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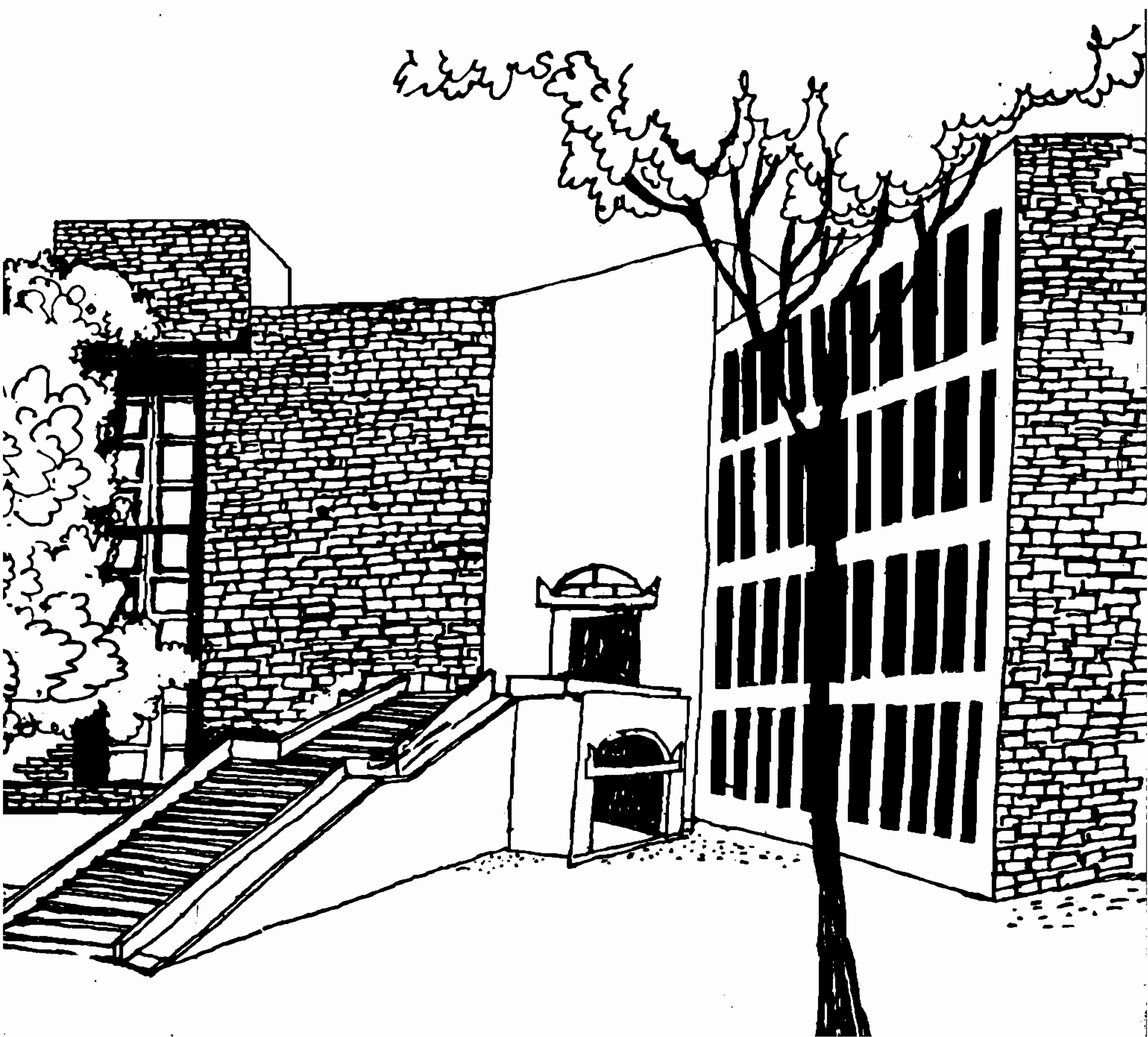

ANALYSIS OF WAGON UTILISATION AND ESTIMATING THE OPTIMAL FREIGHT TRANSPORT EFFORT (LOADED AND EMPTY WAGON MOVEMENT) FOR THE INDIAN RAILWAYS.

By

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Abstract

Over the past four decades, the freight movement output of the Indian Railways has increased substantially. The tonnes originating increased over fourfold from 73.2 million tonnes in 1950-51 to 302 million tonnes in 1988-89. During the same period, the net tonne kilometres (NTKMs) increased nearly sixfold from 37.6 billion in 1950-51 to 222.4 billion in 1988-89.

This phenomenal increase in freight output has been possible primarily through a) better inputs and b) better utilisation of the inputs. In this context, it is the purpose of this paper to:

a) Identify the key inputs whose growth have contributed to the increase in freight output, with an emphasis on wagons.
b) Analyze the determinants of the improved utilization of wagons.

In 1987-88, the empty wagon kilometres was 34% of the total wagon kilometres, up from a low of 26.8% in 1955-56. In absolute terms, the empty wagon kilometres in four wheeler units (FWUs) were 6052 million in 1987-88 while it was 1486 million in 1955-56. This (6052 million wagon kilometres) works out to four trains of nearly 67 FWUs travelling empty, the entire Railway system of 62000 kms, every day. The empty wagon lead has been increasing from 220 kms in 1950-51 to 395 kms in 1987-88.

In this context of the loaded and empty wagon movement, it is the further purpose of this paper to estimate the optimal transport effort in terms of

(a) loaded wagon movement and
(b) empty wagon movement.

In order to estimate the loaded wagon movement, the commodity movement pattern has to be estimated. There are nine commodities, all bulk in nature, which account for 91.0% of the goods carried (tonnes originating), generating 89.7% of the revenue from freight movement and accounting for 89.6% of the tonne kilometres in 1988-89. These nine commodities are coal, iron ore, cement, foodgrains, mineral ois, chemical manures, iron and steel, limestone and dolomite, and salt in the order of importance in terms of tonnes originating. Intrastate allocations are first considered and assumed as taking place by road. Efficient distribution of the remaining surplus/deficit of each of the commodities for interstate movement by rail is assumed and estimated using transportation models for all the commodities.

Acknowledgements

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Chapter I

Freight Movement and Wagon Utilisation

1.1 Introduction

Freight movement is one of the major operations of Indian Railways in terms of earning revenues as well as transport effort. Contribution from freight movement to the total revenue earned has been increasing over the past many years. In 1950-51, 52.91% of the revenue earned came from freight movement. The freight revenue increased to 65.03% of total revenue in 1988-89. The freight earnings went up from Rs.119 crores in 1950-51 to Rs.6198 crores in 1988-89.

