this model is the postulate that the rate at which the first time buyers will emerge at a given time depends directly on the number of farmers who do not yet own a tractor

i.e difference between the total ultimate potential and the actual number of present owners. We shall state the above mathematically.

Let

| | |
|---|---|
| t | time(year) |
| N(t) | tractors present at time t(no) |
| H | holdings of > 4ha.(no.); it is visualised that these consititute the ultimate potential; assumed constant(10.4 million) |
| I(t) | proportion of cultivated area which is irrigated(fraction), it is a function of time since extent of irrigation has been growing; its values are drawn from Statistical Abstract of India. |
| M(t) | effective potential for tractors,is defined to equal(H*I(t)) i.e. the number of those holdings of 4 ha. and above that are irrigated(no); |
| s(t) | sales rate(no/year) |
| c(t) | finance made available by banks(all commercial and cooperative) for farm mechanisation(Rs/year) |
| p(t) | weighted average price of tractors prevailing during the year(Rs/unit) |
| k | an empirical factor |
| L | working life of tractor(yrs) |
| d(t) | rate of purchases by first-time-buyers(no/year) |
| r(t) | rate of replacement purchases by replacement buyers(no/year) |
| j(t) | rate of obsolence(no/year),<br>This can be determined in one of the following ways. It can be made equal to the number of tractor purchased 'L'years ago.<br>Or it can be assumed to be proportional to the tractors present at a given time. The coefficient of proportionality can be derived from the average life of tractors.<br>Or it can be made probablistic.<br>In the model the first method is used. |

Now, the rate of growth in number of tractors at time, t, can be written as

$$\frac{dN(t)}{dt} = s(t) - j(t) \qquad ..1$$

since $d(t)=s(t)-r(t)$, and $r(t)=j(t)$ under assumption of immediate and necessary replacement, (1) will reduce to

$$\frac{dN}{dt} = d(t) \qquad ..2$$

Now in view of postulate stated earlier, d(t) can be expressed as

$$d(t) = k*(M-N(t)) \qquad ..3$$

Equation (3) states that the rate of emergence of new buyers will be proportional to yet untapped potential. The factor of proportionality 'k', as we will see later is a variable.

substituting (3) in (2)

$$\frac{dN}{dt} = k*(M-N(t)) \qquad 4$$

For discrete time interval of one year an approximate solution of this can be written in the form of a difference equation

$$N(t+1) = N(t)+k*(M-N(t)) \qquad ..5$$

The factor 'k' can be interpreted as a facilitating factor which determines the rate at which the untapped potential will diminish. In turn, 'k', will be influenced by all those factors that facilitate purchase by a new buyer. Most important among such factors will be the availability of finance- from banks and his own surpluses. The financial allocation for mechanisation by banks changes from year to year. We have actual data on this. The investible surplus generated by the farmer will also change depending on the state of his farm economy.

Other factor can be his awareness of the usefulness of the machine, the marketing effort made by industry etc. There are also factors that will tend to reduce 'k'. Most important of these will be the rise in price of machine. The factor 'k' will need to be determined emperically.

Since the form of relationship between the above factors and 'k' is not known, a priori, we shall first determine 'k' using past data.

Values of 'k' can be determined by using eqn(5) if a sequence of values of N(t) are known. Periodic count of tractors is given only by the livestock census. It, however, gives the number of tractors only at intervals of 5 years( for instance 1972, 1977, 1982 etc.). To compute values of 'k' it is necessary to estimate the values of intervening years as well. It can be done by starting with the one of the census figures, say 1972(148,000). The next years value can be obtained by adding to it the net increment, i.e. the difference between the total sales and the number of tractors junked during the year. The latter is assumed to equal the number of tractors purchased 'L' years(here 12) ago. The number of tractors so estimated are shown in Table (2a) column (6).

Note the estimated number of tractors differs only by 1% with the census figure of 1977, and 4% with that of 1982. This would suggest that the computed values of intervening years would be reasonably close to the actuals. We will treat these as such.

The resulting values of 'k', using eqn (5), are shown in Table 2(b). It is seen that 'k' is not a constant but a variable.

We shall now investigate the possible relationship between 'k' and the factors affecting it, mentioned earlier. Presently we shall consider only two factors- availability of finance from the banks and the prices. Other factors are ignored in this analysis. Among the factors excluded, the surplus of farmers is likely to be most important. The only justification offered for ignoring it is the fact that a very large proportion of tractor are bought through bank credit. There is also the problem of obtaining reliable estimate of farmers own surpluses.

