CHAPTER - VI

TECHNICAL CHANGE.

In the earlier chapters, we have discussed Output, Labour and Capital — the three variables with which our analysis is intimately connected. This chapter attempts in establishing relationships between capital and labour on the input side and the resulting production on the output side. The purpose of this chapter is to analyse technical change in the context of growth and productivity over a span of 21 years.

Meaning of Technical Change:

6.2 Technological change or technical change — the advancement in knowledge relative to the industrial arts — is an important, perhaps the most important factor responsible for economic growth.[1] Technology is society's pool of knowledge regarding the industrial arts. It encompasses knowledge used by industry pertaining to the principles of physical and social phenomena, application of these principles to production and conducting the day-to-day operations. Thus technical change is the advance of technology taking the form of new methods of producing the existing products, new designs, new techniques of organisation, marketing and management. Solow defines technical change as "a short-hand expression for any kind of shift in the production function. Thus slowdowns, speed-ups, improvement in the education of labour force and

1. E.Mansfield, The Economies of Technological Change, W.W. Norton & Co., New York, 1968, p.8.

all sorts of things will appear as technical change."[2] In a broad sense, technical change is represented not merely by changes in the characteristics of capital but also includes increases in productivity due to better skills developed by labour on account of training and education and also improvements in managerial efficiency, external economies, etc.

6.3 Since a nation's economic growth depends heavily on the rate of technological change, the post-war period had witnessed growing awareness and intense interest in the study of technical change. We shall presently discuss the motivation for technical change.

Cause of Technical Change:

6.4 It is possible to establish a causal sequence where due to entrepreneurial decisions, K/L (Capital per unit of labour) changes, giving rise to changes in O/L (output per unit of labour). But the problem is: why do entrepreneurs change K/L (factor proportions)? In a developed economy, when capital grows faster than labour, capital-intensive techniques come into effect to avoid recession and unemployment. Alternatively severe competition may force entrepreneurs to adopt new techniques of production to keep-up with their rivals. In developing countries it is very likely that rising levels of current input prices, sometimes as a sequence of trade union activities, might induce technical change. It is also possible

2. R.M.Solow, 'Technical Change and Aggregate Production Function', Review of Economics & Statistics, Vol.39,1957.

Table 6.1

INDICES OF WAGES, LABOUR PRODUCTIVITY, OUTPUT AND INPUT PRICES

(Base 1951-52 = 100)

Years	Money Wages	Real Wage Cost	Labour Productivity	Machinery Transport Equipment prices	Fares	Freight	Inter-Industry Purchases
	1	2	3	4	5	6	7
1951-52	100.0	100.0	100.0	100.0	100.0	100.0	100.0
-53	103.3	98.8	100.8	112.6	96.6	110.8	107.2
-54	106.7	102.2	98.7	110.4	95.4	111.8	105.9
-55	108.1	104.7	110.5	109.0	94.9	109.6	105.4
-56	108.6	103.9	108.0	109.7	98.3	108.6	105.9
-57	109.8	103.2	110.6	111.4	98.3	111.8	117.4
-58	114.6	107.2	113.8	114.5	98.3	112.7	125.8
-59	117.1	109.1	116.0	117.0	97.7	113.7	131.3
-60	119.4	108.9	121.1	119.9	97.7	115.8	133.1
-61	129.0	114.7	128.3	126.0	97.7	120.2	139.2
-62	131.9	112.4	131.0	128.9	105.7	123.6	135.6
-63	139.2	112.7	134.2	132.8	114.9	128.0	140.9
-64	140.7	108.2	135.5	139.9	119.4	135.4	152.7
-65	150.8	113.2	132.8	144.1	120.0	139.5	158.5
-66	164.6	119.2	137.2	153.0	130.3	141.9	165.3
-67	177.4	126.3	135.5	168.7	128.6	146.3	175.8
-68	192.1	132.1	140.8	174.6	134.9	150.6	192.7
-69	205.7	135.1	147.8	177.5	141.7	157.8	203.4
-70	218.4	142.0	149.3	184.5	140.6	160.6	202.4
-71	235.5	147.3	148.3	200.0	142.9	160.6	211.3
-72	250.3	152.2	151.6	214.9	145.7	174.2	222.8

Sources: (1). Cols.1,2 and 3 are from Table 3.5.
(2). Col.4 is from Table 5.3.
(3). Cols.5,6 and 7 are from Table 2.A.6.

that as a sequel to demand pressures generated from other sectors in the economy, the transport sector will be forced to introduce technical change.

