

**EMPTY WAGON MOVEMENT  
- A PRELIMINARY STUDY**

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- A Preliminary Study

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CONTENTS

	<u>Pages</u>
Chapter I      Introduction	1 - 12
Chapter II     Empty Flows on the Network, - An Overview	13 - 52
Chapter III    Analysis of Empty Wagon Movement and Management at a Node - A Case Study of the Pune Terminal	53 - 74
Chapter IV     Cost Considerations	75 - 84
Chapter V      Summary and Conclusions	84 - 89
References	90 - 92

Author's Note

This preliminary study was undertaken at the instance of the Planning Commission, Government of India, New Delhi. The draft report has been prepared for private circulation only. The report will be finalised upon receiving comments and suggestions from the Commission, the Railways and my colleagues.

September 1985.

S. Sriraman

## CHAPTER I

### INTRODUCTION

#### 1. Background

The problem of providing adequate wagon capacity on the Indian railways has been severe for quite some time. In a more general context, the National Transport Policy Committee (NTPC, 1980) observed, "During the last decade in particular, the growth of transport capacity lagged behind requirements of the economy, so much so that difficulties and problems arose in almost every part of the country in regard to movement of essential commodities needed for industrial and agricultural development and for meeting the consumer needs of the community." And the Railways, being the principal mode of transport of goods and people over long distances, have found it difficult to meet the increasing requirements for railway services.

A major problem, it is felt, has been the shortage of wagons. Acquisition of new wagons every year has been more for replacement of old ones; there has been virtually no net increase in the number of wagons in the past few years. In fact, the wagon stock has gone down in recent years as a result of withdrawal from service of a good number of overaged wagons. As a result, it is argued that the supply of freight services has not grown in consonance with the demand for the same. However, as Rao and Sriraman (1985) observe, such a facile explanation is inadequate primarily because the shortage of

wagons can be assessed only in relation to the demand for them. They note that since the demand for freight movements is variable over space and time, an allocation of wagons which appears inadequate may turn out to be a surplus by proper and efficient scheduling over space and time. It is further pointed out that the shortages in the availability of wagons have mainly resulted from the persistent deterioration in turn-round time of wagons. This has been partly due to the sharp increase in the average lead of freight traffic from about 550 kms. in 1950-51 to about 750 kms. in recent years. The increase has been very substantial for certain commodity groups. An increase in the lead of traffic keeps a wagon on wheels for a longer time and therefore increases the number of wagons required to handle a given quantum of shipments. Greater the lead, the more number of times is a wagon subject to routine checks. These cause transit delays. Besides, it is also observed that policies regarding allocation of wagons, assignment to destinations, scheduling, etc., have all contributed to increased turnround times.

On the other hand, with the increasing diversion of high-rated traffic to road transport, the railways have been increasingly involved in the movement of bulk commodities like coal, ores, foodgrains, cement, fertilizers, mineral oils, etc. These commodities accounted for nearly 90 per cent of the revenue-earning traffic in 1983-84 as against 58 per cent in 1950-51. And the bulk traffic is moved in block/unit

trains from the origin to the destination. The uni-directional movement of these commodities over long distances has contributed to a significant portion of the wagon movement being empty.

It is true that in order to sustain a set of traffic flows, a certain magnitude of empty movement is unavoidable. The number of wagons arriving with loads in any terminal area seldom coincides with the number required for shipments out of the area. Not all the incoming wagons are of the types suitable for the outward traffic. Thus, the railways are compelled to move empty wagons from points at which there is a surplus to points at which the vehicles unloaded may be inadequate to supply the needs of traffic likely to be offered. The basic problem then in freight operations is matching the demand for a specific type of transportation unit with the availability of these at other points on the system. This is to be achieved with the minimum amount of empty movement.

In the United States, nearly 45 per cent of movement is empty since the predominant movement of traffic is towards the east. This arises from the fact that most manufacturing takes place in the east and most farming and mining in the midwest and west; so bulk raw materials move east and compact manufactured items go west. The result is that empty wagons for western loading must be supplied from the east and a considerable amount of empty movement is brought about in the process. In India, empty wagon movement constitutes about 33 per cent of the total wagon movement on the railway network. <sup>annually</sup>

4

We have considerable movement of bulk material such as coal, ores, etc., from the mining areas in the Bihar/Bengal belt to industrial centres in the north, south and west. But in the case of the United States, the highways predominate even in long-distance movement so much so that the railroads have excess capacity on almost all routes. Besides, the passenger component of the total flows is negligible. In India, it is observed that nearly three-fourths of the freight traffic is concentrated on about 25 per cent of the network. Moreover, these very sections are utilized for providing passenger services on a large scale. Thus the problem is one of shortage of capacity, especially on the main routes. While expansion of the wagon fleet is definitely called for, it must be remembered that the railways cannot go on increasing their wagon holding without a corresponding increase in their track capacity to run them. Alternatively, given the wagon stock and its efficient use there can still be limitations on their use due to the availability of track capacity. Additional traffic on saturated routes would only lead to diminishing returns in respect of overall wagon mobility.

Forecasts of freight traffic for the late eighties clearly indicate that the Railways would be called upon to carry a much heavier volume of traffic in <sup>the</sup> years to come. The annual freight demand by the mid-nineties is expected to be more than 400 billion tonne kilometers as against the present demand of 170 billion tonne kilometres. It appears



from production forecasts that the mining areas in the Bihar/Bengal belt as also the industrial areas in the different parts of the country will continue to dominate in the future too. Thus the main brunt of the traffic increases will fall on the very routes which are already under pressure. The railways would surely like to strengthen and consolidate these critical routes which would yield immediate benefits before taking up new lines and conversions which have great popular appeal. However, even such a limited expansion of track capacity may not be feasible. The electrification of the main routes, which is being currently done rapidly, would probably help to some extent. But according to the Railway Reforms Committee (Sarin Committee - 1983), renewal of track is to be given the highest priority. It is felt that inadequacy of investment, on renewals has resulted in the track getting 'sick'. By 1982, arrears of track replacement amounted to nearly 11,000 kms. of primary tracks and 6500 kms. of secondary track capacity. According to the Committee, "the Railways had fallen into the habit of neglecting the maintenance aspect". However, since all the resources for track renewal, which is top priority, may not be available, the possibility of significant expansion of track capacity/line capacity would appear rather remote.

#### Objective of the Study

Wagon stock represents one of the major capital investments by the railways but it is an asset that is very poorly used in general. Under the circumstances described above.

there is an imperative need to aim at a better utilisation of existing wagon capacity. A major dimension of improvement that could be visualised is in the sphere of empty wagon movement and management. This refers to the process of controlling the empty wagons from the time they are unloaded to the time they are placed for the next loading. It is often held that this aspect of wagon usage is handled rather inefficiently and that there is need for more attention and research directed towards better utilisation of capacity represented by such flows. With this view in mind, our primary objective is to conduct a preliminary study of empty wagon movement and management on the Indian Railways. Such a study, it is to be emphasised, would not only analyse the problem from the point of view of the railways but would also look into certain aspects of developmental policies under the plans, which have been major influences on the emergence of empty flows on the network.

#### Methodology for the study

In this section while we develop the methodology for the study, we will also seek guidelines from the available literature to the extent it helps us in formalising the methodology appropriate for our study.

To understand the logistics of empty flows on the network, it is necessary to examine the existing pattern of empty flows. This would indicate their underlying characteristics. In his scholarly study, Thor Maltgren (1948) examined,

in brief, the empty component of car (wagon) movement in the context of <sup>prosperity</sup> prosperity and depression in the United States. With the help of certain ratios, he observed that a cyclical increase in railroad (railway) traffic was usually accompanied closely by a growing movement of empty cars (wagons) and a decline in traffic by diminishing empty mileage, though swings in empty car-miles seems to be proportionately less than those of loaded car-miles. Thus, there is relatively more empty movement in a contraction and this is explained by changes in the composition of traffic. For our purpose, a similar analysis would be helpful, though in a different context. For instance, we have observed that bulk commodities predominate in the total freight movement. It would be useful to examine the extent to which their increasing importance over the years has contributed to the emergence of empty flows on the system. Some other pertinent questions that we ~~will~~ look into are:

- (a) How have the shifting patterns of traffic from Metre Gauge to Broad Gauge affected this dimension?
- (b) Do the trunk routes account for most of such movement?
- (c) What is the influence of empty movement on turn round time?
- (d) How does the seasonal nature of movement of certain commodities result in considerable movement of empties?

(e) Further, it would be useful to examine the extent of utilisation of wagon capacity. A number of wagon utilisation measures have been proposed and are currently in use important among them being wagon kilometres per wagon day and net tonne kilometres per wagon day. The former is a measure of wagon mobility while the latter is a measure of goods <sup>SERVICES</sup> rendered on an average by each wagon per day. While these are useful measures, it is felt that there is a need to explicitly measure the utilisation of wagon capacity.

Typically the average wagon needs to be examined from the point of view of loaded movement that is a part of the total movement and also of each wagon cycle (turn round time). In the course of their studies on Railway Freight Operations, the Australian Bureau of Transport Economics made a survey of wagon utilisation (1977) on five major railway systems in Australia. In this context they have proposed certain measures of wagon utilisation which we propose to use in our study. This is done at two levels as follows:

1st Measure

$$\frac{\text{Capacity Used}}{\text{Capacity in transit}} = \frac{\text{Tonnes of freight in transit}}{\text{Tonnes of capacity in transit}}$$

$$\frac{\text{average wagon load}}{\text{average wagon capacity}} \times \frac{\text{Loaded transit time}}{(\text{loaded+empty tr.time})}$$

This measure would give us an idea of the capacity used in transit. Greater the empty movement component, lesser the capacity used.

### 2nd Measure

$$\frac{\text{Capacity used}}{\text{Capacity available}} = \frac{\text{Tonnes of freight in transit}}{\text{tonnes of capacity available}}$$

$$\frac{\text{average wagon load}}{\text{average wagon capacity}} \times \frac{\text{loaded transit time}}{\text{wagon turn round time}}$$

This measure would also reflect the delays in yards, terminals, sidings, etc.

To answer some of these questions besides many others, it was necessary to look into the broad pattern of flows of bulk items. Data needs have been sought in the Annual Statistical Statements of the Railway Board and Zonal Railway as also the Statements of Domestic Statistics brought out each month at the Zonal level. Statements regarding utilisation of line capacity on various sections of the different zones in terms of loaded and empty flows have also been looked into. Above all, detailed discussions with officials in the Traffic Transportation, Planning and Economic Cells have been held to give better insights.

Efforts to measure the magnitude of empty flows originating at various points from the point of view of their utilisation would indeed be a formidable task, considering

the magnitude of our railway network. For a preliminary study such as ours, such a comprehensive attempt is not a feasible proposition. Therefore, it was proposed to confine ourselves to a part of the network. We begin with the study of empty movements originating at the terminal at Pune. Pune is one of the major freight terminals on the Central Railway network. The objective is essentially to examine the tonnage associated with such flows <sup>and</sup> also the direction of movement. This would give us an idea of the existing pattern and availability of wagons at well-defined points of time. At this level of analysis, some of the relevant questions that could be conceptualized and examined are as follows:

- (a) What is the extent of backloading at present as compared to the available capacity?
- (b) How far is it possible to make use of this capacity in the form of available empties given the pattern of demand and variations in them?
- (c) Does the primary responsibility for empty wagon distribution lie at this local level? In other words, what are the present policies of assignment of empties to other points on the system?
- (d) What is the extent of allocation delays which contribute to large scale idle empty wagon time at terminals?

To look into some of these issues, it was thought necessary to look into loading data as well as shipper order

data. Typically, a forecasting exercise based on either would underestimate demand or overestimate shipper's requirements. Data for consideration of these aspects were got from the Manuals of Operating Statistics of Terminals published by the railway Board and other unpublished records of daily empty movements and detention at Pune.

The ultimate cost of moving freight is significantly affected by the extent of empty movement. The unit costs vary with the level of empty flows associated with the movement of particular commodities. The varying necessity for empty haulage is considered together with many other factors in the rate-making for the various commodities. The interesting question that arises is that regarding the adequacy of transport rates to cover this additional cost of empty haulage. Wherever there is imbalance in movement, there is an opportunity for carrying freight in empty wagons at low rates. When goods are carried in the predominant direction of movement, costs are high because every wagon load of freight implies the return of an additional empty wagon. To induce shipper to use the excess capacity represented by empty hauls probably requires, among other things, that rates reflect the costs by being lower where empty backhauls can possibly be used. Quoting low rates for backhaul in certain cases could permit the railways to get back traffic from the highways. Efforts were made to look into these aspects in discussions with officials in the costing cell of the railway Board. As

anticipated, not much headway has been possible in this direction. But we do intend to make some comments on the basis of available information.