Over the past four decades, the freight movement output of the Indian Railways have increased substantially. The tonnes originating increased over fourfold from 73.2 million tonnes in 1950-51 to 302 million tonnes in 1988-89. During the same period, the net tonne kilometers (NTKMs) increased nearly sixfold from 37.6 billion in 1950-51 to 222.4 in 1988-89. Exhibit 1.1 gives the key transport output parameters from 1950-51 to 1988-89.

This phenomenal increase in freight output has been possible primarily through a) better inputs and b) better utilisation of the inputs. In this context, it is the purpose of this paper to:

(a) Identify the key inputs whose growth have contributed to the increase in freight output, with an emphasis on wagons.
(b) Analyse the determinants of the improved utilisation of wagons.
(c) Examine an important external factor that influences the pattern of rail transport demand, namely the supply-demand allocation mechanisms of the major commodities transported by rail. A consequence of this is the transport demand for empty wagon movement and its relationship to the technological consideration of special purpose wagons vs general purpose wagons.

1.2 Key Inputs

The key inputs for the Indian Railways (in fact, for any transportation system) can be examined under the following heads:

(a) Right of Way
(b) Rolling Stock
(c) Motive Power
(d) Terminals
(e) Manpower
(f) Control Systems

Capital invested is not being considered as an input since it will be reflected through the above physical parameters.

Right of Way: This input is measured by the running track kilometers. As can be seen in Exhibit 1.2, the running track kilometers have gone up from 59315 in 1950-51 to 77845 in 1988-89, that is an increase of 31%. Another important aspect of the right of way is that the electrified running track kilometers have gone up from 937 in 1950-51 to 16887 in 1988-89, that is over an eighteenfold increase. The electrification of track has contributed significantly to the increased transport output, since it is being done along the high density traffic routes.

Rolling Stock: One of the major inputs for the freight movement, namely the number of wagons, increased from 2.06 lakhs in 1950-51 to 4.05 lakhs in 1979-80 and then decreased to 3.46 lakhs by 1988-89 (Exhibit 1.3). This net 1.68-fold increase in the number of wagons is deceptive since effective load carrying capacity has improved in other ways. Firstly, the Railways are replacing four wheeler wagons by eight wheelers (equivalent to two four wheelers). Hence we should talk in terms of four wheeler equivalent units (FWUs). The FWUs (which could be calculated only from 1981-82, based on available published data) were 4.90 lakh units in 1981-82 when total number of wagons were 3.92 lakhs and 4.77 lakh units in 1988-89 when number of wagons were 3.46 lakhs. Secondly, the Railways have been increasing the pay load per FWU, through better design. Tonnes per FWU has progressively increased since 1950-51. In 1950-51, an FWU carried an average of 12.15 tonnes which increased to 17.70 tonnes in 1981-82 and then to 18.95 tonnes in 1987-88. It dropped marginally to 18.80 tonnes in 1988-89. Thus, between 1950-51 and 1988-89, the wagon loading capacity has gone up due to the above-mentioned two reasons, influencing the freight output.

Motive Power: The Railways have been following a policy of electrification (on the high density routes) and dieselisation (on all non electrified routes) to improve freight throughput. This is reflected in the changing profile of locomotives, as seen in Exhibit 1.4. Since steam power is still a large component of the motive power, it would be inappropriate to examine any index of motive power. Suffice it is to state that total motive power capacity has gone up significantly.

Terminals: The number of stations have gone up from 5976 in 1950-51 to 7083 in 1980-81 (Exhibit 1.5). This measure indicates that the reach for generating traffic has increased. Another measure of improvement would be the capacity of the more important terminals where much of the traffic originates or terminates. Published data on this is not available.

Manpower: The number of employees has increased from 914000 in 1950-51 to 1624000 in 1988-89, an increase of 78% (Exhibit 1.5). Though there have been claims of overstaffing, the increase has improved throughput, especially since Railways have not yet gone in for any significant automation.

Control Systems: Improvements in signalling constitute this input. Though the Railways have been modernising signalling technology over the past few decades, published composite measures of this are not available.

Wagon Utilisation: Apart from the better inputs described above, the key inputs whose improvement in utilisation have a direct effect on transport output are the right of way, rolling stock and motive power. We will examine the possibilities of better wagon (rolling stock) utilisation further. The main indicator of wagon utilisation is net tonne kilometers per wagon day. The wagon utilisation has gone up from 500 ntkms/wagon day in 1950-51 to 1149 ntkms/wagon day in 1981-82 (Exhibit 1.6). At this time, the ntkms/FWU day, which could be calculated from the Indian Railways annual report data, was 918. (The ntkms/FWU day between 1950-51 and 1980-81 is not calculated since the mix of four wheelers and eight wheelers is not available for this period. The ntkms/wagon day is always larger than the ntkms/FWU day.) The ntkms/FWU day has increased to 1276 in 1988-89. To study this further, we need to examine the concept of a wagon cycle.

1.3 Wagon Cycle

A wagon cycle is the average time between two successive loadings. A wagon passes through several stages in between two loadings. Delays occur at many of these stages. After loading, a wagon will have to go to a yard where it is grouped with other wagons to form a train for a particular destination. If it is a load offered in wagon units (rather than a full train load) it may have to go to more than one such yard. While the train is on the move, it may have to stop enroute at stations and yards for operational purposes. Again it goes through a yard before it ultimately reaches the destination. At the destination, some time is taken for unloading. After unloading, the empty wagon goes through a similar cycle before it is made available for the next loading. The wagon cycle is diagramatically represented in Exhibit 1.7. The various stages of the wagon cycle are:

(a) Loading Time
(b) Unloading Time
(c) Maintenance Time
(d) Movement Time - Loaded
(e) Movement Time - Empty
(f) Yard Time - Loaded
(g) Yard Time - Empty

While stages (d) and (f) constitute loaded use of the wagon, (e) and (f) constitute the empty movement.

1.3.1 Wagon Cycle Calculations

An attempt has been made to estimate the time spent under these various stages, as described in Exhibit 1.7, for broad guage wagons (which constitute over 82% of total wagons, serving over

90 % of net tonne kms.). Exhibit 1.8 gives the input data being used for the calculations. The assumptions and the calculations are described below.