6.5 Now let us examine what could have been the probable reason for technical change in the Indian Railways. Table 6.1 is suggestive. By 1972, money wage index rose to 250 points (base 1951) and interindustry price index to 222. The Railways have two options before them. They either shift the burden to the consumer or raise labour productivity through technical change. Alternatively they can partially shift and have recourse to technical change. Table 3.7 and paras 3.24 and 3.25 clearly demonstrate how the Railways had to bear a large part of money wage burden during the time span 1951-61 and still, more than compensate the burden through technical change.[3] From 1961-72 shifts of the burden to the consumer are relatively higher and once again technical change was able to make-up for the remaining burden. To sum up, technical change to a certain extent appears to have taken place on account of the pricing policy of the Railways. The Railways were chary of increasing fares and freights - see 3.22. Not even one-half of the burden was ever shifted to the consumer.

6.6 But the entire causation cannot be placed on wage burdens alone. Probably the demand pressures due to development activities

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3. Strictly we should take a measure to reflect wages as well as interindustry purchases burdens. Since productivity is with reference to value added, we have desisted from using a combined measure. However interindustry purchases price index (222) is not so far removed from wage index (250) to vitiate the results.

in the macro-setting have also exercised their influence. The following table is illustrative.

Table 2.10 (repeated)

GROWTH OF THE RAILWAYS VIS-A-VIS INDIAN ECONOMY (1950-51 to 1971-72).

Annual Rate of Growth (%) of						
Passenger service.	Population.	Freight Service.	Agricultural Production.	Industrial Production.	Passenger and Freight Services.	Real National income
3.9	2.1	5.5	3.1	6.6	4.6	3.6

6.7 It is obvious from the table that while industrial production was increasing at an annual rate of 6.6%, agricultural production was increasing at 3.1%. These increases must have put pressures on the Railways to increase their services. Since track expansion is relatively more costly, and the same track could carry larger loads with technical improvements, technical change became inevitable.

We, therefore, conclude that the cause of technical change was partly due to the rising input prices and partly due to the pressures put on the Railways on account of overall increases in national output.

A study of the relationship between capital-intensity and labour-productivity will reflect the cost of capital intensity to achieve higher productivity. Let us therefore study the nature of technical change i.e. the functional relationship between K/L (capital intensity) and O/L (labour productivity).

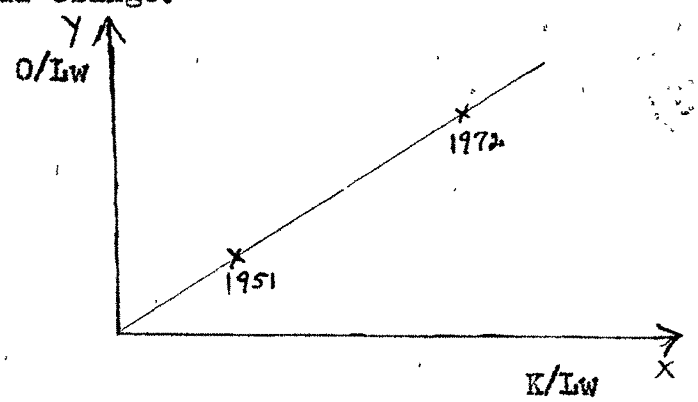
Types of Technical Change:

6.8 Three types of technical change are usually visualised, viz. neutral, capital-saving and capital-using. Generally, it is believed that in developed economies the technical change is neutral. This is the result of empirical research of Phelps Brown, Simon Kuznets and others.[4] In many theoretical models like that of Kaldor, Mrs. Joan Robinson and others, neutral technical change is assumed. Kaldor through his technical production function proved that neutral technical change was a dependent variable, and not merely an exogenous factor. Modigliani for a different reason concludes that O/K is constant.[5]

If O/L and K/L are increasing at the same rate, obviously O/L divided by K/L must be constant. This means that O/K ratio should be constant. In graphical terms, under neutral technical change the shift in production function is such that all the techniques would be on the same radius vector. If the shift is to the right of the radius vector, it is capital using and to the left it is capital-saving. Neutral technical change is nothing but unit elasticity of substitution between labour and capital.

4. See N. Kaldor, Essays on Economic Growth and Stability, Gerald Duckworth, 1960.
5. P.A. Samuelson, Economics, McGraw-Hill, Kogakushan, New Delhi, 1973, p.759.

6.9 The following diagram illustrates the different types of technical change.



Measurement of Technical Change:

6.10 According to strict theoretical considerations, it is extremely difficult to measure technical change and the methodology is still being discussed. However, conventionally the residual effect on increases in output is attributed to technical change. It is argued that partial productivities of labour and capital are responsible for a certain level of output. Anything that is not explained by these partial productivities is assigned to shifts in production function (technical change). We have the Cobb-Douglas and Robinsonian production functions (apart from several variants) based upon neo-neoclassical school and the post-Keynesian schools respectively. Asit Banarjee[6] B.H.Dholakia[7] and several others have used Solow's methodology based on neo-neoclassical school. Solow concluded that of the total growth of productivity per man hour in the USA during

6. A.Banerjee, 'Productivity Growth and Factor Substitution in Indian Manufacturing', Indian Economic Review, Vol.6 (New Series), No.1, April, 1971.
7. B.H.Dholakia, Sources of Economic Growth in India, Good Companions, Baroda, 1974, pp. 241-246.

1909-49, one-eighth was attributed to capital, per man hour, the remaining seven-eights (residual) was attributed to shifts in production function.[8] If this were to be true the most important factor responsible for growth is the technical change.

On the other hand Jorgenson and Griliches[9] commenting on Denison's[10] work remark that there is no residual to explain after corrections for aggregation and utilisation ratios.

6.11 Since there is no accepted methodology for measurement, we have followed Solow's method which has been followed by many researchers. However, we have put forward an alternative method, based upon Joan Robinson's and Kaldor's earlier theoretical works, though they now repudiate the very concept of production function[11] and incline towards macro-economic theory based on income distribution.

6.12 We shall now present measurement of technical change adopted by Hashim and Dadi[12] based upon Solow's analysis. They start with an identity: $g = \lambda + \alpha l + \beta_k$.
Where g is rate of growth of output, λ rate of shift in

8. R.M.Solow, op.cit.
9. D.W.Jorgenson and Z.Griliches, 'The Explanation of Productivity Change', Review of Economic Studies, Vol.34, 1967.
10. E.F.Denison, The Sources of Economic Growth in the United States and the Alternatives before us, Committee for Economic Development, New York, 1962.
11. P.A.Samuelson, op.cit., 1973, p.758.
12. S.R.Hashim and M.M.Dadi, Capital-output Relations in Indian Manufacturing, M.S.University of Baroda, Baroda, 1973.

Table 6. 2

INDICES OF O/L, K/L AND O/K RATIOS.

YEARS	O/L (1)	K/L (2)	O/K (3)
1951-52	100.0	100.0	100.0
-56	108.0	99.1	109.5
-61	128.3	103.5	124.0
-66	137.5	114.7	119.9
-72	151.6	125.3	120.9
Trend rates of growth 1951-72.	0.023	0.011	

Source: Tables 3.4 and 5.4.

Table 6.3

RATE OF TECHNICAL PROGRESS.