Intuitively, 'k' is likely to be associated positively with finance and negatively with prices. One form to reflect this could be

$$k = f\,\frac{c(t)}{p(t)}$$

where 'f' is a function. The finance made available for farm mechanisation each year and the weighted average prices of tractors during the year are shown in Table 2b. Fig(1) shows a plot of 'k' and c(t)/p(t) ratio. Visual observation suggested the likelihood of a linear relationship. The equation resulting from least square method is

$$k = 9.2*10^{-3} + 1.52*10^{-7}*\frac{c(t)}{p(t)} \qquad ..6$$

($r^2$ =Ø.53, 'r' is significant at 5% level.

Equation (5) can now be written as

$$N(t+1)=N(t)+\left[9.2*10^{-3} + 1.52*10^{-7}*\frac{c(t)}{p(t)}\right]*(M-N(t)) \qquad ..7$$

Equation(7) can be used as a model to describe the growth in number of tractors. For instance, beginning with N(1975) as 215,705 and using the finance and prices of subsequent years, the growth pattern has been worked out and is shown in Fig 2a.

Note the closeness between the two graphs, one using eqn(7) and other of values taken from table 2a column (6). It is only to be expected that these be close. It should not be taken as conclusive test of validity. Here it is ment only to illustrate the ability of equation (7) to track the real data. It may be mentioned that further test of validity of the model will need to be made by using independent set of data. Such data may be drawn from some of the individual states such as Punjab, UP etc. The finance data relating to specific states is not easily available. It is being assembled in order to test the model, further.

Actual and calculated sales are shown in the figure 2b. The calculated sales are fluctuating, indicating the effect of finance allocation and tractor prices. Recall the studies cited earlier, where the projections were invariably higher than the actuals. Here the difference is both positive and negative. Note also the maximum difference between the actual and computed is now only 17%, much less than was the case in the studies cited earlier.

**Future Scenario**

We shall now use the model to project the growth of tractors upto 2000AD. The model requires expected financial allocation and prices that may prevail each successive year till 2000AD. Tractor prices have risen at a rate of 5.5% per year between 1980

and 1987. It is assumed this will hold in future. For finance, three separate policies have been imagined. One, in which it increases by 5.5% per year, that is just enough to neutralise the price rise. In the second, the finance is incremented by a fixed amount each year. And third, in which the finance increases at the rate of 10% per year. The projections begin from year 1985, when the number of tractors was 624527, finance Rs 5191 million and prices Rs 78,500/unit.

**Case-I**: Bank credit grows at the same rate as of tractor prices i.e. 5.5% per annum

Growth in number of tractors is shown in fig 3a. It is seen that number rises from 625 thousands in 1985 to 870 thousands in 1990, 1107 thousands in 1995 and 1335 thousands in 2000AD.

Total annual demand(first-time-buyers +replacement) that emerge from the model are shown in fig3b. The annual sales(demand) was 79,000 in 1985. It will increase to 101 thousands in 1990, 121 thousands in 1995 and 134 thousands in 2000AD.

Tractor industry at present has licensed capacity of 175 thousands and installed capacity of 110 thousands. Under this scenario, the licensed capacity will not need to be increased before 2000AD. However, industry will have to increase installed capacity after 1991.

Credit required will be Rs 6780 millions in 1990, Rs 8870 millions in 1995 and Rs 11600 millions in 2000.

**Case-II**: Bank credit grows by Rs 500 millions each year, choice is arbitrary though not unrealistic.

Number of tractors will increase to 877 thousands in 1990, 1131 thousands in 1995 and 1372 thousands in 2000. Annual demand in these years will be 104 thousands, 124 thousands and 136 thousands respectively.

The credit requirement in 1990 will be Rs 7700 millions, Rs 10200 millions in 1995 and Rs 12700 millions in 2000.

**Case-III**: Credit allocation increases by 10% each year.

Number of tractor will increase to 880 thousands in 1990, 1158 thousands in 1995 and in 2000 the number is likely to be 1454 thousands. Annual demand by these years will be 106 thousands, 132 thousands and 151 thousands.

Credit requirement will be Rs 8360 millions in 1990, Rs 13470 millions in 1995 and Rs 21690 millions in 2000. Table (3a) and (3b) gives summary of the three scenarios.