#### Plan of the Report

In the following chapter, we analyse the various issues related to the railway network as a whole and also take up the analysis of wagon utilisation. In the third chapter, we take up the case study of the rail terminal at Pune and analyse the relevant issues. Chapter IV relates to the analysis of cost considerations within the limited framework of the study. The final chapter would give a summary of the findings and also our concluding remarks.



## CHAPTER II

### EMPTY FLOWS ON THE NETWORK - AN OVERVIEW

Our investigations of empty flows on the railway network begins with a macro-view of empty wagon movement on the Indian railway system. In this chapter we examine the various issues that have been raised earlier.

#### Trends in Loaded and Empty Wagon Kilometrage

The trends in loaded and empty wagon kilometrage (all gauges) and the corresponding proportions in total wagon movement are given in Table 1. The percentage of loaded to total wagon movement was around 69 in the early fifties which gradually rose to about 73 in the late fifties. Since then the percentage has been hovering around 67-68 per cent, except for a couple of years in the early seventies when it touched 70 per cent. A similar picture emerges even when the broad gauge and meter gauge sections are considered separately though the fall in the percentage of loaded movement has been much more in the case of the Broad gauge than on the Metre Gauge. These trends are given in Table 2.

At the aggregate level, it would be useful to examine certain other trends which indicate the increasing trend in empty movement. These are set forth in Table 3. When considering the net tonne kilometres per goods engine hour, we observe that the increase in these indices have not been

Table 1 : Wagon Kilometrage (All Gauges) ('000)

Year	Loaded W. kms.	% in total	Empty W. kms.	% in total
1950-51	3092304	69.2	1264153	30.8
1951-52	3233765	69.4	6323028	30.6
1952-53	3324298	69.1	6378354	30.9
1953-54	3348320	69.3	1351367	30.7
1954-55	3613909	70.4	1415490	29.6
1955-56	4023104	72.0	1461861	28.0
1956-57	4319441	71.6	1597751	28.4
1957-58	4724748	73.3	1668450	26.7
1958-59	4763395	71.6	1837529	28.4
1959-60	5032484	71.0	2055647	29.0
1960-61	5229942	70.6	2277475	29.4
1961-62	5466276	69.4	2389404	30.6
1962-63	5901748	70.1	2491729	29.9
1963-64	6726018	69.4	2731872	30.6
1964-65	6291681	68.7	2841931	31.3
1965-66	6906441	69.3	3020390	30.7
1966-67	6906998	69.4	2985396	30.6
1967-68	7139581	68.9	3094751	31.1
1968-69	7500871	69.1	3320921	30.9
1969-70	7740122	68.4	3530063	31.6
1970-71	7648735	69.3	3306567	30.7
1971-72	7950485	70.7	3271011	29.3
1972-73	8114496	71.4	3230925	28.6
1973-74	7280156	70.2	3070976	29.8
1974-75	7688000	70.1	3260435	29.9
1975-76	8318238	68.3	3845414	31.7
1976-77	8749144	67.0	4296394	33.0
1977-78	8998019	67.7	4260620	32.7
1978-79	8625014	69.0	3857776	31.0
1979-80	8563030	70.2	3630916	29.8
1980-81	8456914	69.5	3707936	30.5
1981-82	9278921	69.2	4122234	30.8
1982-83	9476578	68.1	4817285	31.9

**Table 2 : Percentage of Loaded to Total Wagon Kilometrage**

Year	Broad Gauge	Metre Gauge
1950-51	69.2 (30.8)	76.2 (23.8)
1951-52	69.4 (30.6)	76.2 (23.8)
1952-53	69.2 (30.8)	76.1 (23.9)
1953-54	69.3 (30.7)	78.2 (21.8)
1954-55	70.4 (29.6)	77.6 (22.4)
1955-56	72.0 (28.0)	78.1 (21.9)
1956-57	71.6 (28.4)	77.7 (22.3)
1957-58	73.3 (26.7)	76.0 (24.0)
1958-59	71.6 (28.4)	74.2 (25.8)
1959-60	71.9 (28.1)	76.5 (23.5)
1960-61	71.8 (28.2)	75.4 (24.6)
1961-62	68.2 (31.8)	73.2 (26.8)
1962-63	69.3 (30.7)	73.0 (27.0)
1963-64	68.7 (31.3)	72.2 (27.8)
1964-65	68.3 (31.7)	70.1 (29.9)
1965-66	68.6 (31.4)	72.0 (28.0)
1966-67	69.1 (30.9)	71.7 (28.3)
1967-68	67.5 (32.5)	70.7 (29.3)
1968-69	68.5 (31.5)	71.4 (28.6)
1969-70	67.4 (32.6)	72.2 (27.8)
1970-71	68.9 (31.1)	72.8 (27.2)
1971-72	70.2 (29.8)	72.6 (27.8)
1972-73	70.8 (29.2)	73.8 (26.4)
1973-74	69.4 (30.6)	73.5 (26.5)
1974-75	69.5 (30.5)	72.8 (27.2)
1975-76	67.7 (32.3)	71.2 (28.8)
1976-77	66.2 (33.8)	70.5 (29.5)
1977-78	67.0 (33.0)	71.0 (29.0)
1978-79	68.2 (31.8)	73.4 (26.6)
1979-80	69.4 (30.6)	74.6 (25.4)
1980-81	69.0 (31.0)	72.8 (27.2)
1981-82	68.7 (31.3)	72.1 (27.9)
1982-83	67.3 (32.7)	73.6 (26.4)

N.B. : Figures in bracket give the empty percentages.

Table 1: Some Aggregate Figures

Year	Net Tonne Kms. per Goods Engine Hour		Net tonne Kms. per wagon day		Average Train Load (Broad Gauge) (tonnes)	
	Broad Gauge	Metre Gauge	Broad Gauge	Metre Gauge	Net Weight	Gross Weight
1950-51	3283	1238	709	304	-	-
1951-52	3360	1254	757	324	-	-
1952-53	3208	1352	726	334	-	-
1953-54	3162	1395	721	316	-	-
1954-55	3337	1424	790	317	-	-
1955-56	3473	1496	884	332	-	-
1956-57	3558	1366	932	332	-	-
1957-58	3725	1625	978	343	-	-
1958-59	3735	1599	937	368	-	-
1959-60	3964	7624	970	345	631	1311
1960-61	4170	1766	998	405	656	1354
1961-62	4041	1860	973	445	657	1358
1962-63	4201	1931	1007	474	699	1405
1963-64	4231	1984	987	487	701	7424
1964-65	4244	1991	921	476	707	1427
1965-66	4446	2194	940	510	721	1470
1966-67	4523	2169	699	485	733	1484
1967-68	4660	2195	985	474	724	1494
1968-69	4446	2194	905	503	733	1510
1969-70	4790	2415	916	522	721	1496
1970-71	4904	2525	907	524	737	1509
1971-72	5075	2642	935	540	748	1518
1972-73	5210	2806	943	558	754	1534
1973-74	4992	2771	837	482	745	1538
1974-75	5326	2945	907	528	781	1567
1975-76	5568	2839	982	545	782	1577
1976-77	6047	3005	1019	570	796	1607
1977-78	6125	3023	1045	570	818	1638
1978-79	5941	3131	976	543	857	1648
1979-80	6096	3165	972	534	863	1694
1980-81	6295	3345	986	522	884	1724
1981-82	7007	3662	1112	538	911	1780
1982-83	7289	3865	1123	576	898	1766

proportional to increase in freight traffic indicating (in terms of tonne kilometres, it has gone up from 37 million in 1950-51 to nearly 170 million in 1982-83, i.e., by 5 times.) imbalanced traffic, lighter loads and increased amount of light engine hours. Once again it is observed that increases have been only half as much on the Broad Gauge as compared to the Metre Gauge. The rise in net tonne kilometres per wagon day was higher in the years upto the 2nd Plan end, which could be explained by the introduction of higher capacity wagons. Thereafter, there was a downward trend except in 1976-77, 1977-78, and the past two years. This basically reflects the want of improvement in wagon mobility, excessive turn round time and imbalanced flow of traffic. The comparison of the gross average train load and the net average train load shows an increasing trend in difference which again is a reflection of the increase in incidence of empty haulage.

Table 4 gives the trend in empty movement per unit of loaded movement and net tonne kilometrage performed per unit of total wagon movement. The aggregate figure moves down from .40 to .36 between 1950-51 and 1960-61 and thereafter shows an increase till 1982-83, when it is about .51. Thus for every kilometre that a loaded wagon moves, it travels empty for about half a kilometre. Again, the services performed per unit of wagon kilometrage, from the point of

Table 4

Year	Empty W. Kms. per unit of loaded W. Km.	Net tonne Kms/Total W. Kms.
1950-51	.40	10.09
1951-52	.40	10.33
1952-53	.41	9.99
1953-54	.40	9.89
1954-55	.39	10.04
1955-56	.36	10.71
1956-57	.36	11.11
1957-58	.35	11.67
1958-59	.39	11.59
1959-60	.37	11.57
1960-61	.37	11.68
1961-62	.43	11.57
1962-63	.42	11.90
1963-64	.43	11.81
1964-65	.45	11.64
1965-66	.43	11.74
1966-67	.43	11.74
1967-68	.44	11.46
1968-69	.45	11.52
1969-70	.46	11.33
1970-71	.43	11.61
1971-72	.41	11.82
1972-73	.39	12.00
1973-74	.43	11.72
1974-75	.42	12.26
1975-76	.46	12.16
1976-77	.49	11.91
1977-78	.47	12.22
1978-79	.45	12.32
1979-80	.42	12.74
1980-81	.43	13.01
1981-82	.45	12.98
1982-83	.51	12.71

view of net tonne kilometres, does not show significant improvement. For every kilometre that a wagon moves, net tonne kilometres performed was about 11.5 in the fifties and hovered around 12.5 in recent times.

### Factors Influencing Empty Wagon Movement

#### 1. Shipping Pattern on the Network

##### a. Increasing importance of bulk items

A good deal of empty movement takes place on account of traffic imbalance by direction, which is basically a function of the spatial distribution of supply and demand points for shipments. Thus, the railways are compelled to move empties back from the unloading areas to supply the needs at the loading points. In India, we have considerable movement of bulk commodities over long distances. The increasing importance of bulk movement to the total movement has contributed to growing empty movement. The percentage of bulk to total has been steadily increasing from 55 per cent in 1950-51 to around 88 per cent in 1982-83. This trend is shown in Table 5. To cater to this changing composition of traffic, the rail movement has been sought to be achieved in block rakes/unit trains, which is more economical especially when there is a large volume of traffic to be lifted. At present, almost all the iron ore and a major portion of coal and mineral oil movement is being carried in block rakes as can be seen from Table 6.

**Table 5 : Percentage of Bulk Movement to Total Movement (Commodities)**

Year	% to Total
1950-51	55.20
1955-56	58.20
1960-61	61.90
1961-62	67.41
1962-63	68.32
1963-64	68.30
1964-65	67.34
1965-66	66.16
1966-67	70.58
1967-68	72.10
1968-69	72.95
1969-70	72.55
1970-71	70.36
1971-72	78.18
1972-73	75.63
1973-74	77.20
1974-75	78.21
1975-76	74.83
1976-77	83.56
1977-78	84.86
1978-79	84.86
1979-80	84.83
1980-81	85.71
1981-82	86.77
1982-83	87.85

**Table 6 : Movement in Block rakes (1982-83)**

Commodity	% to total movement
Coal	94.4
Cement	81.7
Iron-ore	100.0
Manganese Ore	87.90
Mineral oils	89.60
Foodgrains	74.00
Raw material for steel Plants	97.10
Finished products from steel plants	66.00



Moreover, the average lead of freight traffic has been increasing sharply. It is observed that the average lead (for all commodities) has gone up from about 560 kms. in 1960-61 to about 750 kms. in recent years. The increase has been very substantial for certain commodity-groups. For instance, in the case of foodgrain traffic, the lead increased from 760 kms. in 1960-61 to about 1250 kms. in 1982-83. In the case of cement it has doubled from about 360 kms. to nearly 740 kms. As for fertilizer traffic, the lead went up from about 675 kms. in 1965-66 to about 1150 kms. in 1982-83. Even iron and steel traffic has a lead of about 1100 kms. in recent years as against 700 kms. in 1960-61. Only in regard to coal traffic, the average lead has come down marginally to 570 kms. from about 650 kms. Such unidirectional movement of commodities, (and thereby of loaded wagons since the <sup>k</sup>trains have to be sent back empty to the loading points) results in a good deal of empty movement.