YEARS	$\frac{A(t)}{A(t)}$	A(t)
	(1)	(2)
1951-52 to 1955-56.	0.084	1.000
1965-66 to 1960-61.	0.171	1.084
1960-61 to 1965-66.	0.027	1.269
1965-66 to 1971-72.	0.070	1.304

Source: Computed from Table 6.2

production function or rate of technical change over time, αl is rate of growth in output due to growth in employment and β_k is that due to growth of capital. From the time series data, g, l, k can be directly estimated. $\lambda \beta \alpha$ have to be estimated from a production function as given below.

$G = f(L, K, t)$ where t is the trend variable representing a shift in the production function. Assuming constant returns to scale, the function in the Cobb-Douglas form can be written as:

$$\frac{G}{L} = Ae^{\lambda t} (K/L)^{\beta}$$

Hence $\log \frac{G}{L} = \log A(t) + \beta \log (K/L)$.

The incrementals can be expressed as

$$\Delta \log \frac{G}{L} = \Delta \log A(t) + \beta \Delta \log (K/L)$$

or approximately

$$\frac{\Delta(G/L)}{(G/L)} = \frac{\Delta A(t)}{A(t)} + \beta \frac{\Delta(K/L)}{(K/L)}$$

$$= \frac{\Delta A(t)}{A(t)} = \frac{\Delta(G/L)}{(G/L)} - \beta \frac{\Delta(K/L)}{(K/L)}$$

Where is the share of surplus in income.

6.13 Table 6.3 (derived from 6.2 table) reveals that over a period of 21 years, the contribution of technical change is about 30%, whereas the contribution of other factors is 70%. Actual contribution of technical change should be higher than 30% since the output figures are net of depreciation to a certain extent - see para 2.10. Table 6.2 reveals that O/L has risen faster than K/L. Thus a capital-saving technical change has taken place in the Railways. The contribution of technical change is not remarkable though not insignificant. During the 1955-61 period, the rate of technical change was very small, only 8%. The largest contribution (20%) is during 1960-68. The results are not in consonance with Solow's conclusions with respect to the American Economy where 90% of the growth of productivity is attributed to technical change. We should remember that Solow's data referred to the American Economy and he had not precisely adjusted for capacity utilisation. But we have adjusted our figures for under-utilisation vide Table 5.4. Had we not done so, probably we would have had more impressive contribution of technical change. Hashim and Dadi in their work[13] conclude that about one half of the growth in output in manufacturing Industries in India is attributable to factors other than labour and capital namely technical progress. Compared to Solow's figures, the conclusions of Hashim and Dadi are not depressing. One of the reasons could be that these two researchers have probably not used imputed labour.

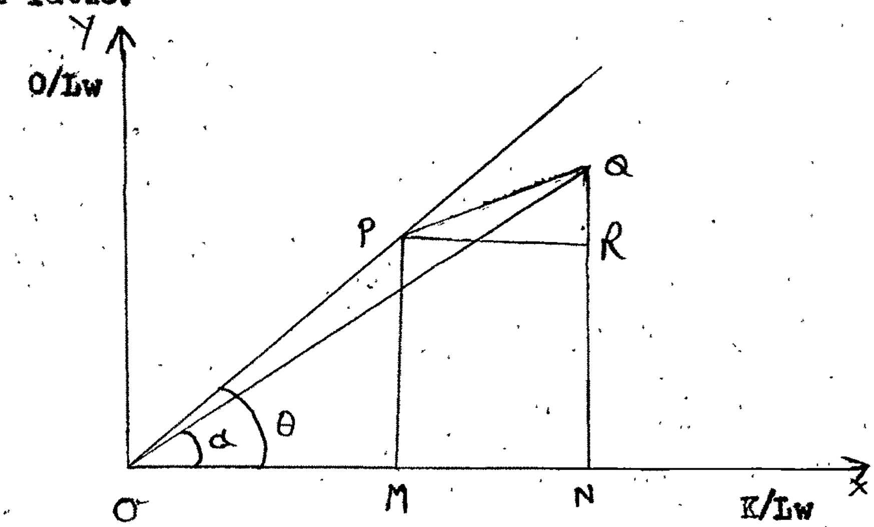
Let us turn our attention to alternative measurement based upon Robinsonian production function.