Loading and Unloading Time: There is no data available about the time taken for loading and unloading. Normally if a customer detains a wagon for more than two days, Railways charge demurrage for it. So an average loading time of two days and another half a day for clearing formalities is being assumed. The unloading time is being assumed as 1 day and another half a day for clearing formalities.

Maintenance Time: Assuming 15% of the wagons are not available due to maintenance activities, a wagon spends 1.71 days during the turn around time of 11.4 days (for broad gauge wagons, 1988-89) for maintenance.

Movement Time: After accounting for delays at all the above stages, the remaining 5.69 days are spent in movement and in yards. On an average, a BG wagon covers 113 kms. per day and the turn around time is 11.4 days which means it would cover 1288 kms. within this period. As per the Railway data, 65.4% of the movement of a wagon is loaded, i.e. 842 kms. At an average speed of 22.8 kms per hour, it would take 1.54 days for the wagon to cover this distance. Similarly, it would take about 0.81 days for a wagon to cover 446 kms of empty run (34.6% of total wagon movement). Thus the total movement time is 2.35 days.

Yard Time: Out of the remaining 3.34 days, 2.18 days will be the yard time during loaded movement and 1.16 days during empty movement, in the ratio 65.4 is to 34.6.

1.3.2 Analysis of the Wagon Cycle

Exhibit 1.9 gives the wagon cycle component calculations for broad guage from 1950-51 to 1988-89. The turnaround time has increased from 11 days in 1950-51 to 15.2 in 1980-81. This is primarily due to the increase in traffic lead (513 Kms in 1950-51 to 754 Kms in 1980-81 - Exhibit 1.1). The turnaround time has since decreased to 11.4 days in 1988-89, (even though the lead reduced only marginally to 736 Kms. in 1988-89). Not withstanding the limitations of the assumptions made above, we can claim that the major cause for the reduction in turnaround time is the yard time. This has reduced from 6.56 days (4.56 loaded and 2.0 empty) in 1980-81 to 3.33 days (2.18 loaded and 1.15 empty) in 1988-89. The policy measure of moving freight in rakeloads rather than wagonloads has been the single most important reason for this. We examine further the wagon cycle of 11.4 days in 1988-89:

Loading and Unloading Time: The loading and unloading times account for 35.1% (4 days). These times include placement time for wagons and time with the customer. Better terminal facilities and reduction of the demurrage-free hours with the customer could bring this down.

Maintenance Time: Better quality wagons and maintenance systems can reduce the 15% maintenance time (1.71 days).

Movement Time: The travel time constitutes 20.6% (2.35 days) of the wagon cycle. This can be reduced only by increasing goods trains speeds and by reducing the speed differential between passenger and goods trains.

Yard Time: Out of 11.4 days, 29.3% (3.33 days) is still accounted for by yard time. There may be potential to reduce this further.

Empty Wagon Movement: Wagon turn around time can also be reduced by reducing empty wagon movement (which constitutes 17.3% of the wagon cycle - 1.9 days) if the traffic destination and origin are better matched. The leverage to do this will of course diminish with emphasis on special type wagons, or merry-go-round like movement. Exhibit 1.10 gives the increasing trend of special type wagons between 1981-82 and 1988-89.

In order to focus further on the empty wagon movement, we need to examine the pattern of rail transport demand of the major commodities transported by rail.

EXHIBIT 1.1

TRANSPORT OUTPUT

SL.NO.	YEAR	TONNES ORGNTG. (Mill.)	Index	AVG. LEAD (KMS)	TKMS (Mill.)	Index	AVG. RATE (PS./KM)	EARNINGS (Rs.'0000)
1	2	3	4	5	6	7	8	9
1	1950-51	73.2	1.000	513	37551.6	1.000	3.16	118663
2	1955-56	92.2	1.260	541	49880.2	1.328	3.50	174581
3	1960-61	119.8	1.637	603	72239.4	1.924	3.87	279566
4	1965-66	162.0	2.213	611	98982.0	2.636	4.57	452348
5	1970-71	167.9	2.294	659	110646.1	2.947	5.43	600808
6	1975-76	196.8	2.689	685	134808.0	3.590	8.12	1094641
7	1978-79	199.6	2.727	721	143870.0	3.831	8.80	1266056
8	1979-80	193.1	2.638	749	144559.0	3.850	9.64	1393549
9	1980-81	195.9	2.676	754	147708.6	3.933	10.50	1550940
10	1981-82	221.2	3.022	743	164351.6	4.377	13.70	2251617
11	1982-83	228.8	3.126	733	167710.4	4.466	17.10	2867848
12	1983-84	230.1	3.143	734	168893.4	4.498	19.20	3242753
13	1984-85	236.4	3.230	730	172572.0	4.596	20.10	3468697
14	1985-86	258.5	3.531	760	196460.0	5.232	21.50	4223890
15	1986-87	277.8	3.795	771	214183.8	5.704	23.30	4990483
16	1987-88	290.2	3.964	767	222583.4	5.927	26.20	5831685
17	1988-89	302.0	4.126	736	222374.0	5.922	27.87	6197563

Source: Indian Railways Annual Report and Accounts 1988-89.

EXHIBIT 1.2

RUNNING TRACK LENGTH

SL.NO.	YEAR	RUNNING TRACK KMS. (Elect.)	Index	RUNNING TRACK KMS. Total	Index
1	2	3	4	5	6
1	1950-51	937	1.00	59315	1.00
2	1955-56	937	1.00	60845	1.03
3	1960-61	1752	1.87	63602	1.07
4	1965-66	4847	5.17	68375	1.15
5	1970-71	7447	7.95	71669	1.21
6	1975-76	9245	9.87	74255	1.25
7	1978-79	9363	9.99	75195	1.27
8	1979-80	9562	10.20	75450	1.27
9	1980-81	10474	11.18	75860	1.28
10	1981-82	10608	11.32	75964	1.28
11	1982-83	11058	11.80	76187	1.28
12	1983-84	11416	12.18	76407	1.29
13	1984-85	12018	12.83	76963	1.30
14	1985-86	12367	13.20	77153	1.30
15	1986-87	13809	14.74	77254	1.30
16	1987-88	15504	16.55	77671	1.31
17	1988-89	16887	18.02	77845	1.31

Source: Indian Railways Annual Report and Accounts, 1988-89.