**b. Decreasing Importance of the Metre Gauge Component and the Gauge Problem**

Another factor that appears to have contributed to increased empty movement is the falling share of goods traffic on the Metre Gauge sections with shifts to the Broad Gauge taking place. Although the Metre Gauge sections amount for nearly 42 per cent of the total network, they carry only about 12 per cent of the total freight traffic. While its share in the total freight flows in terms of the

<sup>origin</sup> originating tonnage was around 25 per cent in the early fifties, its share has been steadily decreasing and is at present just a little above 10 per cent. Even when this aspect is considered in terms of the loaded wagon kilometrage, its share in the total has declined from 24 per cent in 1950-51 to around 14 per cent in 1982-83. Although the coverage of the MG network is not much less than that of the BG component in terms of the route kilometrage, most sections of the MG are found confined to certain <sup>densely</sup> densely populated areas of the north, the extreme west and south. Consequently, a good amount of traffic is of the local type and involve shorter distances than on the BG. But since these areas have not figured prominently on the industrial map of the country, it has resulted in a constant and large scale movement of goods such as foodgrains, agricultural goods, manufactured items between the MG and BG. This has also resulted in considerable empty movement of wagons in and out of the transshipment points.

There are nearly 100 transshipment points on the Indian railway system. Out of nearly 10,000 wagons loaded daily on the Metre Gauge, 47 per cent represent traffic moving within the MG area itself. While 21 per cent are loaded with traffic sent out of the MG area, 32 per cent represent traffic moving into the MG areas. Basically, the problem with regard to goods traffic at these points is that

involving coordination in the availability and placement of loaded and empty stock on the two gauges. This problem arises mainly due to two factors :

- a) Difference in the carrying capacity of the wagons of the two gauges available for interchange of goods.
- b) Unbalanced movement of traffic necessitating empty haulage.

From the Broad Gauge (BG) to the Metre Gauge (MG), transshipment from 1 BG wagon would involve 1.8 MG wagons, while from the MG to the BG, 1 MG wagon requires .8 BG wagon. For instance, to effect transshipment from 50 BG wagon, 90 empty MG wagons would be required, while for 90 MG loaded ones, 72 BG empties are required. Whenever the traffic in the two directions is more or less balanced on MG, it will be necessary to feed BG empties. But traffic is not quite balanced at all transshipment points. In fact, it is observed that a good deal of empty movement takes place in and out of the transshipment points. In the case of the 15 major transshipment points, it was observed (in 1982-83) that, on an average, around 15,000 wagons are sent back empty and about 10,000 empty wagons are received at these places on the BG side every month. On the MG side, the corresponding figures were 5,000 and 20,000 respectively. Thus, the existence of the gauge problem necessitates movement of empties to and from the transshipment points. Normally,

when empties are constantly required at a particular transshipment point, it is useful to keep a close watch on movements on nearby sections. But more importantly, it is necessary to know the details of the stock that can be made available. It would then be possible to regulate movement of traffic such that no capacity is allowed to go waste. But the problem of synchronisation of an equivalent number of wagons of suitable types of the two gauges remains a formidable one. To the extent that detentions to wagons are to be <sup>minimised</sup> avoided, it should be possible to provide arrangements for releasing wagons and keeping goods stored until they can be worked away on wagons becoming available. This would, at least, eliminate working in empties for loading at these points.

### c. Seasonal Movements

The seasonality of certain types of traffic flows is also an important reason for the emergence of empty flows on the network. This is specially true of commodities like foodgrains, fertilizers.

Freight flows and demand patterns on the Indian railway system also exhibit a seasonal effect. But this is true for most commodity groups and the phenomenon is more closely related to climatic considerations. Normally, nearly the whole of the country experiences the wet season between July and September and this is the slack season

could be a big factor in maintaining a timely and adequate flow of wagons from the supply to the demand nodes. It is possible that terminals maintain excessive inventories of wagons in their areas as a buffer against the uncertainties of the supply and demand levels. Here, unreliability is the direct cause of the problem of utilisation since wagons kept in inventory are for the most part unproductive.

Within the Indian railway system, the railway board is at the apex of the decision making process. It coordinates the policy making as well as the executive functions. In addition, the hierarchical process consists of both horizontal and vertical dimensions of control. The horizontal division is generally by functional areas such as investments in tracks and rolling stock, price policy, and operations and maintenance. The vertical control divides some of these functions at the level of the central and zonal responsibilities. But as pointed out by one of their recent studies on Management Development Perspectives (1982), the devolution of powers to lower levels of authority is more a facade than a reality. There has been an increasing trend towards over centralisation and increasing concern with day to day functions of Railway operation and management. Naturally, policy and strategic planning occupy a back seat in decision making. Zonal Railways in practice have been made to work as subordinate offices with daily accountability in operations. This applies equally well regarding the

zonal headquarters vis-a-vis the terminals in the area. We would have more to say about this aspect when studying the terminal at Pune.

### 3. Special Purpose Wagons

This aspect is closely related to the operational strategy as regards the bulk items is considered. These wagons are generally put into operation at the request of the shipper and results normally in better service to the shipper. At the same time these special fleets usually imply greater levels of empty backhauls for the railway, because most of the commodities shipped in these wagons move only in one direction. On the positive side, these wagons permit faster loading <sup>+</sup> ~~and~~ <sup>Un</sup>loading, have greater capacity but these restrict flexibility in the distribution of empties on the network. On our railway system, with the growing importance of bulk items, the railways have been trying to adapt their supply to the emerging demands on the network. Earlier, practically all the goods traffic was being carried in general purpose wagons. But in the past two decades a number of new bogie wagons with emphasis on higher payload and facility for loading and unloading special types of traffic have been put into service. These include BOX, BCK, BOEK, BOY, MOKM, etc.. While these constituted about 10 per cent of the total wagon stock in 1960-61, the proportion was about 60 per cent in 1982-83. Theoretically, there are specific uses for which these wagons are meant. But operationally, it is found that

irrespective of the purpose for which these wagons were designed for, they are from time to time used for other purposes as and when possible depending on traffic needs. For instance, foodgrain loading takes place in coal empties in the non-monsoon months, especially in Punjab. Rakes carrying steel and iron to the west bring back salt to the eastern parts. However, since it has often been observed that wagons are hauled as empties from various parts to the Bengal/Bihar coalfields even when sufficient traffic is awaiting clearance, such measures do not seem to be <sup>in the</sup> nature of any attempt <sup>aimed at a systematic</sup> ~~at systematically aiming at~~ utilization of empty flows.

#### Empty Flows on the Network

On preliminary observation, it is noted that almost all the sections on the trunk routes and those leading out of the mineral belt in the east account for heavy empty flows. We noted in the first chapter that nearly three-fourths of the freight traffic is concentrated on this part of the network. Moreover, with passenger services being provided on a large scale, these sections are saturated and capacity utilization is as high as 90 per cent on most sections. Thus, a good deal of capacity is preempted by empty flows.

The dominant flow of empty wagons is towards the coalfields and other mining areas in the eastern part of the country. The largest concentration of coal reserves is

in Bihar, West Bengal and Madhya Pradesh. In addition, coal reserves are also found in Orissa, Maharashtra, Assam and Andhra Pradesh. The southern states of Tamil Nadu, Karnataka, Kerala and Andhra get nearly 80 per cent of their coal requirements from the Andhra Pradesh coalfields. Thus, the empty flows on the major routes of Southern railway such as the Madras-Cochin, Madras-Vijayawada routes are towards the A.P. Coalfields. From the western states of Maharashtra and Gujarat, which depend mainly on the Western coalfields in Maharashtra and the Central coalfields in Madhya Pradesh for their requirements, the empty flows are towards these coal areas. A good deal from Western Railway moves to Bina and then on to Katni to be passed on to the coalfields. As regards empty flows on the Central Railway Zone, one stream heads towards Itarsi and then on to Katni and the coalfields while another is in the direction of Wardha towards the Western coalfields. And from the north, the major empty flows are on the Amritsar-Howrah routes (via Delhi and Lucknow) on which some sections predominate. Within the South Eastern Railway Zone itself, besides the flows from other regions, there is a good deal of flow from the steel plants. The coal for the steel plants account for nearly 35 per cent of the total coal traffic on the railways. But these flows do not involve long distances except for coal empties which return from the Bhilai steel plant to coal fields at Jharia and Karagil which are nearly



700 kms. from the plant. According to Siddhu (1983), when public sector steel plants like Durgapur and Rourkela and later Bokaro came into existence, infrastructural facilities were created to facilitate a circulate movement - wagons to bring coal to Rourkela and Bhilai and carry back iron ore from Bhubaneswar region. In practice this did not happen. The main reason was that the quality of ore was different from the ore desired and consequently empty flows could not be used as visualised. From our discussions with officials in the Traffic Directorate (Coal), we came to understand that some circular movement does take place at present in regard to movement of raw materials to the steel plants. But we were unable to get more details of such movement. We feel, however, that this aspect needs to be looked into more closely not only from the point of view of the existing pattern of movement but also the efficiency of existing linkages from a broader perspective.

Another significant flow is the flow of empties back to the iron ore mines. Basically, the movement of iron ore is for two purposes: a) production of steel, b) for export. The movement for export is much more than for domestic consumption. Again, as far as domestic needs are concerned, the movement occurs within a limited area. These movements are mainly confined to certain sections of the South-Eastern and Eastern Railway Zones. On the other hand, the exports are mainly <sup>routed</sup> through ports situated on the east coast of India.

One stream originates from Bailadilla in Madhya Pradesh and heads towards the Vishakapatnam port while another <sup>descends</sup> demands on the Madras port from the Bellary-Hospet area. Both these movements involve significant empty movement back to the mines.

There are flows of empties towards major ports such as Kandla, Bombay, Madras which are fed in to satisfy needs arising out of imports. As far as Kandla is concerned, there is a good deal of empty movement on the broad and metre gauges. In case of Bombay and Madras, while some of the worked in empties may be required for traffic originating at these points, loading of imports also constitute a demand. It is often pointed out that many of our major ports are pressed into service for handling traffic from and to distant areas when logically they ought to be routed through ports closer to these areas. This has been mainly due to the poor infrastructure at these ports and most often due to the congestion at certain ports. For instance according to the Railway Reforms Committee, the port of Bombay handles (even on a normal basis) a good deal of traffic from other coastal states of Tamilnadu, Karnataka, Andhra Pradesh, etc. This would naturally involve movement over long distances (often around 1000 kms.) and need to move special types of wagons in and out of the ports to take care of the special needs of various types of traffic. Once again, it is to be noted that larger issues such as development of ports vis-a-vis the areas that

they serve, the attending congestion, etc., come into focus and need to be looked into in greater detail.

One disturbing feature of empty movement on the network is that there are heavy cross flows of empties occurring in certain segments of the network, especially the Western, Northern and South-Eastern parts. In the case of cross flows on the northern belt, it is observed that in the Punjab area, the foodgrain offering is very large. The inward traffic (into these areas) consists mainly of coal which comes in open wagons. As a result covered empties have to be worked in from other divisions such as Lucknow, etc., for loading of even sponsored foodgrains. As a policy measure, it is accepted that such commodities would be loaded in open wagons in fair weather. To that extent, some empty haulage is avoided. Although it was not possible to get the exact figures, we understand from Board officials that between November and April (dry season), such a practice is allowed. Besides, if it is possible to maximise loading in covered wagons of commodities moving into these areas, then the problem of working in empties could be avoided. But this may not be feasible on a large scale because mechanical handling of items such as coal, ores, etc., would not be possible. On the Western segments, the need to move out coal empties and bring back empty tank wagons to Baroda and covered empties to the parts results in cross hauls. However, in the south-eastern sector, the heavy cross flow

of empties is surprising. This is because the flow in both ways is mostly expected to consist of open empties moving between the steel plants and mining areas, though the movement of coal empties from other parts are also to be included. Empties going in and out of a station at the same time are an example of cross-movement of empties. Monthly figures from the Manuals of the Railway Board also indicate such a cross flow taking place at a number of major terminals on the network as a whole. For instance, the terminal at Wadi Bundar despatches more than 1500 empty wagons while it receives about 1000 empty wagons on an average every month.

We can not possibly say more unless details of wagon types involved in the flows are available. While cross haulage in certain segments may be necessary to take care of the demand for special wagon types, it is of paramount importance to avoid cross running of empties at the same time. Every possible effort should be made to give loads to all empties which are being supplied to feed loading points. It would be useful to initiate detailed studies so as to give a better insight into this aspect of the larger problem of empty movement.

#### Relation between Empty Movement and Turn Round Time (Wagon Cycle)

Turn round time is defined as the average time taken by a wagon from the time it is loaded till the time it secures its next load.