<u>Alternative Method</u>:-

6.14 The diagram shown below gives a graphical idea of the kind of production function we have in mind. It is not identical with Robinsonian production function since her K/L is the real

13. S.R.Hashim & M.M.Dadi, op.cit. p.80.

capital ratio. However capital intensity reflects the real capital ratio.



Let capital intensity (K/Lw) be marked on X-axis and O/Lw on Y-axis. Let P be the initial technique and Q represent the later technique. Let θ and α be the angles which P and Q make with X-axis at origin O. Let PR be parallel to X-axis. The distance PQ = $\sqrt{PR^2 + QR^2}$. This can be easily measured by finding out ΔK/L and ΔO/L. But we have not only to measure the distance PQ (shift in the technique) but also the shift in the angular movement of OP to OQ.

$$\text{Now } \operatorname{Tan} \theta = \frac{PM}{OM}$$

$$\operatorname{Tan} \alpha = \frac{QN}{ON}$$

$$\frac{\operatorname{Tan} \alpha}{\operatorname{Tan} \theta} = \frac{QN}{ON} \div \frac{PM}{OM} = \frac{QN}{ON} \times \frac{OM}{PM} = \frac{QN}{PM} \div \frac{ON}{OM}$$

= Coefficient of growth of O/L ÷ Coefficient of growth of K/L.

Thus when Q lies on OP, then Tan θ = Tan α.

$\therefore \frac{\operatorname{Tan} \alpha}{\operatorname{Tan} \theta} =$ Unity, which is defined as neutral technical change.

When Q lies to the right, as in the diagram $\frac{\tan \alpha}{\tan \theta}$ is less than unity which represents capital using technical change. When the ratio is more than one it represents capital saving technical change.

6.15 It may be noted that Tan α and Tan θ represent respective output capital ratios. The proportion of later output capital ratio to the initial ratio can be used as weights to the shift (PQ in the diagram) to measure the change in technique. Thus the correct measure of shift (S) would be:

$$S = \left[\sqrt{(\Delta O/L)^2 + (\Delta K/L)^2} \right] (O/K)' \div (O/K) \text{ where}$$

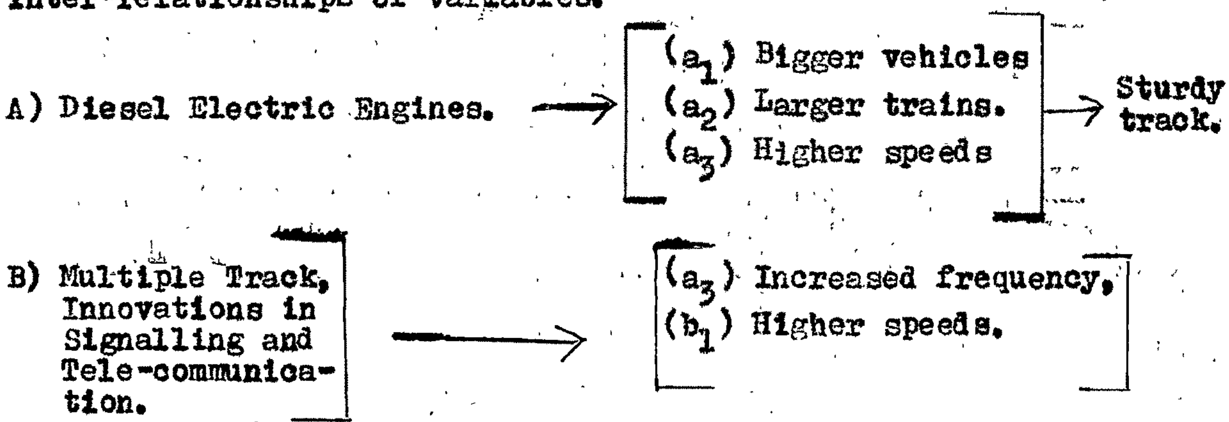
(O/K) and (O/K)' are the initial and later output-capital ratios.