**Uses of Model**

The model can be used by tractor manufacturers for production planning. It is also useful for those who develop long term future perspective for industry's growth. It is relevant for those who plan for training of operators and mechanics such as the Farm Machinery Training and Testing Institutes. It will be useful to the implement manufacturers as demand estimates for their equipment will have to be based on the growth in the number of tractors.

It can be used by apex financial institution such as the National Bank for Agriculture and Rural Development (NABARD), to

work out policies for allocation of credit among various regions.

Recall that the effective potential was defined here to be that part of the land which is irrigated. Potential in unirrigated areas has been ignored. It will however be readily possible to modify the definition of effective potential to include the unirrigated areas.

The model can be refined further by developing more complete expression for 'k', by including those other variables that were ignored here. Important among these will be the annual investible surplus generated by the farmers.

The model ignores the size categories. Further refinement of the model may also take this into account.

Conclusions

1) A dynamic mathematical model to describe growth of tractors in India has been proposed. The model is able to describe the past pattern of growth quite closely.. It yields results that are much better than the available methods of projections in literature. It promises to be of wider validity and needs to be tested on data from individual states such as Punjab, UP etc.

2) Three different scenarios have been outlined for future. The lincensed capacity may not need to be increased till the year 2000. The demand is however, likely to exceed installed capacity after 1991. Further increases in installed capacity will need to be made later.

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Table 1: Summary of past projections

| YEAR | Actual sales | Demand prediction by | | | Actual production | Pdn. prediction by Mehta & Pahoja |
|---|---|---|---|---|---|---|
| | | NCAER | Alam | Gupta | | |
| | (no.) | (no.) | (no.) | (no.) | (no.) | (no.) |
| 1973 | 26485 | 39600 | | | | |
| 1974 | 30315 | 45600 | | | | |
| 1975 | 33116 | 52200 | | | | |
| 1976 | 40582 | 60000 | | | | |
| 1977 | 38889 | 68000 | | | | |
| 1978 | 53003 | 78900 | | | | |
| 1979 | 58095 | | | | | |
| 1980 | 68325 | | | | | |
| 1981 | 83157 | | | | | |
| 1982 | 66746 | | | | | |
| 1983 | 74849 | | | | | |
| 1984 | 80263 | | 92000 | | | |
| 1985 | 78966 | | | 94340 | 80472 | 95356 |
| 1986 | 76107 | | | 97820 | 74116 | 102690 |
| 1987 | 85785 | | | 103760 | 85793 | 110295 |

Note : Data on sales and production taken from Mehta & Pahoja(4) and NABARD

Table 2a: Tractors in India

| YEAR (1) | Total tractors (no.)* (2) | Actual annual sales (no.) (3) | Tractors due for replacement (no.)** (4) | Net additions (3)-(4) (no.) (5) | Total tractors (computed) (no.) (6) |
|---|---|---|---|---|---|
| 1972 | 148000 | 22655 | 3843 | 18812 | 148000 |
| 1973 | | 26485 | 3877 | 22608 | 166812 |
| 1974 | | 30315 | 4030 | 26285 | 189420 |
| 1975 | | 33116 | 4332 | 28784 | 215705 |
| 1976 | | 40582 | 6646 | 33936 | 244489 |
| 1977 | 276000 | 38889 | 7703 | 31186 | 278425 |
| 1978 | | 53003 | 11407 | 41596 | 309611 |
| 1979 | | 58095 | 15432 | 42663 | 351207 |
| 1980 | | 68325 | 20192 | 48133 | 393870 |
| 1981 | | 83157 | 28598 | 54559 | 442003 |
| 1982 | 518000 | 66746 | 33399 | 33347 | 496562 |
| 1983 | | 74849 | 37839 | 37010 | 529909 |
| 1984 | | 80263 | 22655 | 57608 | 566919 |
| 1985 | | 78966 | 26485 | 52481 | 624527 |