Typically, the sequence of load to load turn round time (or wagon cycle) is as follows :

1. Shipper loads the wagon.
2. Shipper notifies the railways that the wagon is loaded and is ready to move.
3. Railways pull loaded wagon from shipper's siding and move it to the terminal.
4. Wagon is processed for outbound movement from terminal.
5. Wagon is hauled to intermediate yard by train.
6. Wagon is processed for outbound movement from intermediate yard.
7. Wagon is connected to train for destination terminal.
8. Wagon is delivered to receiver's siding.
9. Receiver unloads wagon.
10. Wagon is released for despatch.
11. Railways assign destination to empty wagon.
12. Railways pull wagon from receiver's siding.
13. Railways deliver empty to new shipper for loading.

Thus, each wagon goes through a sequence in the course of a single wagon cycle. On most railway systems, a major part of the wagon cycle is spent in terminals, yards, etc., while the time spent in transit is small. On the Indian railway system, nearly 82 per cent of the turn round time of a wagon is taken up by detention in marshalling yards, terminals, etc.. For example, in 1982-83, out of a turn round time of 12.8 days only 2.15 days were spent on transit (both loaded and empty). The rest of the time includes

time spent by an empty wagon for being loaded, despatched, etc.. (See Figure 1)

Basically, the turn-round time is a function of a whole series of factors : time spent in yards, terminals, transit time, etc.. It is only to be expected that though the empty component is not significant, any increase leads to an increase, however marginal, in turn round time.

In their study (1985), Rao and Sriraman observed that there is some sort of a trade-off between the turn round time and empty wagon movement. In the context of the analysis of operating policies, they considered, average loading, speed and empty movement (or scheduling of empty wagons) as policies available to the railways while the turn round time is exogenously given in the sense that there is no possibility of manoeuvrability in that dimension, given the present efficiency of the system. The response of the railways to increased congestion and turn round time is to increase the average train load. But this may be reducing empty movement at the expense of the number of hours a train is on wheels during a day. The results are recorded below. The estimation was of the seemingly unrelated regression type (Zellner's SUR).

$$TL = - 1.34 + 0.37D + 0.23 TAT$$

(6.66) (2.75)

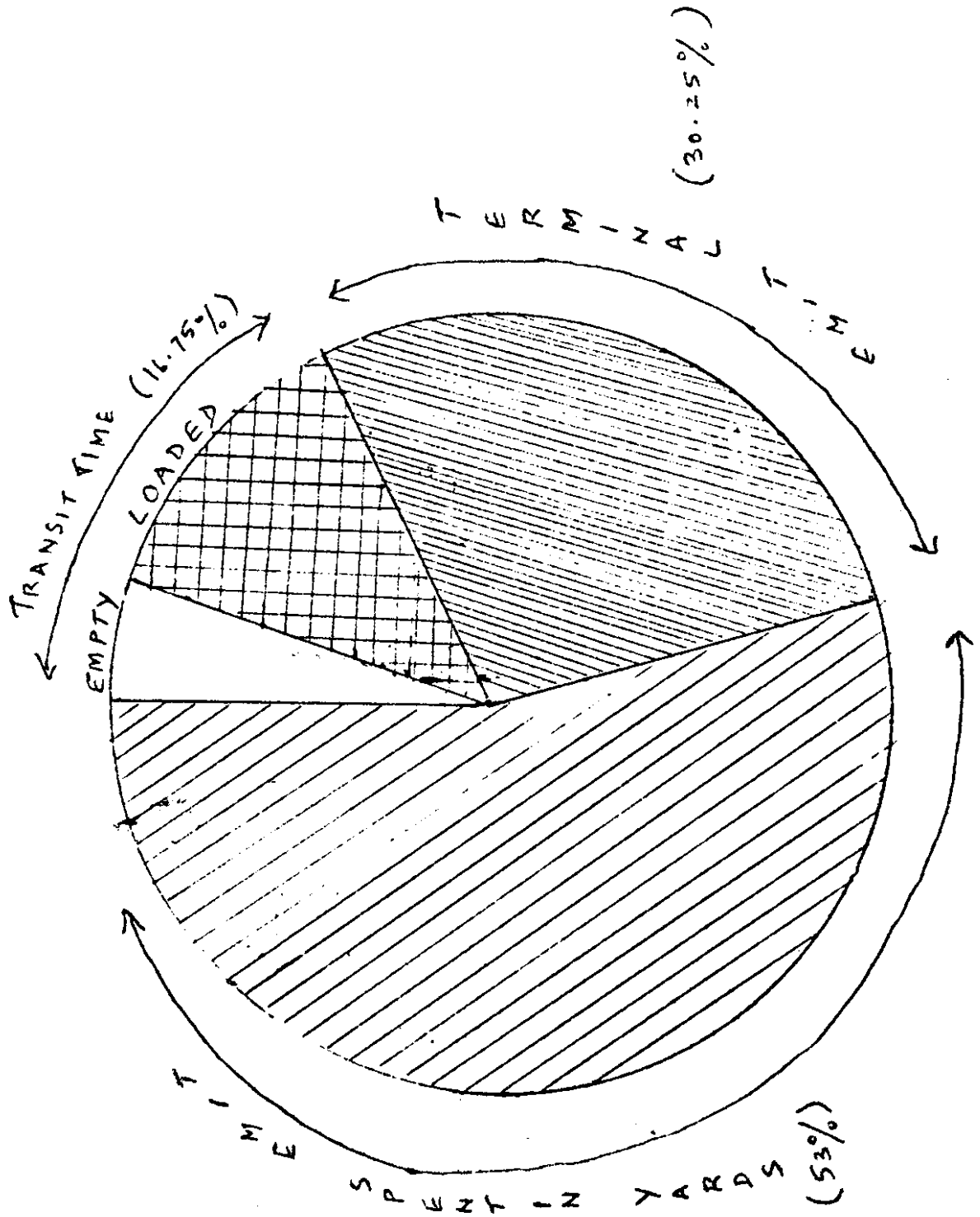
$$WK = 5.56 + 0.21 T - 0.75 TAT$$

(8.66) (8.61)

$$E = 4.23 + .10T - 0.46 TAT$$

(3.29) (3.97)

FIGURE - 1 COMPONENTS OF TURN ROUND TIME



where  $R^2(\text{McElroy}) = 0.89.$

TL = average train load

D = Net Tonne Kilometres per route Kilometre

TAT = Turn round time (in days)

WK = Wagon kilometres per Wagon day.

T = Tariff per tonne (in Rs.)

E = Empty to Loaded Wagon Kilometrage (%)

While it is reasonable to say that the response to increased turn round time could come in the form of improved train loads or increased formation of bulk rates, it is to be noted that such a response has had a positive effect on empty movement. From Table 7 and Figure 2 we note that the turn round time has been gradually increasing in the early years along with the increases in empty movement. But in the last decade or so, they have tended to swing in opposite directions.

The railways in their attempt to maintain the turn round time within reasonable limits have increased empty movements since additional loadings affect the major components of the turn round time such as detention in yards, terminals, etc., much more than the empty movement's influence on the minor component namely, the transit time. In other words, operating policies are geared to the release of block rakes and directing them back to the unloading points and thus involving huge flows. Even this, it is to be



**Table 7 • Turn Round Time and Empty to Total Wagon  
Kilometrage (Broad Gauge)**

Year	Turn round time (days)	Percentage of Empty to Total Wagon Kilometrage
1960-61	11.2	28.2
1961-62	11.5	31.8
1962-63	11.2	30.7
1963-64	11.0	31.3
1964-65	11.9	31.7
1965-66	11.8	31.4
1966-67	12.3	30.9
1967-68	12.6	32.5
1968-69	12.7	31.5
1969-70	12.6	32.6
1970-71	13.3	31.1
1971-72	13.5	29.8
1972-73	13.5	29.2
1973-74	15.0	30.6
1974-75	14.6	30.5
1975-76	13.5	32.3
1976-77	13.0	33.8
1977-78	13.3	33.0
1978-79	14.3	31.8
1979-80	15.1	30.6
1980-81	15.2	31.0
1981-82	13.3	31.3
1982-83	12.8	32.7

noted, has not been done efficiently. This pattern of loading has not resulted in significant reduction in the wagon cycle period. On the other hand, increased bulk loadings have led to greater detentions in loading and unloading points. Given below is the result of regressing the turn round time on empty movement, bulk loading and the wagon mobility figures.

$$TAT = 16.76 - 0.10 E + 0.16 BL - 0.17 WK$$

and detentions. (0.99) (12.06) (6.58)

$$R^2 = 0.87 \quad \text{D-W statistic} = 1.5548$$

where

TAT = Turn round time, (days)

E = Empty to loaded movement (%)

BL = Bulk loadings to total (%)

WK = Wagon-Kms. per wagon day.

We notice that though E occurs in the equation with the negative sign, it is not significant. On the other hand, BL is significant and has a positive sign. This only reinforces our argument above that delays at various points have a very significant effect on the turn round of a wagon. Increase in wagon mobility as represented by WK also has a significant effect on turn round time but the transit component being small, it has only a marginal effect. Given the current state of efficient operation of the railway system, it appears that any attempt to utilise empty flows would increase turn round time to such an extent that supply of wagons for major users could be jeopardised. Introduction of special types of wagons to cater to bulk traffic, policies of unit train loads and despatches have

not brought about significant improvements in wagon mobility, as it has not been possible to bring down detentions en route as also in terminals. In this context, it would be useful to note the observations of the Railway Reforms Committee (1983). According to them, Mughalasarai, which is the biggest of our marshalling yards, has been handling fewer wagons in recent times; but these have suffered increased detentions. In regard to terminals, the Committee observes that the railways have been too preoccupied with movement to give any thought to provision of terminal facilities. This, they claim, is the biggest bottleneck.

#### Utilisation of Wagon Capacity

In this section of the Chapter, we take up the measurement of utilisation of wagon capacity in the past two decades in terms of the measures proposed in the introductory chapter.

Before taking up the proposed measures, we consider the trends in measures currently in use. Figures for wagon kilometres per wagon day and net tonne kilometres per wagon day from 1950-51 to 1982-83 are given in Table 8.

It is noted that there is an initial rise in both dimensions showing a higher percentage increase upto the 2nd Plan. Thereafter, there is a downward trend till 1976 and 1977. Once again, there is a decline till 1980-81 after which they have registered improvements. A wagon in 1982-83 covered daily, on an average, 89.1 Kms. while it

**Table 8. Wagon utilisation (B.G.)**

Year	Wagon Kms. per wagon day	Net Tonne Kms. per wagon day
1950-51	62.3	710
1951-52	65.8	757
1952-53	66.7	726
1953-54	64.5	721
1954-55	69.7	790
1955-56	74.5	885
1956-57	76.9	932
1957-58	76.1	978
1958-59	73.4	937
1959-60	76.6	970
1960-61	76.9	998
1961-62	76.1	973
1962-63	76.4	1007
1963-64	76.0	987
1964-65	72.0	921
1965-66	73.2	940
1966-67	70.3	899
1967-68	72.2	895
1968-69	72.7	905
1969-70	73.6	916
1970-71	73.1	907
1971-72	74.1	935
1972-73	74.4	943
1973-74	67.2	837
1974-75	70.2	911
1975-76	76.8	982
1976-77	81.2	1019
1977-78	81.9	1045
1978-79	75.9	976
1979-80	73.3	972
1980-81	73.4	986
1981-82	83.7	1112
1982-83	89.1	1123

performed, on an average, transportation services equivalent to moving one tonne of freight over a distance of 1126<sup>23</sup> kms. While the introduction of higher capacity wagons and sharp increases in load have contributed to these increases, the absence of significant changes can be explained partly by the deterioration in turn round time and the average speed of trains remaining stagnant despite changes in mix of traction. Thus, want of improvement of wagon mobility remains a recurring problem.

We noted earlier that there is a need to explicitly measure utilisation of wagon capacity. It is important to examine the average wagon from the point of view of loaded movement as a part of the total movement and also as a part of the wagon cycle. For this analysis, we consider the average Broad Gauge wagon in terms of a four wheeler unit. It was not possible to examine wagon utilisation at a more disaggregate level (by wagon types) due to the non-availability of data.

#### 1st Measure

$$\frac{\text{Capacity used}}{\text{Capacity in transit}} = \frac{\text{tonnes of freight in transit}}{\text{tonnes of capacity in transit}}$$

The view is that the speed of our study is

$$\frac{\text{average load}}{\text{average capacity}} \times \frac{\text{loaded transit time}}{\text{loaded + empty transit time}}$$

#### 2nd Measure

$$\frac{\text{Capacity used}}{\text{capacity available}} = \frac{\text{tonnes of freight in transit}}{\text{tonnes of capacity available}}$$

The view is that the speed of our study is

$$\frac{\text{average load}}{\text{average capacity}} \times \frac{\text{loaded transit time}}{\text{turn round time}}$$

The average load and average capacity of a four-wheeler wagon were taken as appropriate for the analysis.