We may add that economic interest lies in the space above OPR. Any point below this line is an inferior technique.

Once S is known S/OP in the diagram gives the annual rate of technical change, given the time period for technique Q to come into operation. In the alternative methodology, capital and output are measured in relative prices - see para 5.36. In the same manner output can be measured. It should also be noted that the ratios are not K/L and O/L but K/Lw and O/Lw i.e. capital and output are divided by current wage bill. We have presented only the methodology but have desisted from making computations since the relative prices in our data do not reflect the true position in view of the pricing policy of the Railways - vide para 3.22. We shall now discuss description of technical change in the Railways.

Description of Technical Change:

6.16 In any transport enterprise, the trend of technical change is generally in three directions — bigger vehicles, higher speeds and better use of rolling stock. Now let us examine the behaviour pattern of the Indian Railways over the span of two decades. The following schematic diagram illustrates inter-relationships of variables.



Note: Other manifestations of technical change like improvements of marshalling yards have not been discussed.

These are consequential changes that come into operation, once the independent variables (A) and (B) come into effect.

Dieselisation and Electrification:

6.17 The use of more spacious wagons and the operation of longer trains, discussed in para 6.18 below, has been possible due to electrification and dieselisation. It is a well-known fact when steam is used as motive power, the space and weight occupied by the engine are relatively high. Given the strength of the track, steam operation has a serious constraint due to the weight of the engine, cost considerations apart. Thus electrification and dieselisation is the most important technical change which we have

Table 6.4

GOODS TRAIN KMS, WAGONS AND NET TONNE KMS.

(Millions)

Years.	Goods Train KMs.	Wagons (4 wheelets)	Net Tonne KMs.	Index numbers of		
				Col.1	Col.2.	Col.3
	(1)	(2)	(3)	(4)	(5)	(6)
1950-51	111.5	0.0206	44117	100.00	100.00	100.00
-56	133.0	0.0235	58576	119.2	114.3	135.00
-61	161.2	0.0301	87680	144.5	146.2	195.7
-66	192.5	0.0395	116936	172.6	192.2	265.1
-72	206.5	0.0442	133265	185.1	215.1	302.1

Source: Indian Railways 1971-72, Ministry of Railways, Government of India, p.24.

2. Supplements.

noticed in the analysis. The most influential factor responsible for higher labour productivity is the change over from one kind of traction to another. In 1950-51, only 2% of the track was under diesel and electric traction and by 1972 it was 56% — see para 1.25. Till 1960-61, the combined share of diesel and electric traction was only about 8% of the total train KMs operated and by 1971-72 its share increased to about 40%.[14] Ever since the oil crisis, there have been regrets in different quarters whether the Railways did the correct thing to introduce this kind of technical change. In fact, in the background, there is a big controversy between the Railway Board and the Planning Commission of India on the use of diesel-electric traction.[15]

If it were not for the somewhat bright picture of oil prospects at Bombay high in recent months, further dieselisation would have to necessarily progress in a tardy manner.

Size of Wagons:

6.18 Here we find two types of changes, viz. trains are bigger and each wagon is also bigger in size. Table 6.4 illustrates the point. Col.5 divided by col.4 for 1971-72 (215/185) gives us a rough idea of the growth in the size of the goods train which works out to 1.2, i.e. the average size of the goods train in 1971-72 was 20% bigger than in 1950-51. The increase in wagon size is arrived at by dividing col.6/ col.5 (302/215) which works out to 1.4. This means wagon capacity has increased by 40% and each train contains 20% more wagons.

14. A Review of Performance of the Indian Government Railways, 1973 Ministry of Railways, Delhi, p.40.
15. See, The Economic and Political Weekly, Sep. 1, 1973, pp 1590-91.

Table 6.5

AVERAGE TRACTIVE EFFORT OF ENGINES OF ALL TRACTION.

(Kgs.)