EXHIBIT 1.3

NUMBER OF WAGONS

SL.NO. 1	YEAR 2	# OF WAGONS 3	Index 4	# OF FWUs 5	Index 6	TONNES PER FWU 7
1	1950-51	205596	1.000			12.15
2	1955-56	240756	1.171			12.25
3	1960-61	307907	1.498			13.65
4	1965-66	370019	1.800			14.34
5	1970-71	383990	1.868			14.43
6	1975-76	395250	1.922			16.20
7	1978-79	401885	1.955			NA
8	1979-80	405183	1.971			16.89
9	1980-81	400946	1.950			17.47
10	1981-82	391702	1.905	490404	1.000	17.70
11	1982-83	383429	1.865	490564	1.000	17.71
12	1983-84	374757	1.823	493955	1.007	17.84
13	1984-85	365390	1.777	488854	0.997	17.76
14	1985-86	359617	1.749	485105	0.989	18.22
15	1986-87	354041	1.722	480754	0.980	18.47
16	1987-88	346844	1.687	484466	0.988	18.95
17	1988-89	345821	1.682	477159	0.973	18.60

Sources:

Col.No.3 - Indian Railways Annual Report and Accounts 1988-89
Col No.5 - Derived as explained in Exhibit 1.3A

EXHIBIT 1.3A

FREIGHT MOVEMENT EFFORT AND NO. OF WAGONS (1950-51 TO 1988-89)

SL. NO.	YEAR	TKMS (Mill.)	FWU WKMS IN (mill.) B.G	N.G	N.G	TOTAL	% EMPTY	TONNES PER FWU	WAGONS IN ABSOLUTE NUMBERS B.G	M.G	N.G	TOTAL	WKMS/WAG-DAY B.G	M.G	N.G	WAGONS IN FWUs B.G	M.G	N.G	TOTAL	TKMS/FWU PER DAY	ABS # / FWU B.G	M.G	N.G	TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1950-51	37552				4370	29.3	12.15				205596												
2	1955-56	49880				5564	26.8	12.25				240756												
3	1960-61	72239				7507	29.5	13.65				307907												
4	1965-66	98982				9760	30.7	14.34				370019												
5	1970-71	110646				10999	30.3	14.43				383990												
6	1975-76	134000				12184	31.7	16.20				395250												
7	1978-79	143870				12501	NA	NA				401885												
8	1979-80	144559				12194	29.8	16.89				405163												
9	1980-81	147709				12165	30.5	17.47				400946												
10	1981-82	164352	11577	1800	39	13416	30.3	17.70	283511	83787	4484	371782	83.7	47.9	12.6	378936	102730	8537	490404	913.18	1.25	1.23	1.90	1.25
11	1982-83	167710	12016	1857	34	13907	31.9	17.71	298624	80028	4777	383429	86.4	50.4	10.7	381039	100924	8601	490564	936.64	1.28	1.26	1.80	1.28
12	1983-84	168893	12548	1762	31	14342	34.0	17.84	293152	76981	4624	374757	88.7	49.4	9.9	387585	97746	8623	493955	936.77	1.32	1.27	1.86	1.32
13	1984-85	172572	12824	1715	31	14570	33.3	17.76	287724	73603	4063	365390	90.8	50.3	9.9	386955	93430	8469	488854	967.16	1.34	1.27	2.08	1.34
14	1985-86	196460	13850	1908	31	15789	31.7	18.22	284923	70908	3786	359617	97.8	58.8	10.4	387977	88879	8249	485105	1109.55	1.36	1.25	2.18	1.35
15	1986-87	214184	15058	2013	32	17104	32.2	18.47	283408	66924	3709	354841	106.6	64.4	10.9	387011	85645	8099	480754	1220.59	1.37	1.28	2.18	1.36
16	1987-88	222583	15865	1905	30	17800	34.0	18.75	282007	63277	3560	348844	109.9	64.6	10.0	395505	80797	8164	484466	1258.74	1.41	1.28	2.29	1.40
17	1988-89	222374	16215	1845	30	18091	34.6	18.80	281877	60547	3397	345821	113.0	66.3	10.6	393147	76258	7755	477159	1276.81	1.39	1.26	2.28	1.38

Source: Indian Railways Year Book

Col 7 = Col 1/(Col 5*(100-Col 6))

Col 15 =(Col 2* 1000000)/(Col 12*365)
similarly for Col 16 and Col 17
Col 19 = Col 1/(Col 18* 365)

Col 20 = Col 15/Col 3
similarly for Col 21, 22 and 23.

EXHIBIT 1.4

NUMBER OF LOCOMOTIVES

SL.NO.	YEAR	STEAM	Index	DIESEL	Index	ELECT.	Index
1	2	3	4	5	6	7	8
1	1950-51	8120	1.000	17	1.000	72	1.000
2	1955-56	9026	1.112	67	3.941	79	1.097
3	1960-61	10312	1.270	181	10.647	131	1.819
4	1965-66	10613	1.307	727	42.765	403	5.597
5	1970-71	9387	1.156	1169	68.765	602	8.361
6	1975-76	8496	1.046	1803	106.059	796	11.056
7	1978-79	8082	0.995	2126	125.059	945	13.125
8	1979-80	7856	0.967	2243	131.941	974	13.528
9	1980-81	7469	0.920	2403	141.353	1036	14.389
10	1981-82	7245	0.892	2520	148.235	1104	15.333
11	1982-83	6292	0.775	2638	155.176	1157	16.069
12	1983-84	6217	0.766	2800	164.706	1194	16.583
13	1984-85	5970	0.735	2905	170.882	1252	17.389
14	1985-86	5571	0.686	3046	179.176	1302	18.083
15	1986-87	4950	0.610	3182	187.176	1366	18.972
16	1987-88	4427	0.545	3298	194.000	1433	19.903
17	1988-89	3826	0.471	3454	203.176	1533	21.292

Source: Indian Railways Annual Report and Accounts 1988-89.

EXHIBIT 1.5

NUMBER OF STATIONS AND TERMINALS

SL.NO.	YEAR	NUMBER OF STATIONS	Index	NUMBER OF EMPLOYEES	Index
1	2	3	4	5	6
1	1950-51	5976	1.00	914000	1.00
2	1955-56	6152	1.03	1025000	1.12
3	1960-61	6523	1.09	1157000	1.27
4	1965-66	6986	1.17	1352000	1.48
5	1970-71	7066	1.18	1374000	1.50
6	1975-76	7056	1.18	1457000	1.59
7	1978-79	7021	1.17	1525000	1.67
8	1979-80	7017	1.17	1550000	1.70
9	1980-81	7035	1.18	1572000	1.72
10	1981-82	7072	1.18	1575000	1.72
11	1982-83	7068	1.18	1584000	1.73
12	1983-84	7065	1.18	1592000	1.74
13	1984-85	7093	1.19	1603000	1.75
14	1985-86	7092	1.19	1613000	1.76
15	1986-87	7105	1.19	1611000	1.76
16	1987-88	7084	1.19	1618000	1.77
17	1988-89	7083	1.19	1624000	1.78

Source: Indian Railways Annual Report and Accounts 1988-89.