These figures in addition to many others necessary for our measurements are given in Table 9. The loaded and empty transit times were calculated as follows:

The average lead of freight traffic (AL) on the B.G. sections gives the average lead of a loaded wagon. On the other hand, the product of the turnround and the wagon kms. per wagon day gives the total lead that a wagon has to go through in the course of a wagon cycle (turn round time). The empty component of the lead (EL) can be worked out as:

$$L = AL + EL$$

we then calculate the time taken (average) to cover these distances (AL, EL) by dividing them by the average speed of a goods train. This latter figure may not be the most appropriate one since it includes the detentions at sidings, intermediate yards, etc.. Moreover, we assume that the speeds of a loaded train and an empty train are the same.

Discussions with Board officials could not give us any lead in this matter. One view is that the speed of an empty goods train is greater since the absence of loads enables faster movement. On the other hand, it was felt that the empty train is normally given least priority and thus has a much lower speed. For our purpose, they are assumed to be the same.

**Table 9 : Figures for Measurement of (Wagon Utilisation)**

Year	Average Wagon Load (in tonnes)	Average Wagon Capacity (in tonnes)	Average Lead of Traffic (Kms.)	Turnover Round Time (days)	Wagon Kms. per wagon day	Speed of Goods Trains (Km./hr.)
1960-61	18.5	21.7	572	11.2	76.9	16.1
1961-62	18.6	23.0	566	11.5	76.8	15.7
1962-63	18.9	22.2	558	11.2	76.4	15.4
1963-64	18.8	21.8	547	11.0	76.0	15.5
1964-65	18.6	21.5	539	11.9	72.0	15.9
1965-66	18.6	21.0	556	11.8	73.2	16.4
1966-67	18.5	20.9	555	12.3	70.3	16.5
1967-68	18.1	20.8	581	12.7	72.2	16.8
1968-69	17.9	20.7	582	12.6	72.7	17.5
1969-70	17.9	20.5	585	12.6	75.6	17.7
1970-71	18.0	20.6	615	13.3	73.1	17.9
1971-72	17.9	20.6	641	13.5	74.1	18.2
1972-73	17.9	20.6	640	13.5	74.4	18.0
1973-74	17.9	19.7	630	15.0	67.2	18.3
1974-75	18.6	22.4	655	14.6	70.2	18.4
1975-76	18.9	22.4	636	13.5	76.8	17.8
1976-77	18.9	21.6	626	13.0	81.2	19.8
1977-78	19.0	22.5	659	13.3	81.9	19.5
1978-79	19.9	22.5	663	14.3	75.9	19.6
1979-80	19.1	22.5	691	15.1	73.3	19.5
1980-81	19.5	22.3	695	15.2	73.4	19.7
1981-82	19.3	21.9	709	13.3	83.7	20.8
1982-83	19.3	22.3	694	12.8	86.4	21.4

Table 10 gives the total lead (L), the empty lead (EL) and the corresponding transit times for the loaded and empty components of the total lead. Table 11 gives the figures obtained for the two measures. These trends are presented graphically in Figure 3.

The first measure essentially gives the percentage of tonne days of capacity provided by the wagons in transit which was used. We observe from the Table and the figure that there have been significant swings in the utilisation. In the sixties, the utilisation varied between 52 per cent and 57 per cent. In the seventies, while utilisation in the earlier years was 55-56 per cent, there was a sharp fall to 50 per cent for a couple of years after which there has been a recovery though utilisation has not reached earlier levels. We could consider utilisation in conjunction with loaded and empty transit times (given in Figure 4). While loaded transit times have been gradually falling, the empty component has been rising steadily. In 1975-76 when empty transit time reached a record level of 50 per cent of the total transit time, utilisation fell to 50 per cent, the lowest in any year of the period under consideration.

While the first measure is important from the point of view judging loaded movement in transit, the 2nd measure is more important in the sense that it analyses one component, namely, loaded movement as part of a wagon cycle. It is noted that swings in this figure are virtually absent, although



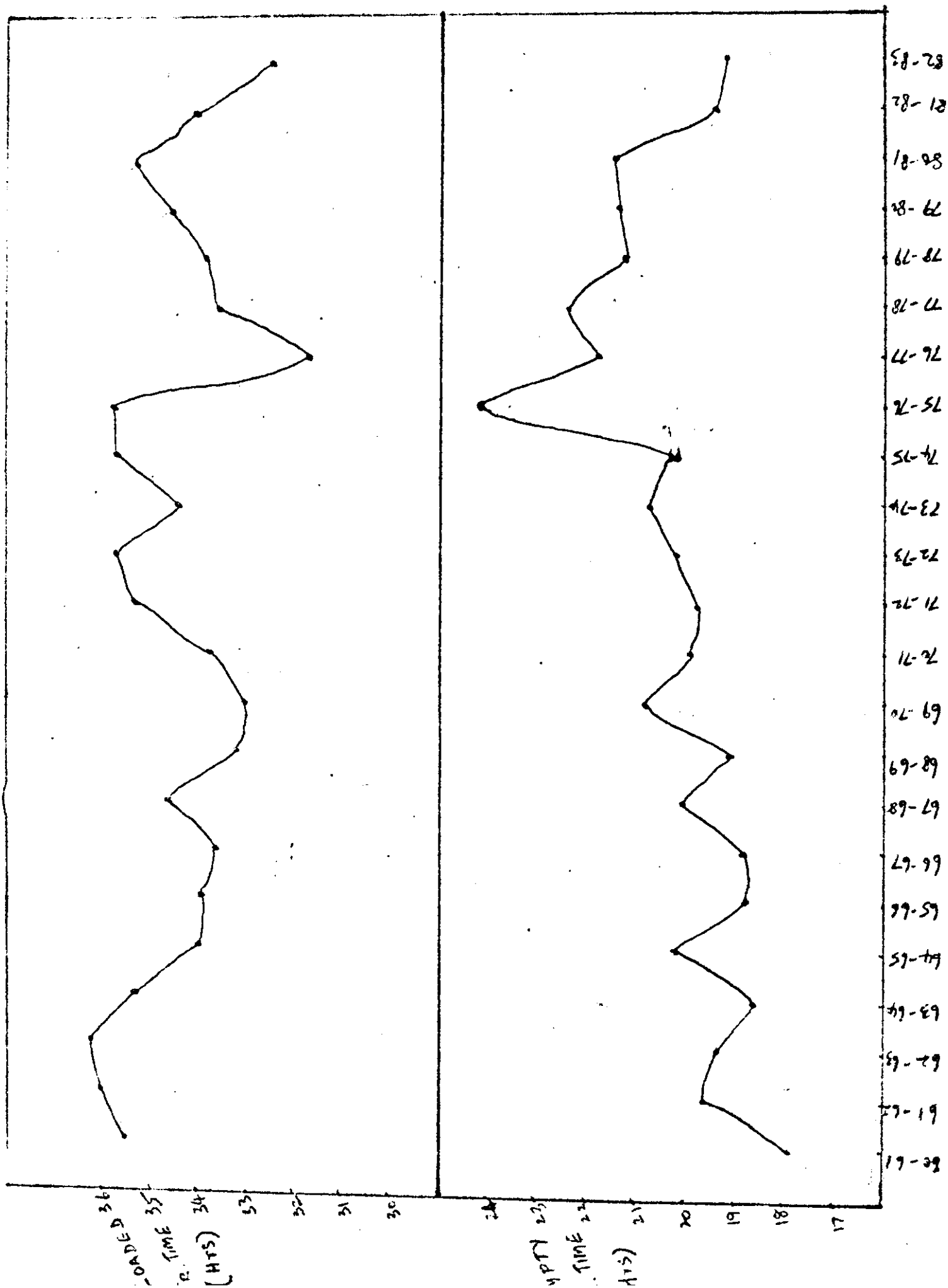
Table 10 - Leads and Transit Times

Year	Average Lead of Loaded Wagon (Kms.)	Total Lead of a wagon (Kms.)	Empty Lead (Kms.)	Loaded Transit Time (hours)	Empty transit time (hours)	Total transit time (hours)
	1	2	3	4	5	6
1960-61	572	861	289	35.52	17.95	53.47
1961-62	566	875	309	36.05	19.68	55.73
1962-63	558	856	298	36.23	19.35	55.58
1963-64	547	836	289	35.29	18.64	53.93
1964-65	539	857	321	33.89	20.18	54.07
1965-66	556	864	308	33.90	18.78	52.68
1966-67	555	865	310	33.63	18.76	52.41
1967-68	581	917	336	34.58	20.01	54.38
1968-69	582	916	334	33.25	19.08	52.33
1969-70	585	953	368	33.05	20.79	53.84
1970-71	615	972	357	33.79	19.94	53.73
1971-72	641	1000	359	35.21	19.72	54.92
1972-73	649	1004	361	35.72	20.05	55.77
1973-74	630	1008	378	34.42	20.65	55.07
1974-75	655	1025	370	35.59	20.10	55.69
1975-76	636	1037	401	35.73	24.15	59.88
1976-77	626	1056	430	31.61	21.71	53.32
1977-78	654	1089	435	33.53	22.30	55.83
1978-79	663	1085	422	35.82	21.22	55.07
1979-80	691	1107	416	35.43	21.33	56.76
1980-81	695	1116	421	35.47	21.37	56.66
1981-82	709	1113	404	34.08	19.42	53.50
1982-83	694	1105	411	32.42	19.20	51.62

**Table 11 : Measurement of Wagon Utilisation (%)**

Year	Measure 1	Measure 2
1960-61	57.1	11.2
1961-62	52.1	10.5
1962-63	54.2	11.4
1963-64	56.3	11.5
1964-65	54.1	10.2
1965-66	56.4	10.3
1966-67	56.6	10.0
1967-68	55.1	9.6
1968-69	54.6	9.4
1969-70	53.3	9.3
1970-71	54.6	9.1
1971-72	55.5	9.3
1972-73	55.4	9.4
1973-74	56.8	8.8
1974-75	52.1	8.3
1975-76	50.1	9.2
1976-77	51.1	8.7
1977-78	50.4	8.8
1978-79	51.6	8.2
1979-80	52.8	8.2
1980-81	54.4	8.3
1981-82	55.1	9.2
1982-83	54.2	9.1

FIGURE - 4 TRENDS IN LOADED AND EMPTY TRANSIT TIME.



utilisation has come down from about 11.5 per cent in the early sixties to between 8 and 9 per cent since the early seventies. This, no doubt, indicates very low utilisation but what is disturbing is that even this low rate is not being kept up. Since the loaded transit time component itself forms only about 10 per cent (1982-83) of the total wagon cycle, the low rate of utilisation is not surprising. But it is to be noted that this component formed about 14 per cent of the wagon cycle in the early sixties. Thus, even its limited significance in the wagon cycle has come down. But from an operating view point, when we consider the effects of additional loading on the non-transit component, the empty component assumes importance, a point that we have emphasized earlier.

### Summing Up

Throughout this chapter, the emphasis was on examining some of the major influences on the emergence of increased empty flows on the network of the Indian railway system. Besides the growing importance of bulk items in the total traffic and the consequent operating strategies, the increased use of special wagon stock, the gauge problem has also been responsible for empty flows. It is also observed that there does appear to be a trade-off between the turn round time and empty movement. From an operating view point and taking into consideration the deleterious effects of additional loading (filling up empties in backhauls) on the turn round

time, it does seem reasonable to suggest that the railways would prefer to increase empty movement, while attempting to keep the turn round time within reasonable limits. A detailed analysis of empty flows on the network indicates heavy concentration of flows on major routes on which a significant portion of loaded flows occur, a good deal of cross flows of empties on certain segments of the network. Finally, analysis of wagon utilisation when looked at from the point of view of loaded movement in the wagon cycle (turnround time) indicates a low and declining utilisation of wagon capacity.

## CHAPTER III

### ANALYSIS OF EMPTY WAGON MOVEMENT AND MANAGEMENT AT A NODE - A CASE STUDY OF THE PUNE TERMINAL

A terminal is an integral part of any railway network. Traffic flows originate and terminate in these. Wagons spend a good deal of their time in terminals, in loading, unloading, standing under load, shunting about, and awaiting despatch (in the adjoining yard). On the Indian railway network, there are more than 7000 terminals, ranging from large ones to small ones. But nearly 90 per cent of these handle only about 10 per cent of the total traffic. Even among the rest, only about 50 per cent of them handle a good deal of the freight traffic involved. Pune is one of the major terminals on the Central railway zonal network. We now examine the relevant issues regarding empty movement at the terminal level. To provide a background for the discussion of the various issues, it would be useful, initially, to look into the pattern of loading and unloading currently taking place. The data on the relevant variables were collected from the Pune goods shed (terminal) and yard offices for the year 1983-84 (April-March).