YEARS.	B.G.	M.G.	Index of Col.1.	Index of Col.2.
	(1)	(2)	(3)	(4)
1950-51	12801	7497	100.0	100.0
-56	13672	7841	106.8	104.6
-61	14733	8201	115.0	109.4
-66	15906	9110	124.3	121.5
-72	17463	9686	136.4	129.2

Source: Indian Railways, 1971-72., Ministry of Railways, Government of India, p.27.

Table 6.6

SPEEDS OF TRAINS

(Average of all Tractions)

(KMPH)

	Passenger Trains		Goods Trains	
	B.G.	M.G.	B.G.	M.G.
	(1)	(2)	(3)	(4)
[illegible]	32.9 (32.2)	25.8 (25.4)	17.4 (16.0)	15.4 (13.7)
[illegible]	32.5 (31.9)	26.0 (25.7)	15.9 (14.5)	14.0 (12.7)
[illegible]	31.8 (31.7)	25.5 (24.8)	16.1 (14.6)	14.2 (12.7)
-56	32.2 (31.2)	26.8 (26.1)	16.8 (14.9)	14.4 (13.2)
72	32.5 (31.8)	27.8 (27.3)	18.6 (15.9)	16.3 (14.3)

Source: Supplements.

Note: Speed is calculated by dividing the Total Train KMs (excluding Departmental) by Total Train Engine Hours (excluding Departmental) Figures in parentheses represent speed of all trains i.e. including departmental trains.

Thus each train in 1972 was carrying 80% more load than it used to carry in 1952.

6.19 Obviously, this is reflected in more powerful engines being used for tractive effort. Table 6.5 gives a rough idea of the increase in the tractive effort per engine. It is evident from the table that the tractive effort of B.G. engines is up by 36% while that of M.G. engines by about 30% during the two decades period. Though the tractive effort has increased by 30-35% yet each train is carrying 80% more of net weight. This has been possible because net weight increases faster than the tare weight as wagons become bigger.

A good description of the technical change effected in the railways is neatly expressed in the following sentence:-

> "202% more net tonne KMs of freight traffic were moved with an increase of only 119% in the number of wagons owned (in terms of 4-wheelers), 77% in the number of locomotives (in terms of tractive units) and 30% in track KMs." 16

<u>Speed of trains :</u>

6.20 Table 6.6 is illustrative. The results are not very impressive. With slight variations, the speed of trains has almost remained constant. Thus, among the two factors — bigger vehicles and higher speeds — the Railways have not been able to significantly improve the speed factor though there is some increase in the speed of trunk route and express trains which is not impressively mirrored in averages.

16. Indian Railways 1971-72, Government of India, Ministry of Railways, Delhi, p.26.

Table 6.7

SINGLE, DOUBLE & MULTIPLE AND RUNNING TRACK

(00s - KMs)

Years	Route Kilometres			Running Track.	Index of Col.4
	Single	Double and Multiple.	Total		
	(1)	(2)	(3)	(4)	(5)
1951-52	485 (90.4)	513 (9.6)	537 (100)	594	1000
-56	498 (88.7)	520 (11.3)	550 (100)	609	1025
-61	495 (88.0)	673 (12.0)	563 (100)	636	1071
-66	491 (84.0)	935 (16.0)	584 (100)	684	1151
-72	485 (80.7)	116 (19.3)	601 (100)	732	1232

Source: Supplements.

Note: (1) Figures in parentheses represent percentages.

(2) Totals of cols. 1 and 2 always do not add up to col.3 due to rounding off.

Track and Telecommunication:

6.21 In Railways, the improvements in track and signalling equipment play a vital role in raising productivity. Multiple track which was about 10% of the total route Kilometrage in 1951-52 increased to about 20% by 1971-72 vide Table 6.7. This is not very impressive. To our mind, relatively speaking, dieselisation and electrification are far more important.