Note: * from livestock census
** equal to sales 12 years ago

Table 2b: Finance, weighted price and emperical factor 'k'

| YEAR | k | -finance from banks- Commercial | Co-op. | Total | Weighted tractor price |
|---|---|---|---|---|---|
| | | --------(Rs million)-------- | | | (Rs 'ØØØs) |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1975 | Ø.Ø12 | 747 | 4Ø8 | 1155 | 41.5 |
| 1976 | Ø.Ø14 | 1Ø32 | 331 | 1363 | 42.2 |
| 1977 | Ø.Ø13 | 833 | 778 | 1611 | 41.3 |
| 1978 | Ø.Ø17 | 764 | 346 | 111Ø | 43.4 |
| 1979 | Ø.Ø17 | 1315 | 448 | 1762 | 47.Ø |
| 198Ø | Ø.Ø19 | 2787 | 638 | 3425 | 54.Ø |
| 1981 | Ø.Ø22 | 2668 | 997 | 3665 | 58.1 |
| 1982 | Ø.Ø13 | 1962 | 924 | 2886 | 63.2 |
| 1983 | Ø.Ø15 | 3330 | 87Ø | 42ØØ | 64.7 |
| 1984 | Ø.Ø23 | 4276 | (87Ø) | 5146 | 68.Ø |
| 1985 | Ø.Ø21 | 4321 | (87Ø) | 5191 | 75.8 |

Note: * Credit allocation obtained from NABARD, except the finance by Co-operative banks for 1984 and 1985, which were not available and were assumed equal to the 1983 value.

** Weighted tractor price calculated from share of four size groups and their prices. Calculated from Mehta & Pahoja(4).

Table 3a: Summary of projections

| Year | Total tractors ('000s) | | | Required finance(Rs million) | | |
|---|---|---|---|---|---|---|
| | I | II | III | I | II | III |
| 1990 | 870 | 877 | 880 | 6780 | 7700 | 8360 |
| 1995 | 1107 | 1131 | 1158 | 8870 | 10200 | 13470 |
| 2000 | 1335 | 1372 | 1454 | 11600 | 12700 | 21690 |

Table 3b: Summary of projections

| Year | Annual demand from first-time-buyers ('000s) | | | Total annual demand ('000s) | | |
|---|---|---|---|---|---|---|
| | I | II | III | I | II | III |
| 1990 | 48 | 51 | 53 | 101 | 104 | 106 |
| 1995 | 46 | 49 | 58 | 121 | 124 | 132 |
| 2000 | 44 | 46 | 61 | 134 | 136 | 151 |