#### Pattern of Unloading

The pattern of inward traffic can be understood from Table 12 which gives the monthwise receipts of commodities (major flows) received at the Pune terminal for the year

**Table 12 : Commodities received at Pune (Wagon Loads)**

	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1. Paper	59	65	32	45	-	65	42	45	20	-	54	39
2. Petrol	189	154	198	162	144	145	195	177	162	189	176	186
3. Iron & Steel	113	46	87	85	95	129	-	80	68	40	88	157
4. Rice	110	44	63	104	63	-	-	-	46	106	156	156
5. Wheat	46	69	65	66	83	56	75	49	78	92	12	5
6. Other foodgrains	147	268	279	182	160	139	101	89	90	223	155	71
7. Timber	-	41	-	32	-	-	-	-	-	-	-	-
8. Sand & Stone	289	207	185	276	301	120	140	226	314	301	273	288
9. Gen. Goods	522	459	456	370	443	347	358	318	332	345	380	339
10. Cement	943	856	854	903	1063	1286	1166	1334	1671	1306	824	1400
11. M. oil	1246	990	875	830	852	861	851	968	1049	1064	1018	1045
12. Salt	-	44	-	-	-	-	-	-	-	-	-	-
13. H. /Cakes	-	39	53	-	66	-	-	81	56	-	40	38
14. C. coal	60	75	43	86	133	101	70	186	209	137	133	112
15. Oilseeds	-	38	62	-	-	-	-	-	-	-	-	-
16. Manures	196	97	179	59	80	246	90	98	98	157	224	100
17. Oil cakes	-	45	63	31	33	31	-	-	-	-	37	62
18. Lime and livestock	-	-	-	-	-	-	-	32	30	91	107	40
<b>Total :</b>	<b>4252</b>	<b>3663</b>	<b>3675</b>	<b>3380</b>	<b>3661</b>	<b>3647</b>	<b>3280</b>	<b>3808</b>	<b>4457</b>	<b>4277</b>	<b>3818</b>	<b>4150</b>

under consideration. Table 13, on the other hand, gives the monthwise receipts of types of loaded wagons received. These latter figures were obtained from the yard office and do contain a small element of 'through' loaded traffic.

It is observed that the inward traffic consists mostly of foodgrains, cement, stones and sand, fertilizers and general goods. There is a good deal of flow of petroleum products in oil tankers. But we do not include oil tank wagons in our analysis since they have necessarily to be sent back empty to the loading point at Bombay. This is the general pattern of traffic right through the year. When the total of inward receipts (monthwise) <sup>is</sup> are considered, it is observed that there is a fall in receipts during the wet season. This reflects the lower level of activity on the railways in this season. Figures relating to other terminals also clearly reflect this feature. As observed earlier, there is roughly a twenty per cent decrease in freight traffic in this season. But in the case of cement, there is an upswing in receipts. When looking into Table 13, the same holds for certain types of wagons. But in the case of CRT's, BCI's, we note that there is an upswing. This again is a part of the general feature of <sup>greater</sup> ~~more~~ loadings in covered wagons to the various parts. From Table 13, it is noted that most of the inward movement is in the conventional C-type wagon (4 wheeler) which still forms an important part of the total wagon stock and plays a significant role in traffic operations,



**Table 18 : Types of loaded wagons received at Pune (in terms of 4-wheelers)**

Wagon type	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
C	1096	1004	1151	950	851	612	617	860	1410	1032	831	942
CA	10	10	15	14	18	8	20	23	38	31	20	12
CRT	432	331	346	352	357	444	429	386	450	442	309	460
KC	90	72	64	125	84	40	55	56	90	62	83	112
BCX/BCXT	640	775	645	850	820	1045	860	803	930	900	740	1010
BOX/BOXT	175	110	95	95	220	95	15	250	242	170	230	380
BKC	50	40	50	50	30	40	35	25	20	25	20	20
BFR/BFU	25	15	30	30	15	20	3	15	22	25	10	20
Oil Tankers	1435	1144	992	995	996	1006	1046	1145	1202	1253	1194	1281

especially in transport of goods which come under the 'general' category. But given the limited availability of other special types, these are still being used for bulk movement, especially those that need covered spaces for loading. On the other hand, CRT's are water-tight 4-wheeler covered wagons having higher capacity for general goods, while BCI's are water-tight covered wagons (2 1/2 times a 4-wheeler) for carrying foodgrains, cement, etc.. There is a constant flow of cement from the Wadi/Shahabad factories in Andhra, Karnataka. These mostly occur in block rakes consisting mostly of BCI's and CRT's. Foodgrains are received in CRT's and C's from various parts. Wheat comes from Punjab, Haryana while rice comes from Punjab and Andhra Pradesh. Other grains such as pulses, cereals flow from Uttar Pradesh and Rajasthan. Fertilizers are mostly received from Broach in Gujarat and imports are had through the Bombay port.

#### Pattern of Loading

Table 14 gives the monthwise description of traffic (commoditywise) loaded at the Pune terminal. It is observed that the loading hardly touches 200 wagons a month on an average except February and March when loadings go up by about 100 wagons. A cursory glance into loading data in some of the earlier years gives the same picture. The outward traffic consists mostly of soap, waste paper, onions and sugar (in certain months only), railway material and general goods. In Table 15, we have monthwise loading figures by wagon types.

**Table 14 : Description of Traffic (commoditywise) Loaded at Pune (monthwise) : 1983-84**

(Wagon loads - in terms of 4 wheelers)

Commodity	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1. Compression/ electric equipment	4	5	3	3	6	-	10	4	18	6	-	3
2. Sugar	-	-	-	-	-	-	-	-	-	6	184	162
3. Soap	18	6	-	4	8	2	7	3	3	19	25	40
4. Onions	52	-	-	-	-	-	-	-	-	-	-	-
5. W. paper	31	4	18	8	17	7	-	13	9	6	7	7
6. Junction sealed vans (small)	46	56	58	31	47	41	53	64	48	35	48	29
7. Rly. Material	49	36	44	27	22	18	24	22	20	17	28	17
8. Structures	7	15	6	2	5	-	2	14	-	1	20	3
9. Misc.	68	79	90	124	40	56	86	30	56	57	61	78
<b>Total :</b>	<b>275</b>	<b>200</b>	<b>219</b>	<b>219</b>	<b>145</b>	<b>125</b>	<b>182</b>	<b>152</b>	<b>154</b>	<b>143</b>	<b>371</b>	<b>329</b>

**Table 15 : Monthwise loading (by wagon types) (in terms of 4-wheeler) at Pune (1983-84)**

Month	C	CRT	KC	KE	BCX/ BCXT	BOX/ BOXT	BUC/ BPU	Total
April	217	1	32	3	17½	5	-	275½
May	131	-	32	-	5	16½	7½	199½
June	145	-	37	4	15	17½	-	218½
July	119	-	28	3	12½	10	-	210½
August	121	-	14	-	2½	5	2½	145
September	90	-	22	1	7½	5	-	125½
October	118	2	29	1	10	10	15	182
November	115	51	58	-	7½	2½	2	152
December	102	-	28	2	22½	-	-	154½
January	107	6	13	-	12½	-	5	140½
February	123	59	20	-	35	140	-	370½
March	146	42	29	-	55	57½	-	329½

We note that most of the loading (nearly 60 per cent) takes place in the ordinary C type wagon. Loading in KC's, BCX's and BOX's takes place to a much lesser extent. Goods coming under the 'general' category which fall under 'smalls' are normally despatched in C type wagons. This is true in the case of commodities like soap and waste paper which are sent to various parts of the country. Onions are sent in C's and CRT's while sugar is mostly loaded in CRT's and BCX's. Sugar is normally sent to Bihar, Orissa and Andhra Pradesh.

When the pattern of unloading is considered along with the pattern of loading, it follows that this results in a good deal of empties <sup>over</sup> being generated at this terminal. We now turn to these figures.

Pattern of Despatch of Empties

Figures relating to monthwise despatches of empty wagons from the yard at Pune terminal are set forth in Table 16. To a small extent they include some through despatches.

Table 16 : Despatch of Empties (Block rakes - 4 wheelers) from Pune 1983-84 (excluding oil tankers)

Month	C	GRT	KC	BOX/ BCKT	BOX/ BOXT	BKE/ BFU	Total
April	1066	392	61	602	176	-	2297
May	1069	253	136	628	28	-	2214
June	1076	274	92	560	128	-	2130
July	939	299	164	690	40	-	2132
August	890	283	116	700	205	14	2268
September	625	407	31	960	195	-	2218
October	612	397	48	757	68	-	2282
November	833	399	67	940	63	-	2302
December	1592	380	27	970	418	14	3401
January	1229	500	33	1088	145	-	2995
February	826	403	44	1042	130	-	2449
March	374	436	87	900	275	-	2872

also but a majority of despatches refer to those from the terminal area. Broadly speaking, most wagon despatches are of types C, CRT; KC, BCX/BCXT and BOX/BOXT. Besides, there are also some releases of BRH/BFU units which are special type wagons meant for transport of rails, steelbars/over-dimensional consignments.

On an average, about 2000 wagons (in terms of 4-wheelers) are sent every month from the Pune terminal area.. Apart from these despatches, there are also despatches, in piecemeal, of empties in various despatches. In the case of C type wagons, there is a dip in the despatches of empties in the wet months when the inward movements of these types of wagons are lower. On the other hand, the inward movements of special types CRT, BCXT, etc., are higher and correspondingly the despatches are higher than the previous period. It must also be noted that more than 85 per cent of the despatched wagons are of the ~~g~~ covered variety. Inward movements in these are mostly cement, foodgrains. These invariably return empty due to the lack of a 'typical' backload.

Going further on empty despatches from the terminal, we get an idea of the empty despatches (block rate movement) regarding the direction of movement and immediate destination from Table 17. Nearly 55 per cent of the despatches are in the direction of Wadi, which is around 410 kilometres away. Nearly one-third of the wagons heading towards Wadi is of the special type BCX/BCXT, etc.. These are mostly returning for

**Table 17 : Directionwise despatches (major) of empties from Pune (1983-84) (4-wheelers)**

Month	Wadi (413 kms)		Dhond (70 kms)		Kalyan (139 kms)		Miraj (280 kms)	
	C/CRT/KC	BCX/BOX/BOXT	C/CRT/KC	BCX/BCXT/BOX	C/CRT/KC	BCX/BOX/BCXT	C/CRT/K	BCX/BCXT/BOX
April	1328	600	193	100	-	-	-	-
May	1229	525	186	27½	-	-	43	102½
June	880	300	331	132½	27	35	91	190
July	598	-	311	145	193	362½	39	92½
August	459	-	442	227½	160	440	22	42½
September	410	495	288	250	365	410	-	-
October	727	450	136	67½	172	312½	-	-
November	789	690	130	40	150	217½	210	57½
December	1781	1067½	66	277½	-	-	19	70
January	730	735	501	395	-	-	-	-
February	472	532½	663	442½	-	-	20	62½
March	466	415	566	555	56	157½	-	-
<b>Total</b>	<b>9819</b>	<b>5800</b>	<b>3813</b>	<b>2650</b>	<b>1123</b>	<b>1935</b>	<b>444</b>	<b>678</b>
<b>Total (all types)</b>	<b>15619</b>		<b>6473</b>		<b>3058</b>		<b>1062</b>	

further loading in rake loads in the Wadi/Shahabad cement industrial area. About 23 per cent of the total moves towards Dhond and are then directed to Mannad at which point they join the flow on the trunk routes. It is not known whether any significant loading takes place at Ahmednagar, for example, which is in the heart of the sugar belt. It should be possible to utilise these empty flows to despatch sugar to the north, especially during the busy period. Another significant flow is towards Kalyan. From here, empties may be worked to Wadi Bunder or to the Port Trust railway for loading imports. Empty flows in these three directions constitute nearly 90 per cent of the total empty movement originating at Pune. Other points to which some empty movement takes place are Miraj, Sholapur, Nagpur, Trombay, etc.