EXHIBIT 1.6

LOADED WAGON UTILISATION

SL.NO.	YEAR	TKMS PER WAGON PER DAY	TKMS PER FWU PER DAY
1	2	3	4
1	1950-51	500.40	
2	1955-56	567.62	
3	1960-61	642.78	
4	1965-66	732.89	
5	1970-71	789.45	
6	1975-76	934.44	
7	1978-79	980.79	
8	1979-80	977.46	
9	1980-81	1009.32	
10	1981-82	1149.54	918.18
11	1982-83	1198.35	936.64
12	1983-84	1234.72	936.77
13	1984-85	1293.96	967.16
14	1985-86	1496.72	1109.55
15	1986-87	1657.45	1220.59
16	1987-88	1758.19	1258.74
17	1988-89	1761.73	1276.81

Source:
Col 3 = Col 1/(Col 11*365) of EXH 1.3A.
Col 4 = Col 1/(Col 18*365) of EXH 1.3A.

EXHIBIT 1.7

ANALYSIS OF WAGON CYCLE

```
Maint--->Loading--->Loaded Movement-->Unloading-->Empty Movement
Time     Time       Train/Yard        Time        Train/Yard
         (2.5 days)                   (1.5 days)

<---------------------------------TT----------------------------->

        <-------X=0.85 TT----------------------------------------->

   Y=X-2.5-1.5         <------LMT------->                <----EMT------>
    =LMT+EMT              (LTT+LYT)                        (ETT+EYT)
```

1)	T	=	Turnaround Time (Days)	
2)	L	=	% Loaded Movement	
3)	WK	=	Wagon Kilometers/Wagon Day	
4)	S	=	Average Speed (Kms/Hour)	
5)	0.85 *TT	=	X	(Turnaround Time excluding maintenance)
6)	X - 2.5 (loading time) - 1.5 (unloading time)	=	Y	(Loaded Movement Time + Empty Movement Time)
7)	L/100 * Y	=	LMT	(Loaded Movement Time)
8)	$\frac{WK*TT*L/100}{S}$	=	LTT	(Loaded Train Time)
9)	LMT-LTT	=	LYT	(Loaded Yard Time)
10)	(1-L/100) Y	=	EMT	(Empty Movement Time)
11)	$\frac{WK*TT*(1-Y/100)}{S}$	=	ETT	(Empty Turn Time)
12)	EMT-ETT	=	EYT	(Empty Yard Time)

EXHIBIT 1.8

INPUTS FOR WAGON CYCLE CALCULATIONS

SL.NO.	YEAR	% Empty	Turn Around Time (Days)		Speed (KMPH)		WKS.per Wagon day	
			B.G	M.G.	B.G	M.G.	B.G	M.G.
1	2	3	4	5	6	7	8	9
1	1950-51	30.00	11.0	NA	17.4	15.0	62.3	50.2
2	1955-56	26.80	10.5	NA	15.9	13.6	74.5	45.9
3	1960-61	29.50	11.2	7.2	16.1	13.7	76.9	51.6
4	1965-66	30.70	11.8	8.4	16.4	14.0	73.2	60.1
5	1970-71	30.30	13.3	10.1	17.9	14.7	73.4	58.4
6	1973-74	29.80	15.0	12.5	18.3	15.5	67.2	50.8
7	1975-76	31.70	13.5	11.6	18.8	14.9	76.8	56.4
8	1979-80	29.80	15.1	14.1	19.5	14.8	73.3	49.7
9	1980-81	30.50	15.2	15.3	19.7	15.1	73.4	47.3
10	1981-82	30.80	13.3	14.2	20.8	16.1	83.7	47.9
11	1982-83	31.90	12.8	13.8	21.4	16.5	86.4	50.4
12	1983-84	34.00	13.0	14.2	21.9	17.0	88.7	49.4
13	1984-85	33.30	12.8	14.8	21.9	16.9	90.8	50.3
14	1985-86	31.70	12.0	14.3	22.3	16.7	97.8	58.8
15	1986-87	32.20	11.6	12.7	22.4	17.0	106.6	64.4
16	1987-88	34.00	11.6	12.3	22.7	17.3	109.9	64.6
17	1988-89	34.60	11.4	12.3	22.8	17.5	113.0	66.3

Source: Indian Railways Year Books.

EXHIBIT 1.9

WAGON CYCLE (Broad Gauge)

YEAR	Turn Around Time	Speed (KMPH)	WKS. per Wagon Day	% Loaded	Maintenance Time (Days)	Loading Time (Days)	Loaded Movmt Time: Train (Days)	Loaded Movmt Time: Yard (Days)	Un-Loading Time (Days)	Empty Movmt. Time: Train (Days)	Empty Movmt. Time: Yard (Days)
1	2	3	4	5	6	7	8	9	10	11	12
1950 -51	11.00	17.40	62.30	70.00	1.65	2.50	1.15	2.60	1.50	0.49	1.11
1955 -56	10.50	15.90	74.50	73.20	1.58	2.50	1.50	2.10	1.50	0.55	0.77
1960 -61	11.20	16.10	76.90	70.50	1.68	2.50	1.57	2.32	1.50	0.66	0.97
1965 -66	11.80	16.40	73.20	69.30	1.77	2.50	1.52	2.66	1.50	0.67	1.18
1970 -71	13.30	17.90	73.40	69.70	2.00	2.50	1.58	3.51	1.50	0.69	1.52
1973 -74	15.00	18.30	67.20	70.20	2.25	2.50	1.61	4.53	1.50	0.68	1.92
1975 -76	13.50	18.80	76.80	68.30	2.03	2.50	1.57	3.54	1.50	0.73	1.64
1978 -79	14.30	19.60	75.90	69.00	2.15	2.50	1.59	4.03	1.50	0.72	1.81
1979 -80	15.10	19.50	73.30	70.20	2.26	2.50	1.66	4.54	1.50	0.70	1.93
1980 -81	15.20	19.70	73.40	69.50	2.28	2.50	1.64	4.56	1.50	0.72	2.00
1981 -82	13.30	20.80	83.70	69.20	2.00	2.50	1.54	3.51	1.50	0.69	1.56
1982 -83	12.80	21.40	86.40	68.10	1.92	2.50	1.47	3.22	1.50	0.69	1.51
1983 -84	13.00	21.90	88.70	66.00	1.95	2.50	1.45	3.21	1.50	0.75	1.65
1984 -85	12.80	21.90	90.00	66.70	1.92	2.50	1.47	3.11	1.50	0.74	1.55
1985 -86	12.00	22.30	97.80	68.30	1.80	2.50	1.50	2.74	1.50	0.70	1.27
1986 -87	11.60	22.40	106.60	67.80	1.74	2.50	1.56	2.41	1.50	0.74	1.15
1987 -88	11.60	22.70	109.90	66.00	1.74	2.50	1.54	2.32	1.50	0.80	1.20
1988 -89	11.40	22.80	113.00	65.40	1.71	2.50	1.54	2.18	1.50	0.81	1.15