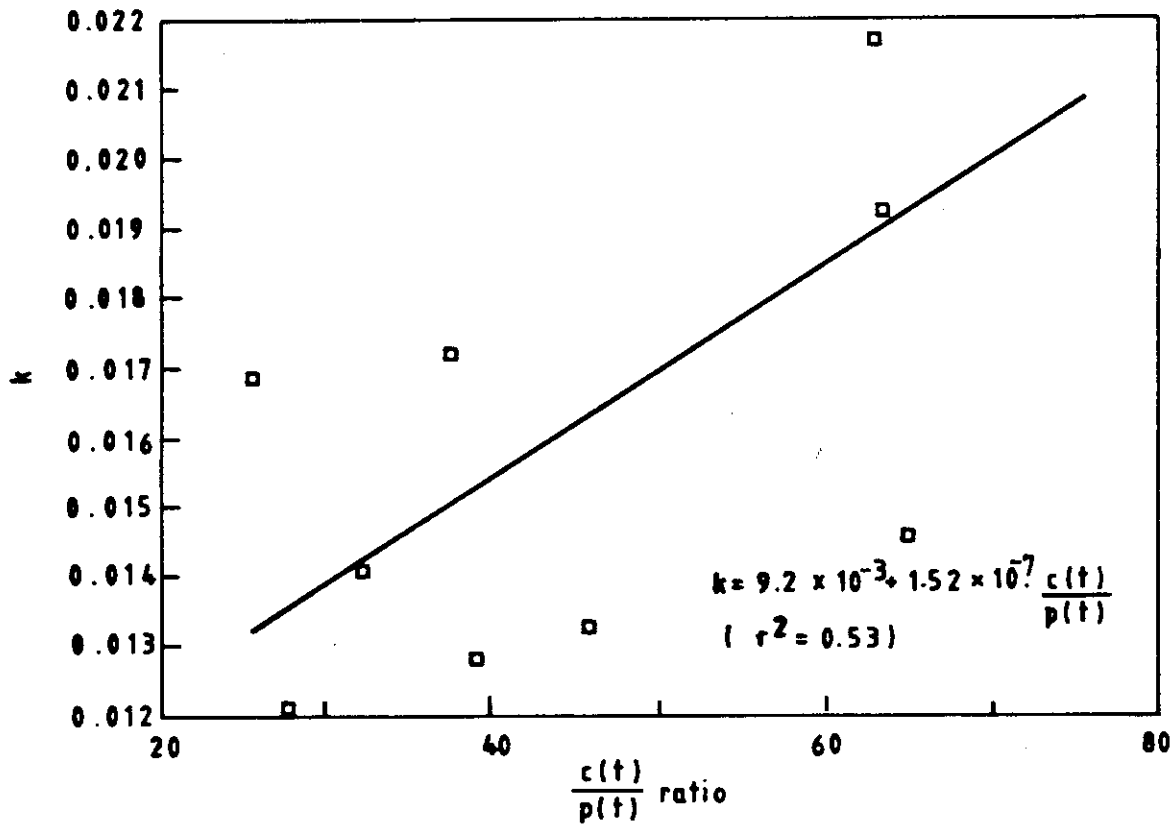


Fig 1 : Factor 'k' and finance to price ratio

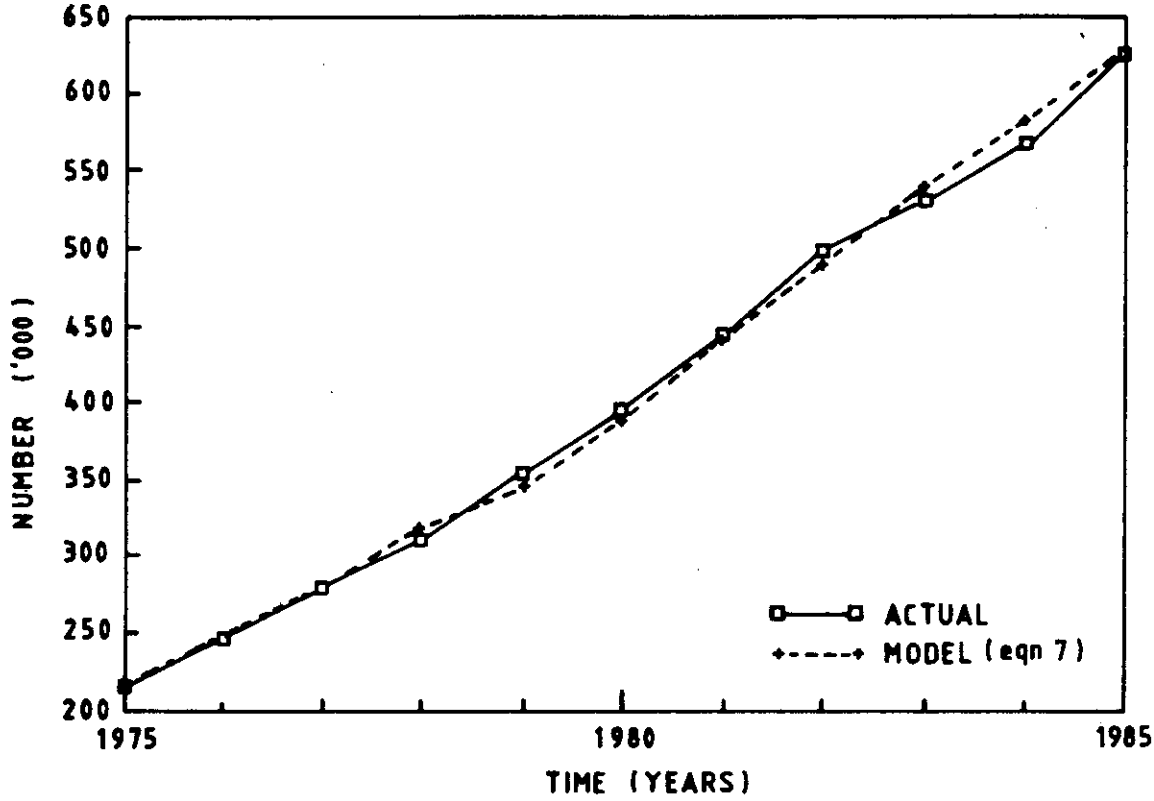