Backloading vis-a-vis the available capacity in terms of empties

From the earlier tables, it is easily observed that back-loading constitutes a basic problem as far as the Pune terminal is concerned. But aggregate data on other terminals (21 major areas) also indicate a similar problem though in the case of a few terminals, a good deal of empties are also moved into the terminal area to satisfy loading orders. It is possible that the need for special types of wagons may necessitate such a movement into a terminal. But this may also be due to a certain temporal pattern of



Inward and outward movement which requires empties to be fed into the area. Table 18 gives loading and unloading figures for 21 major terminals. Column 4 indicates inward movement of empties into the various terminals.

In Pune, while the magnitude of unloading is to the extent of about 2500 wagons in a month, the loading is only around 200 wagons on an average. A good deal of the incoming traffic is on C's while a significant portion of empty movement is also in C's (about 60 per cent of the total). Movement in CRT's occurs in a somewhat significant way only in the busy season although the inflows occur mostly in the slack season. Another ordinary type wagon KC is also used a good deal for loading. On the other hand, loading on special stock such as BCK, etc., is not at all important, while the inflows are significant.

Although there is very little movement of empties into Pune in block rakes, there is a good deal of piecemeal movement of empties in both directions on various sections connecting Pune. This indeed constitutes an example of cross flows that was earlier indicated with respect to many segments of the railway network. A knowledge of the time profile of such movement (even though insignificant) could help in attempts to use empty flows. But this is a part of the larger problem of rationalisation of empty flows on the net work.

**Table 18 : Unloading and loading at terminals (including oil tankers in terms of 4 wheelers) (1983-84)**

Terminal	Wagons unloaded	Wagons loaded	Receipt of empties
1. Cochin	23,396	22,643	14,325
2. Coimbatore	16,492	2,305	673
3. Salt	30,504	22,083	6,964
4. Hyderabad	27,940	11,428	6,383
5. Belangary	16,030	5,098	587
6. Jhansi	7,464	4,673	3,328
7. Nagpur	12,044	3,476	1,338
8. Pune	43,503	2,528	244
9. W. Bunder	71,399	52,393	10,720
10. Sholapur	17,058	3,715	8,696
11. Kanpur	41,103	9,667	9,600
12. Amritsar	32,644	6,433	7,882
13. New Delhi	91,681	28,527	1,600
14. Jullunder	17,664	6,802	1,732
15. Ludhiana	22,609	3,778	772
16. Lucknow	36,026	9,431	3,755
17. Bareilly	30,643	11,580	1,770
18. C. Bridge	33,816	16,633	709
19. Shalimar	70,024	25,067	1,542
20. Sealdah	20,502	1,457	6,108
21. Howrah	41,324	40,591	23,043
22. Chitpur	1,12,986	4,742	5,141

Pattern of demand vis-a-vis the availability of capacity

We observed that backloading seems to be a basic problem as regards usage of empty flows is concerned. We examined loading as compared to the available capacity. Another aspect of the problem is to look at it from the point of view of actual demands on the system. Recall that in the introductory chapter we had emphasised the need to base forecasting exercises (in the present context) on shipper order data as well as historical data on loadings. This would effectively remove biases (upward or downward) effected by these variables separately. It would thus be proper to look into the order data for wagons in order to examine the issue in the proper perspective. But it is not difficult to guess that the lack of demand is a major problem as far as the Pune terminal is concerned. This may not be true in the case of many other terminals. Huge flows of empties originating at some of these points may still be observed in spite of demand pressures. As already emphasised, the need for special wagons may be responsible for the cross flows. Moreover, operational decisions, when viewed from a macro-perspective, may dictate more empty running rather than attempt at utilising empty flows.

Figures relating to shipper order data at the Pune terminal (monthwise and type of wagons) are given in Table 19. It is noted that the demand is for the G type wagon in most

Table 19 : Figures relating to shipper order data (in units)

Month	C	CRT	KC	BCX/ BCXT	BOX/ BOXT	BFO/ BRH	Total
April	174	-	31	1	3	2	211
May	75	-	32	-	3	7	117
June	90	-	27	-	5	4	126
July	77	-	17	-	5	1	100
August	80	-	8	-	2	2	92
Sept.	50	-	12	-	2	1	65
October	91	-	23	-	1	9	125
November	52	-	11	-	4	6	73
December	47	-	32	-	5	-	84
January	70	62	10	1	1	3	147
February	82	100	7	1	1	14	206
March	112	180	25	-	3	2	322

months. Again, a slump is observed during the wet season. The other category of wagons that is in considerable demand is the conventional KC type wagons. Both these wagons are mainly used transport high valued manufactured items (as seen earlier). In the months of January, February and March, there is a demand for the CRT type of wagon. This is mainly intended to move sugar (levy and free) to various parts. When it is not possible to satisfy demands for these wagons,

attempts are made to provide BCX's which are also engaged in transport of these items, even though indenting for these is not normally permitted. In our discussions, we came to understand that since CRT's and BOX'a/BCXT's are in restricted movements, indenting is not allowed normally. But it is observed that indents for CRT's are made in the busy season for moving sugar and they are not always supplied. We also understand that there are times (especially the busy months) when there is enough material to be loaded in rake loads, it is not possible to meet these demands, on direction from the headquarters. This is another aspect of the problem which is more closely related to the problem of allocation and distribution of stock among the various competing users given certain priority specifications.

#### Assignment of Empties

Basically, there are a number of ways in which empty wagons could be assigned to areas where they are required for loading. In practice, this is determined by a host of institutional factors. A variety of mathematical programming models have been proposed to deal with the problem of assignment of empties on a railway network. The earliest was the one proposed by Beckmann et al (1956). This model was a simple one and involved minimizing costs associated with movement of empties between <sup>12</sup> representative points in the United States. More recently, more ambitious models have

been worked out by Herren (1973), Miller (1972), Mendiratta (1982). They have tested the models with the data and found the assignments by the models to be useful in minimizing flows. We do not, however, propose to go into such an exercise since the scope of our study is rather limited. It is hoped that a more comprehensive study of the problem in the framework of a modelling exercise can be taken up as part of the next phase of the project which would be undertaken on a much larger scale whence it would be possible to generate the enormous data that would be required for a modelling exercise. For the present study one would only deal with the general problem of decision making at the terminals as related to assignment of empties and the consequent effects on operations.

#### Decision making

It is widely claimed that all matters regarding the transportation are within the powers of the Zonal General Managers. But this is subject to the overall policy and coordination laid down by the Railway Board. This is done keeping in view the overall priorities laid down at the national level for the transport of essential commodities, on the basis of which the Railway Board lays down certain policies with regard to inter-railway commitments for movement of empty wagons and obligations required to be fulfilled.

Further, delegation of powers to the Divisional Superintendents has also been attempted to bring about greater decentralisation of power to lower formations. Thus the vertical dimension of control divides some of the functions at the level of the central, zonal and divisional responsibilities. Different managerial groups control the choices at the level of each of the sub-systems. The manager of each sub-system is expected to organise and control the particular set of resources available to him in the sub-system. In making these choices, they necessarily have to follow certain overall guidelines and constraints defined at higher levels. But a common observation has been that the burden on each of the decision making levels is disproportionate to the resources available with them to function effectively. Moreover, it is <sup>often felt</sup> ~~also observed~~ that since responsiveness at any level is related to the demands on the system. <sup>But</sup> ~~And the~~ railways being a virtual monopoly (with no effective competitive mode, especially in certain traffics), the performance does not normally correspond to the highest possible level, or, for that matter even to a level which takes care of the prevailing demands on the system.

As regards the terminal at Pune, the problem is <sup>trivial</sup> ~~trivial~~ since demand pressures are virtually absent and the <sup>loading</sup> ~~loading~~ is very low almost all through the year. But even within this limited scope of loading, it is <sup>not</sup> ~~possible~~ not to observe flexibility in decisions at the terminal since

the manager has virtually no control over certain types of wagons and their usage. We have already reported the case of demand for closed wagons of the CRT and BCX/BCT types which is difficult to cater due to restrictions on their movement. It is not possible to generalise, merely on the basis of experience at a single terminal. However, if this pattern of scheduling practices are so adopted with only the macro perspective in view while overlooking the micro viewpoint, it would not be possible to solve the problem regarding empty scheduling.

But even when this perspective is taken into consideration and acted upon, it is still not quite clear why the pattern of empty despatches has resulted in high detention times, given that they have to be moved to other points on the system, even when loads are being offered. Table 20 gives figures of detention to the average empty wagon for 10 day periods in 1983-84 at the Pune terminal. It is observed that more often than not, an empty wagon is kept waiting for more than a day before it could be despatched. It is also to be noted (Table 21) that this component of detention (empty detention) is often more than 50-55% of the total time spent at the terminal. One problem could be the difficulty in forming empty rakes in order to move them out. But this need not be a problem especially if 70-80 wagons are being released on an average from the terminal. Lack of adequate



**Table 20 : Detentions at Pune terminal (empty wagons)**  
 (10 period - in hours)

Month	Periods		
	1st	2nd	3rd
April	26.10	37.75	33.25
May	26.60	21.60	25.30
June	25.90	32.30	26.80
July	31.40	29.40	41.25
August	29.70	36.90	41.00
September	38.90	40.75	37.20
October	36.90	33.45	31.10
November	31.50	47.80	21.75
December	37.10	24.00	29.20
January	32.50	24.90	18.42
February	37.10	26.50	23.90
March	23.45	12.20	38.20

motive power could also be a problem. But we understand that this is not at all a problem here. Our own impression in the matter is that the allocation and the consequent despatching processes are carried out on the basis of orders received from the zonal headquarters which in turn depend on the Railway Board for advice regarding allocation and despatch of empties. Here we must take note of an observation of a <sup>IRU</sup> study on railway management <sup>development</sup> perspectives (1982) that the

Board's preoccupation with day to day movement on a zone-wise basis leaves it with little time being left for important policy aspects of a long term nature and thus do not get the sustained attention at the requisite intensity.

### Conclusion

Given the pattern of loading and unloading at the Pune terminal and also considering the demand aspect, back-loading of empties is a basic problem and thus a good deal of empties are generated here. Moreover, the system of priority allocation of wagons as also the restricted movement of certain types of wagons results in empties being generated in an area. But what is more surprising is the

Table 21 : Percentage of empty detention to total  
(10 day period)

Month	Periods		
	1st	2nd	3rd
April	59.10	45.10	35.60
May	44.90	39.50	40.10
June	47.37	43.75	32.40
July	37.58	52.90	48.74
August	49.60	34.57	34.91
September	34.20	56.55	56.90
October	53.50	58.40	56.20
November	45.64	49.32	47.20
December	51.90	48.43	59.07
January	46.90	35.60	36.70
February	49.50	52.61	54.86
March	55.10	32.40	44.25

detention involved in the case of empties awaiting despatch at Pune. Of course, no generalisations can be made. This, we feel, is due to the lack of an effective allocation process which invariably involves a highly centralised but apparently hierarchical set up which results in considerable delays in decision making.

## CHAPTER IV

### COST CONSIDERATIONS

The ultimate cost of moving freight is significantly affected by the extent of empty movement. The unit costs of transportation (say, costs per tonne kilometre, wagon kilometre, etc.) are highly sensitive to the intensity of utilisation of wagons and empty percentages. Moreover, unit costs vary with the level of empty flows associated with the transport of particular commodities. Thus, these considerations also need to be taken into account in the process of rate-making for the various commodities.

#### Costs of Empty Returns

The concept of jointness when applied to transportation normally means that certain product mix costs such as the Costs of return line-haul cannot but arbitrarily be assigned between specific movements and transportation services. Together with the constant costs, the division and distribution of these joint costs between particular elements or units of services is, thus, held to be arbitrary at best. Since any specific distribution of these costs is by accepted definition arbitrary, the least arbitrary method, it is normally agreed, consists of an average pro-rata charge to all revenue producing items. Again, the relevance of demand to differentiate the ability of buyers to absorb these costs

is deemed important. Thus, the consideration of these costs has invariably been submerged under the cloak of the value of service principle, the guiding factor in rate-making on many systems.

On the Indian Railway system, the value of service principle adopted in rate-making tends to create higher freight-cost margins for high valued commodities. The volume of these items therefore tends to be low. On the other hand, the bulk movements of low-value freight do not offer adequate profit margins. When we consider the allocation of costs of empty returns, the tradition has been to levy an arbitrary pro-rata charge on different revenue-earning items. The empty return ratios for the various commodity groups which are taken into cost considerations on the Indian Railways are given in Table 22.