Source: Columns 6 - 12 are derived based on assumptions and calculations explained in Exhibit 1.7

Exhibit 1.10

NUMBER OF SPECIAL TYPE WAGONS

SL. NO.	TYPE OF WAGONS	1981-82	1982-83 B.G	1982-83 M.G	1984-85 B.G	1984-85 M.G	1985-86 B.G	1985-86 M.G	1986-87 B.G	1986-87 M.G	1987-88 B.G	1987-88 M.G	1988-89 B.G	1988-89 M.G
1	BOX	44378	49915		51149		50948		50747		50564		49824	
2	BOY	974	918		884		862		862		815		774	
3	CA/BCA		5469	1627	4551	1438	4212	1353	4015	1195	3780	1247	3424	1109
4	BRH	6499	6692		566		7733		7715		7702		7664	
5	BFU	462	461	143	419	133	419	131	417	130	414	131	410	130
6	TANK	29063	30175	5159	30940	4811	30602	4689	30649	4569	31141	4437	32401	4297
7	CONT.FLAT		318	8	325	8	322	8	322	8	322	8	324	8
8	BCX	15734	16943		18706		18977		18947		18935		18939	
9	BOBS/BOBX	2359	2496		2492		2387		2352		2324		2290	
10	CRT	19303	20710		20618		20683		20584		20524		20414	
11	BOXN		201		6260		10380		13263		17560		20755	
	TOTAL	117772	134298	6937	136910	6390	147725	6181	149873	5902	154081	5823	157219	5544
	No.of Wagons	392062	298624	80028	287724	73603	284923	70908	283408	66924	280007	63277	281877	60547
	% Special	30.04	44.97	8.67	47.58	8.68	51.85	8.72	52.88	8.82	55.03	9.20	55.78	9.16

Type of wagon	Brief description
BOX	High sided open bogie wagons with side discharge arrangement for transport of coal and other bulk traffic.
BOY	Low sided open bogie wagons to carry iron ore etc.
CA/BCA	Wagon designed for the transportation of cattle.
BRH	Flat wagons for rails, steelbars, etc.
BFU	Well wagons for over dimensional and heavy consignments.
Tank	Tank wagons for liquid consignments like petroleum products, molasses, vegetable oils, etc.
Container flat	Flat wagons to carry container for door to door service.
BCX	Watertight covered wagons for foodgrains, cement, etc.
BOBS/BOBX	Open Hopper wagons with bottom discharge arrangments to carry ballast, ores, etc.
CRT	Watertight 4-wheeler covered wagons having higher capacity for general goods.
BOXN	High sided bogie open wagons with improved compartments.

Source: Indian Railways Year Books.

Chapter II

Bulk Commodity Movement

2.1 Introduction

There are nine commodities, all bulk in nature, which account for 91.0% of the goods carried (tonnes originating), generating 89.7% of the revenue from freight movement and accounting for 89.6% of the tonne kilometers in 1988-89. These nine commodities are coal, iron ore, cement, foodgrains, mineral oils, chemical manures, iron and steel, limestone and dolomite, and salt in the order of importance in terms of tonnes originating (Exhibit 2.1). The ranking in terms of tonne kilometers and freight revenue earned are given in Exhibits 2.2 and 2.3 for the years 1983-84, 1987-88 and 1988-89. All commodities have shown an increase in originating tonnes, tonne-kms and revenue earned between 1983-84 and 1987-88. Cement and Chemical Manures have improved their ranking over these years. Between 1987-88 and 1988-89, all commodities have shown an increasing trend in all the indicators, except foodgrains.

Exhibit 2.4 gives a ranking based on the ratio of percentage earnings to the percentage tkms, which reflects the rate per tkm of these commodities. It is quite apparent that mineral oils are the most lucrative for the Railways while chemical manures, foodgrains and salt are the least lucrative due to the subsidies built in.

Efficient distribution of these commodities is essential for the industrial and agricultural development of the country. Railways carry these commodities predominantly in rakes and form the prime mode of transportation of each of these commodities except in the case of limestone and dolomite. The freight movement policies regarding special versus general purpose wagons, and empty wagon distribution play a major role in the distribution of these commodities. Availability of appropriate wagons affects the cost in terms of packaging, handling, etc. At the same time, ensuring adequate supply of wagons at the right time reduces the inventory related costs at the production center.

2.2 Intermodal Split and Average Lead

The intermodal (Rail - Road) split in tkms for the top nine commodities computed by RITES, based on their study (1978-79 and 1986-87) shows that the share by roads has increased in the case of all the nine commodities. One reason for this increase could be the Railways' policy of insisting on higher rake movement. The piecemeal movement which existed on Railways must have shifted to road. The intermodal split and average lead during 1978-79 and 1986-87 are shown in Exhibit 2.5.

The average lead in the case of road movement shows an increase in the case of six commodities. Among these, foodgrains, fertiliser (chemical manures) and iron ore showed a decreased lead by rail, while coal, iron and steel and limestone and dolomite increased by rail. Cement, salt and mineral oils which showed a decrease in the average lead (59, 4 and 1 kms. respectively) by road, also registered a decrease in the lead by rail.

The average lead by rail for the nine commodities being discussed is given in Exhibit 2.6 over the years 1950-51 to 1988-89. Leadwise (1987-88), the top nine commodities are in the following order: Salt, foodgrains, iron and steel, fertiliser, cement, coal, mineral oils, limestone and dolomite, and iron ore. The lead has increased considerably for all these nine commodities over the last three to four decades. The average lead for all the commodities by rail increased from 513 kms in 1950-51 to 754 in 1980-81. This was reflective of a developing economy over a large spatial spread. Location policies with regard to backward area development also contributed to this. In the eighties, as more industries were set up, and controls were relaxed, location and distribution decisions could more consciously consider economies of transportation. The average lead decreased to 730 kms in 1984-85, increased again to 771 kms in 1986-87 and decreased to 736 kms in 1988-89.