Fig 2a : Tractors in India

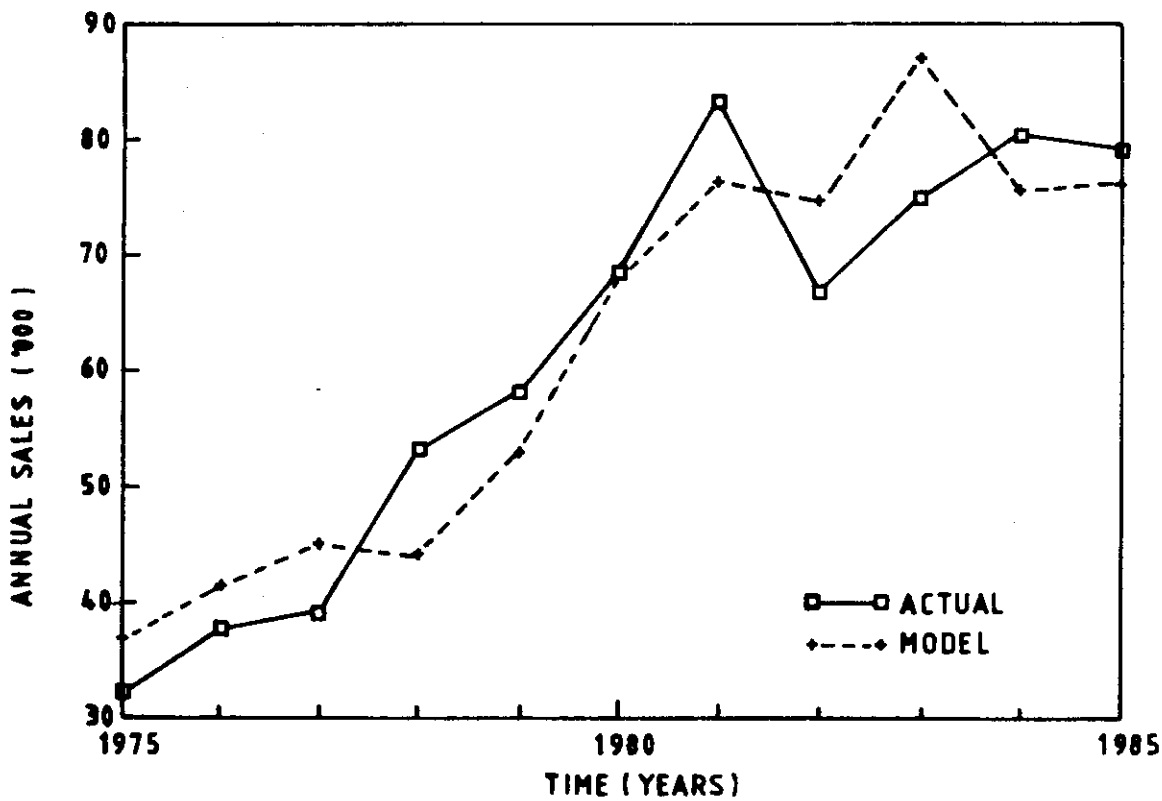


Fig 2b : Annual Sales of Tractors in India

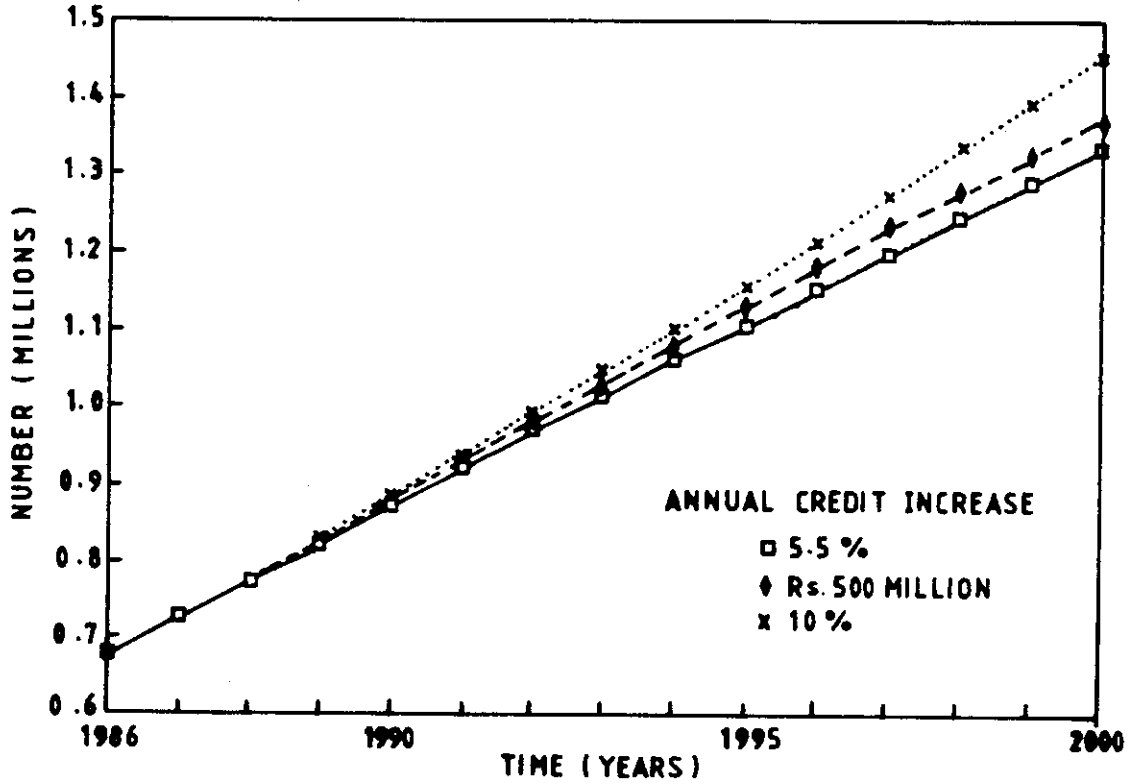