In our discussions with Board officials, we came to understand that these ratios are quite arbitrary and are reliable only to the extent that they are based on past experience of traffic flows on the network. While it is reasonable to expect that Coal, Iron-ore and POL products would have such high ratios, it is not easy to understand the low figures attributed to other commodities. This is especially so in the context of movement of these items in block rakes. However, we felt it necessary to check the feasibility of these ratios on the flows occurring on the network. For the year 1982-83, the loaded and empty flows associated with

**Table 22 • Empty Return Ratios (ERR) - Broad Gauge**

Commodity	ERR
1. Coal	30%
2. Iron-ore	100%
3. POL Products	100%
4. Cement	23%
5. Fertilisers	24%
6. Iron and Steel	23%
7. Foodgrains	23%
8. Other Goods	23%

the major commodity groups were calculated. This was done on the basis of the originating/terminating tonnage on the various Railway zones, the average load for the different groups and the average lead of traffic for these commodities. These calculations are presented in Table 23. Nearly 40 per cent of the empty flows can be attributed to the movement of coal while 15 per cent is due to the movement of raw materials to steel plants, steel products from steel plants and iron-ore for exports. Foodgrains, fertilizers and cement account for about 10 per cent of the empty flows while POL products movement results in about a sixth of the empty flows. On accounting for the flows relating to non-revenue traffic also, we find that the total empty movement

**Table 23. Estimates of Loaded and Empty Wagon Kilometrages (by Commodity) (Billions)**

Commodity	Loaded Wagon Kilometrage	Empty Wagon Kilometrage
1. Coal	1.9228	1.5799
2. Raw Material for Steel Plants	.2162	.2162
3. Iron Ore for Export	.2410	.2410
4. Pig Iron and Steel	.4490	1.032
5. POL Products	.6121	.6121
6. Cement	.3601	.0828
7. Foodgrains	1.2330	.2835
8. Fertilisers	.3190	.0737
9. Others	2.5301	1.5117
10. Non-Revenue	.2110	.2110
	<u>8.0943</u>	<u>3.9151</u>

Actual Flows 8.0887 3.9277

(estimated) comes to about 3.9 billion wagon kilometres. This figure more or less corresponds to the actual flows in 1982-83. Thus, it appears that the ratios adopted for rate-making seem to be reasonably good. But what is surprising is that the ratios for cement, foodgrains, fertilizers, etc., are low despite the claim that they are increasingly being moved in block rakes. While it is relatively easier to trace back flows associated with coal movements, it would be

an enormous task to look into backhauls associated with these commodities since their loadings and unloadings are spread over a much larger area.

But the important issue that is to be tackled is the one regarding the adequacy of transport rates to cover the additional cost of empty movement. The arbitrary assignment of costs may not necessarily cover the costs associated with empty haulage. But it must be remembered that there are many factors which influence rate-making, the factor of empty haulage being one of them. Thus, it is a formidable problem to separate the effect of this element. It would perhaps be useful to compute costs, however simplistic it may seem, which explicitly includes the factor of empty haulage. Following Jagjit Singh (1965) we take up the consideration of the average cost of hauling, say, a tonne of coal over a kilometre. The information that is provided is the cost of hauling a goods vehicle over one kilometre. As coal is always carried in full loads and the average wagon load in the case of coal turns out to be 22.4 tonnes, the average cost of hauling 22.4 tonnes of coal could be assumed to be equivalent to the cost of hauling a goods vehicle over one kilometre. Therefore, the cost of hauling a tonne of coal one kilometre can be calculated. We made these calculations for 1982-83.



Average cost of hauling a goods vehicle one kilometre	107.99 (paise)
Average wagon load of Coal	22.4 tonnes
Cost of hauling a tonne of Coal over one kilometre	$\frac{107.99}{22.4} = 4.82$

This, however, takes into account only the fact that coal is carried in full wagon loads but does not take into account the empty haulage involved in carrying coal. The empty return ratio in respect of coal movements is given to be 80 per cent, i.e., for every kilometre that a loaded coal wagon moves, it travels .8 kilometre empty. Thus, the cost of hauling one tonne of coal taking into consideration the empty haulage involved is

$$4.82 \times 1.80 = 8.67 \text{ (paise)}$$

The average lead of coal traffic is 545 kms. and the average rate charged per tonne was Rs. 43.26. We then get the average rate per tonne per kilometre to be

$$\frac{43.26}{545} = 7.93 \text{ (paise)}$$

Comparing this with the cost of movement, we find that the tariff is lower. But this may be a very simplistic way of incorporating considerations when there are many factors involved in the process required for these calculations.

#### Some Perspectives for Rate Making

It was noted earlier that the basis underlying the prevalent method of distributing joint costs of return move-

movements is a simple two<sup>way</sup> movement between two period points,  
 an origin and a destination. Under this over-simplified  
 assumption costs not directly related to the revenue produc-  
 ing kilometrage are treated as indivisible costs of the  
 two-way trip in the simplest form. But this requires that  
 the identity of each forward movement and that of the return  
 are maintained. However, this point-to-point relation that  
 is postulated hardly corresponds to the highly complex net-  
 works and various levels of flows in current day transporta-  
 tion operations. Thus, as Rahbany (1962) says, if tracing  
 back each haul to its originating forward leg is impractical,  
 it is of little relevance to associate the average empty  
 return with revenue producing forward movement. According  
 to him, the traditional allocation of costs of empty returns  
 (charge all revenue producing movement on an average pro rata  
 cost of all empty, non-revenue movement) does not take into  
 consideration the effect and contribution of each terminal  
 area to traffic imbalances. The effect of such a treatment  
 can result in certain distortions. Firstly, the costs of  
 empty returns from geographic areas of high imbalances could  
 be shifted to those of low imbalances resulting in inaccurate  
 cost calculations. Less directly, to the extent to which  
 transportation costs are crucial in the location of industries  
 and markets, the shifts in economic activity away from areas  
 of relatively<sup>low</sup> imbalances to others with high imbalances could

be spurred rather than mitigated by these practices. Moreover, the unchecked growth of traffic imbalances and its continued subsidy through current practices will further aggravate the problem of surplus capacity. In fact, a good deal of the surplus capacity can be ascribed to the increasing imbalances of flows rather than the decreasing volume of traffic.

Since it is clear that the incidence of empty movement is traceable to traffic imbalances at terminals, it would be useful to quantify the effects of imbalance on empty return. This can possibly be done by expressing the imbalance in terms of indices showing the ratio of volume of inbound to outbound traffic and also by determining the relationship between the ratios, empty returns, and the load factors. Having done this, one way of distributing costs of empty returns on a system-wide basis would be to assess the contribution made by each terminal area to the cost of empty movement required to maintain the flow of transportation.

It is possible to suggest several practical applications which may result from determining and calculating the effect of traffic imbalances as a factor in the costs of transportation. For the railway management, the use of data on traffic imbalances on traffic balances/imbalance may be illustrated by the need to develop realistic targets regarding loads and empty returns. Moreover, an analysis of traffic flow data may bring forth a need to develop operating

policies with a view to raise the utilisation of line-haul capacity. Also, a variable scale of load factors and empty returns based on seasonal and other variations in the balances may be designed to serve as a standard for line-haul equipment utilisation and management.

Broadly speaking, the arguments advanced above favour discriminatory <sup>rates</sup> based on directions. More specifically, a system of point-to-point rates ought to be adopted on the basis of differing area costs. These rates may be granted to promote back-hauls in recognition of specific and unique characteristics of the concerned traffic and operations thereby involved. Such a step would be prudent in the context of choice of location of a new economic activity requiring inter-regional movement especially since it would take into consideration the effect of the location of the new activity on balances/imbances in transport capacity. For instance, the location of a heavily importing industry may further worsen the existing imbalance. This will result in increased freight costs whereas the heavily importing industry may bring about balance if located elsewhere. Such an argument for discriminatory rates is also advanced by Miller (1977). In the context of attempting to simulate empty flows on the network in the United States, he observed that a good deal of movement of empties is towards the coalfields and felt that this movement could be utilised for the transport of, say, Ironore <sup>an</sup> leading on the Eastern shores. To induce shippers

to use the excess capacity represented by empty back-hauls, he feels that rates must reflect the true marginal cost by being lower where empty back-hauls can be used. In many

cases, low rates for back-hauls may enable the railways to get back the lost traffic from other modes. But such direction that the Indian Railways have been, for conventional rates have been traditionally opposed as involving undue discrimination, characterized by an ever increasing demand for wagon and track capacity. While expansion of track capacity is virtually ruled on financial considerations, the guiding factor in rate making, is basically discriminatory in nature.

## CHAPTER V

### SUMMARY AND CONCLUSIONS

#### SUMMARY

This preliminary study was motivated by the observation that the Indian Railway System has been, for quite some time, characterised by an acute and ever increasing shortage of wagon and track capacity. While expansion of track capacity is virtually ruled out on financial considerations, an increase in wagon holding may not be useful unless line and power capacity could be correspondingly increased. An effective way of dealing with the problem is to improve utilisation of existing wagon capacity. A major dimension of improvement that could be envisaged is in the sphere of empty wagon movement and management. Against this background, we made an attempt to undertake a preliminary study of this aspect of wagon movement and management on the Indian Railways.

Firstly, we took up some of the issues related to empty flows at the macro-level. It was observed that in addition to the growing importance of bulk items and the consequent adoption of appropriate operating policies (despatches in block rakes, etc.), the use of special stock to cater to the variety of emerging demands on the network, the decreasing importance of the Metre-Gauge component of the network have also been responsible for the growing magnitude of empty flows. More important is the finding that there is a trade-off between the turn round time (wagon

cycle) and the magnitude of empty movement, especially in the last decade. This suggests the interpretation that the railways would prefer to increase empty movement rather than make attempts to use back-hauls in any significant way. And this is mainly due to the potential adverse effects of additional loading on the turn-round time. Further, a rather detailed analysis of empty flows on the network indicates heavy concentration of such flows on the trunk routes which are also the main arteries for loaded flows, thus pre-empting a good deal of track capacity. Finally, an analysis of wagon utilisation when viewed from the point of view of loaded movement in the total movement and also in the wagon cycle reveals a very poor utilisation of wagon capacity.

The case study of the goods terminal at Pune reveals that backloading is a basic problem and thus heavy outflows occur at this node. But the demand for special types of wagons is not necessarily taken care of always due to restrictions on them. This, we suppose, may be a common feature at many nodes. However, more surprising is the extent of detention that wagons suffer while awaiting despatch. This, we feel, is a result of the lack of an effective allocation and disposition policy as far as wagons are concerned, which is invariably dictated by a highly centralised but apparently hierarchical set-up.

It was not possible to go, in detail, into the problem of costs of empty returns as related to the overall costs and the tariffs due to the absence of any information on these aspects. We have, however, tried to provide some insights into the problem on the basis of our discussions with Railway officials and our reading of the relevant but sparse literature.

#### Perspectives on Further Research

We chose to undertake this preliminary study with a view to set up the framework for a more comprehensive study of empty movement and management on the entire system. In our opinion such a comprehensive study would require an exercise of the programming type which would, in turn, require a good deal of data for the major nodes of the system. This would, no doubt, be a formidable task. But in view of our experience of collection of relevant data at Pune, we feel that the task would be less burdensome. More importantly, it would be essential to incorporate the decision making process involved at all levels within the framework of the programming exercise. But it is not enough having an information and a control system which provides for a knowledge of location of units and ad hoc rules for allocation of these units. Given the information, such a determination, as Felton (1978) has emphasised, should be an economic decision. This aspect, which is essentially behavioural in nature, is also to be included in the exercise. In the next phase of the work, we



expect to proceed along these lines. From the railways point of view, there is need for a thorough and comprehensive examination of the turn round time of wagons. And it is even more important to look into this aspect at a disaggregate level since there are wagons of different types that are engaged in the process of moving freight. With the non-transit component playing a significant role in the turn round time, it would be useful to initiate studies into the problem of excessive detentions at various terminals, yards, etc., which contribute in a major way to the poor utilisation of wagon capacity. We do hope to take up the dimension of turn round time also for detailed study in the next phase of our work. Also, in the context of consideration of costs and the related problem of rate-making, it is necessary to examine the effects of the pro-rata apportionment of empty movement on various streams of traffic and also look out for an alternative if the current practices <sup>are</sup> is not satisfactory.

When examining the problem from the point of view of the economy, a number of issues could be visualised and looked into separately. An interesting one would be that relating to the location of major parts, <sup>o</sup> movements through them and the hinterland that they serve. This would give us an insight into the efficiency of flows occurring from and to the <sup>or</sup> ports. Similarly, in the context of location of major industries in an area, it would be useful to look into the potential demands on the system in the area and relate them

to the available capacity resulting from imbalances.

Concluding Remarks

To conclude, it is heartening to note that the Indian Railways are going in for a massive computerised freight operations management system which is mainly aimed at facilitating and improving operational decisions in practice. However, it must be remembered that such a system could also serve as the basis for information for the conduct of large-scale studies such as the one that we have conceptualised. The operating system must take into consideration this aspect too.

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