6.22 As a result of expansion of diesel and electric traction, changes have been effected in the track. Heavier rails are being used, the rails are welded upto one Kilometre length on important trunk routes, concrete and steel sleepers are laid with double elastic fastenings. These are all changes that get reflected in productivity by increasing speed and frequency, but we would consider these technical changes as secondary and as consequential changes to diesel-electrification. Let us now discuss technical changes effected in signalling and telecommunication. Inter-locking of stations, multiple aspect upper quadrant signals, expansion of microwave system, centralised traffic control, etc. are all changes that have taken place in this area. These should properly get reflected in the speeds of trains. However, we do not find any significant change in average speed of trains, vide para 6.20.

6.23 Technical changes mentioned above should normally be reflected not only in the speed of trains but frequency as well. Superficially, it might appear that the causation for increased frequency is higher speeds. This might not be so. Between two

Table 6.8

GROWTH OF TRAIN KILOMETRES:

(Millions per annum)

Years	Passenger & Proportion of Mixed (including)	Goods and proportion of Mixed experimen--tal)	Index Numbers of	
			Col.1.	Col.2.
	(1)	(2)	(3)	(4)
1951-52	168.9	117.6	100.0	100.0
-56	186.8	133.0	110.6	113.1
-61	205.1	161.2	121.4	137.1
-66	231.4	192.5	142.9	163.6
-72	253.2	206.5	146.4	175.6

Source: Indian Railways 1971-72, Ministry of Railways, Government of India.

points, more trains might be run at the same average speed and thus increase frequency. Alternatively, on account of increased speed, the same train might be able to cover the distance more number of times.

6.24 Let us now study with the aid of table 6.8, this particular aspect — frequency. It is obvious from the table that passenger train KMs have gone up by 46% and goods train KMs have increased by 76%. Since there has been an increase of about 23% in running track KMs (vide Table 6.7), frequency can be judged by dividing 146/176, the end figures with 123. Thus, making allowance for track increase, it can be roughly estimated that frequency of passenger trains has gone up by 18% while that of goods trains by 43%. These statistics point towards a conclusion that the track utilisation has improved on account of increase in frequency. But in para 4.18, we have noted that the utilisation of track has decreased in spite of more trains running on the same track — a paradoxical result. However, we have to point out that there is no contradiction between these two results. On account of improvements in signalling and telecommunication, the capacity of the track has so much increased that in spite of higher frequencies, utilisation of track has come down - vide foot note 10, chapter 4.

To sum up, the contribution of diesel-electrification appears as the chief contributing factor of productivity. Innovations in signalling and telecommunication seems to be of next importance. The third in importance seems to be multiple track with the proviso that the productivity of the track itself is favourably influenced by innovations in signalling and tele-communication. Thus, it is not really possible to isolate the effects of track improvements from the innovations in signal and telecommunication. Hence, the most important contributions are dieselisation-electrification and improvements in signal and telecommunication. However, it looks as if improvements in signalling and telecommunication have not been fully exploited by the Railways because the speed of the trains has shown no big changes.

Wagon Turn-Round:

6.25 However, there is one contributing factor to increased productivity which depends on the behaviour of the consumer and the managerial efficiency. To illustrate, the wagon turn-round is an important factor, especially for the goods vehicles. Some rough figures are available which are presented below:

WAGON TURN-ROUND (DAYS)

Gauge / Years	1950-51	1955-56	1960-61	1965-66	1971-72
B.G.	11.0	10.5	11.2	11.8	13.5
M.G.	6.7	7.2	7.9	8.4	10.6

Source: Indian Railways 1971-72, Government of India, pp.34-35

These figures indicate that the utilisation of the wagons has been a little tardy. But these turnround figures depend upon the average load and other technical and demand factors. The percentage of specialised wagons has got a serious effect on turnround of wagons.

For instance, a specialised wagon like (TPG (Oil tanker) when it goes on onward journey, many times has to be returned as an empty. Same is the case with coal wagons. In any case, a higher wagon turn-round is detrimental to productivity.

Effects on Employment:

6.26 As discussed in para 3.10, Operation staff (transportation) during the 21 years has not only decreased proportionately but also absolutely. The proportion of Civil Engineering staff has decreased from 26 to 21%. Signalling and Tele-communication staff has increased by 157% during 1956-72.