Changes in government policy regarding distribution and price controls are consequently reflected in the lead. For example, in 1982, the Government partially decontrolled cement distribution. The average lead has since been decreasing from 781 kms in 1982-83 to 652 kms in 1988-89. In the current year (1988-89), Government has lifted all the controls in the distribution of cement and this is likely to have an impact on the lead. Similarly, policies like freight equalization encourage manufacturers to transport their commodities to distant places, as in the case of iron and steel.

The government decision to set up non-port based refineries have resulted in movement of petroleum products over shorter distances. This is reflected in the average lead coming down in recent years (760 kms in 1980-81 to 625 in 1988-89). A similar pattern can be expected in the future for fertiliser as many new plants are being setup in the interior.

A graph of the average lead for rail movement over the year 1950-51 to 1987-88 is given in Exhibit 2.7 .

2.3 Commodity-wise Flow Analysis

The objectives of the commodity-wise flow analysis are

(a) to determine the optimal tkms for rail movement if the most effecient allocation between production centers and demand centers (using a transportation model) were made

(b) to explain the difference between the optimal tkms obtained above and the actual tkms by rail

(c) to determine the resulting empty wagon kilometers under different scenarios

Transportation Model: The allocation exercise is done using a transportation model and solved on the computer using a linear programming software. The supply and demand data are examined at the state level since reliable secondary data is available only at this level of aggregation.

It is assumed that demand in a state is satisfied to the extent possible from within the state (lesser of the supply or demand in that state) and then the states are categorised as surplus states or deficit states. This is used as the source and destination data for the transportation model for interstate movement. Sometimes supply from a neighbouring state may be more economical than from within the state in the case of border areas. This is possible only if the neighbouring state has got a production center, but such a movement will generally attract interstate tax problems. Due to data limitations, we have not taken this into account. Since intrastate movements have shorter leads, we have assumed that all intrastate movements are likely to take place by road. Correspondingly, all interstate movements are assumed to be by rail.

The objective of the model is to minimise the total transportation effort, measured in tonne kilometers. Since the output of the model is a tkm figure, the transportation costs are in distances and surplus and deficit quantities in tonnes. The distance data are generated by taking the straight. line distances between the "supply center" (if it is a surplus state) and the "demand center" (if it is a deficit state). The supply and demand centers are chosen away from the geographical center according to the knowledge available regarding the actual location of production and consumption points. The distances are thus generated separately for each commodity.

Empty Wagon Movement: This is calculated under four scenarios, using either the optimal or actual tkms for the loaded movement, and applying either 34.4% (as per the current empty proportion) or 50% (if the wagons are returned to source as empty). The 34.4% empty movement is applicable under the assumption that railways use general purpose wagons and continue their empty wagon allocation practices as at present. The 50% figure reflects the assumption that special purpose wagons would be used or even with general purpose wagons trains would be run in a source to destination circuit as merry-go-round trains. The empty wagon movement, which is 34.4% as a proportion of total movement, can also be viewed as 52% of the loaded movement. This figure is used for obtaining empty wagon kilometers from loaded wagon kilometers. Similarly, when the empty wagon kilometers is 50% of the total movement, it is exactly equal to the loaded wagon kilometers. An average wagon capacity of 20.1 tonnes is taken to convert the tkms into loaded wagon kilometers.

Net Flow Analysis: To arrive at the least possible empty wagon movement, an optimal allocation between points where empty wagons are generated and where they are required is attempted. Here also, the sources and destinations are aggregated at the state level, with the assumptions that wagon arisings in a state are first used for requirements within the same state.

Each of the nine commodity flows are analysed in greater depth in the following chapters. After a brief introduction, the production, demand and distance data are discussed. This is followed by a discussion of the transportation model output and the calculations of the empty wagon kilometers contributed by each of the commodities.

EXHIBIT 2.1

RANKING BASED ON TONNES ORIGINATING 1983-84

SL.NO.	COMMODITY NAME	TONNES ORIGINATING (000's)	% TO TOTAL	CUM. %
1	Coal	88974	38.66	38.66
2	Iron Ore	24821	10.79	49.45
3	Foodgráins	24566	10.68	60.12
4	Mineral Oils	17949	7.80	67.92
5	Cement	15550	6.76	74.68
6	Iron and Steel	10214	4.44	79.12
7	Limestone and Dolomite	9064	3.94	83.06
8	Chemical Manures (fert.)	8147	3.54	86.60
9	Salt	2707	1.18	87.77
	Total for Bulk Commodities	201992	87.78	-
	Total for All Commodities	230120	100.00	100.00

RANKING BASED ON TONNES ORIGINATING 1987-88

SL.NO.	COMMODITY NAME	TONNES ORIGINATING (000's)	% TO TOTAL	CUM %
1	Coal	119842	41.29	41.29
2	Iron Ore	31256	10.77	52.07
3	Foodgrains	30135	10.38	62.45
4	Cement	22315	7.69	70.14
5	Mineral Oils	21690	7.47	77.61
6	Chemical Manures (fert.)	13177	4.54	82.15
7	Iron and Steel	12298	4.24	86.39
8	Limestone and Dolomite	9129	3.15	89.54
9	Salt	3044	1.05	90.58
	Total for Bulk Commodities	262886	90.58	-
	Total for All Commodities	290210	100.00	100.00

RANKING BASED ON TONNES ORIGINATING 1988-89

SL.NO.	COMMODITY NAME	TONNES ORIGINATING (000's)	% TO TOTAL	CUM %
1	Coal	128012	42.38	42.38
2	Iron Ore	33013	10.93	53.31
3	Cement	25911	8.58	61.89
4	Foodgrains	24882	8.24	70.13
5	Mineral Oils	22598	7.48	77.61
6	Chemical Manures (fert.)	16100	5.33	82.94
7	Iron and Steel	12055	3.99	86.93
8	Limestone and Dolomite	9159	3.03	89.96
9	Salt	3266	1.08	91.04
	Total for Bulk Commodities	274996	91.04	91.04
	Total for All Commodities	302050	100.00	100.00

Source : Indian railways year books.