Fig 3a : Projected Growth of Tractors in India

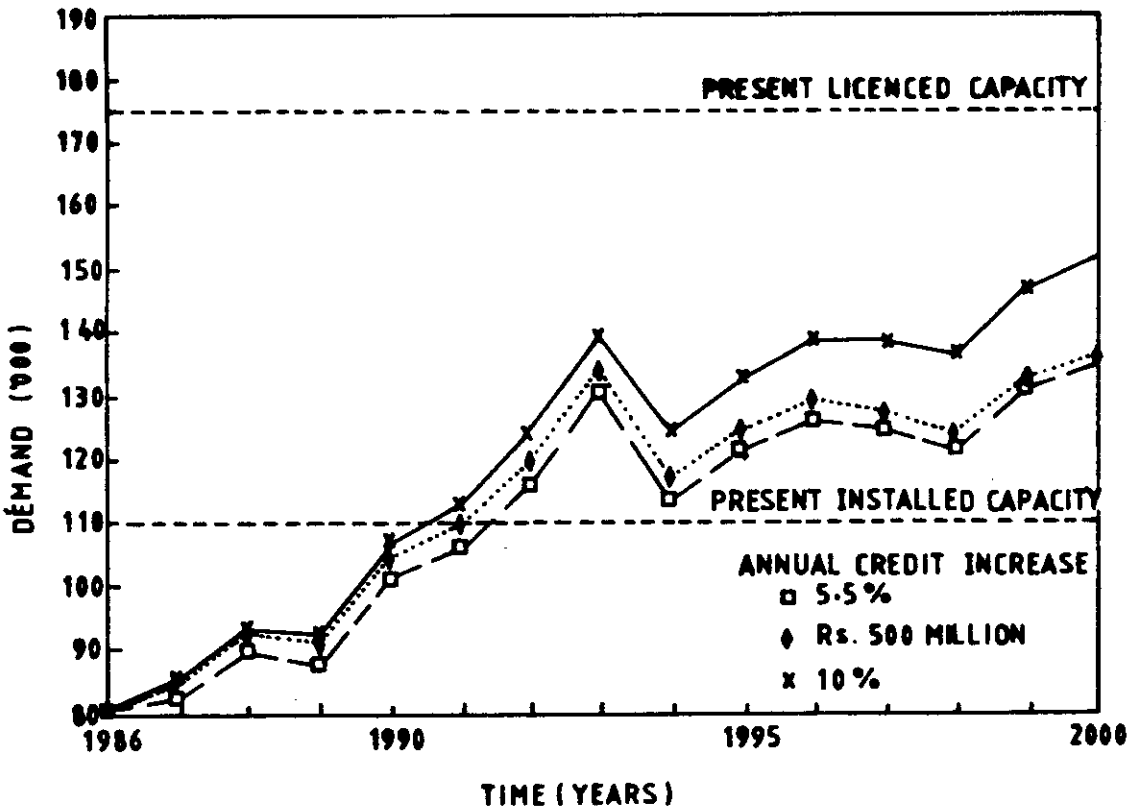


Fig 3b : Projected Annual Demand