EXHIBIT 2.2

RANKING BASED ON TONNE-KMS. 1983-84

SL.NO.	COMMODITY NAME	TONNE-KMS (Million)	% TO TOTAL TONNE-KMS	CUM %	AVERAGE LEAD (KMS.)
1	Coal	54719	32.40	32.40	615
2	Foodgrains	30265	17.92	50.31	1232
3	Iron and steel	11715	6.94	57.25	1147
4	Mineral oils	10716	6.34	63.59	597
5	Cement	10558	6.25	69.84	679
6	Iron ore	8365	4.95	74.80	337
7	Chemical Manures(fert)	8310	4.92	79.72	1020
8	Salt	4115	2.44	82.15	1520
9	Limestone and Dolomite	2955	1.75	83.90	326
	Total for Bulk Commodities	141718	83.90	83.90	702
	Total for All Commodities	168908	100.00	100.00	734

RANKING BASED ON TONNE-KMS. 1987-88

SL.NO.	COMMODITY NAME	TONNE-KMS (Million)	% TO TOTAL TONNE-KMS	CUM %	AVERAGE LEAD (KMS.)
1	Coal	78672	35.35	35.35	656
2	Foodgrains	41673	18.73	54.08	1383
3	Cement	14542	6.53	60.62	652
4	Chemical Manures(fert)	14355	6.45	67.07	1089
5	Mineral oils	13778	6.19	73.26	635
6	Iron and Steel	13590	6.11	79.37	1105
7	Iron ore	11872	5.34	84.70	380
8	Salt	5362	2.41	87.11	1761
9	Limestone and Dolomite	3425	1.54	88.65	375
	Total for Bulk Commodities	197269	88.65	88.65	750
	Total for All Commodities	222528	100.00	100.00	767

RANKING BASED ON TONNE-KMS. 1988-89

SL.NO.	COMMODITY NAME	TONNE-KMS (Million)	% TO TOTAL TONNE-KMS	CUM %	AVERAGE LEAD (KMS.)
1	Coal	82694	37.19	37.19	646
2	Foodgrains	33436	15.04	52.22	1344
3	Cement	16895	7.60	59.82	652
4	Chemical Manures(fert)	16267	7.32	67.14	1010
5	Mineral oils	14135	6.36	73.49	625
6	Iron and Steel	13284	5.97	79.47	1101
7	Iron ore	13131	5.90	85.37	369
8	Salt	5476	2.46	87.83	1675
9	Limestone and Dolomite	3908	1076.00	89.59	427
	Total for Bulk Commodities	199226	89.59	89.59	718
	Total for All Commodities	222374	100.00	100.00	736

Source: Indian Railways Year Books.

EXHIBIT 2.3

RANKING BASED ON EARNINGS 1983-84

SL.NO.	COMMODITY NAME	EARNINGS (Lakh Rs.)	AV.RATE PER TKM (Paise)	% TO TOTAL EARNINGS	CUM %
1	Coal	96095	17.6	29.71	29.71
2	Mineral Oils	40526	37.8	12.53	42.24
3	Iron and Steel	37625	32.1	11.63	53.87
4	Foodgrains	31379	10.4	9.70	63.58
5	Cement	22816	21.6	7.05	70.63
6	Iron Ore	15656	22.9	4.84	75.47
7	Chemical Manures (fert.)	14548	17.5	4.50	79.97
8	Limestone and Dolomite	6744	22.8	2.09	82.06
9	Salt	4727	11.5	1.46	83.52
	Total for Bulk Commoditie	270117	14.2	83.52	83.52
	Total for All Commodities	323427	19.1	100.00	100.00

RANKING BASED ON EARNINGS 1987-88

SL.NO.	COMMODITY NAME	EARNINGS (Lakh Rs.)	AV. RATE PER TKM (Paise)	% TO TOTAL EARNINGS	CUM %
1	Coal	204919	26.05	35.09	35.09
2	Mineral Oils	71758	52.08	12.29	47.38
3	Foodgrains	64266	15.42	11.01	58.39
4	Iron and Steel	60182	44.28	10.31	68.69
5	Cement	40200	27.64	6.88	75.58
6	Chemical Manures (fert.)	32541	22.67	5.57	81.15
7	Iron Ore	25954	21.86	4.44	85.60
8	Limestone and Dolomite	9094	26.55	1.56	87.15
9	Salt	8179	15.25	1.40	88.55
	Total for Bulk Commoditie	517093	26.21	88.55	88.55
	Total for All Commodities	583923	26.24	100.00	100.00

RANKING BASED ON EARNINGS 1988-89

SL.NO.	COMMODITY NAME	EARNINGS (Rs.Lakhs)	AV. RATE PER TKM (Paise)	% TO TOTAL EARNINGS	CUM %
1	Coal	226739	27.42	36.59	36.59
2	Mineral Oils	76395	54.05	12.33	48.92
3	Iron and Steel	62404	46.98	10.07	58.99
4	Foodgrains	53473	15.99	8.63	67.62
5	Cement	49119	29.07	7.93	75.54
6	Chemical Manures (fert.)	38019	23.37	6.14	81.68
7	Iron Ore	31065	23.66	5.01	86.69
8	Limestone and Dolomite	10509	26.89	1.70	88.39
9	Salt	8374	15.29	1.35	89.74
	Total for Bulk Commoditie	556097	27.91	89.74	89.74
	Total for All Commodities	619674	27.87	100.00	100.00

Source : Indian railways year books.

EXHIBIT 2.4
RANKING BASED ON 1983-84 DATA

SL.NO. 1	COMMODITY NAME 2	% EARNINGS 3	% TKMS 4	RATIO 3/4 5	RANK 6
1	Mineral oils	12.53	6.34	1.9763	1
2	Iron and steel	11.63	6.94	1.6758	2
3	Cement	7.05	6.25	1.1280	3
4	Iron ore	4.84	4.95	0.9778	4
5	Coal	29.71	32.40	0.9170	5
6	Chemical Manures (fert.)	4.50	4.92	0.9146	6
7	Salt	2.09	2.44	0.8566	7
8	Limestone and Dolomite	1.46	1.75	0.8343	8
9	Foodgrains	9.70	17.92	0.5413	9

RANKING BASED ON 1987-88 DATA

SL.NO. 1	COMMODITY NAME 2	% EARNINGS 3	% TKMS 4	RATIO 3/4 5	RANK 6
1	Mineral oils	12.29	6.19	1.9855	1
[illegible]	Iron and steel	10.31	6.11	1.6874	2
3	Cement	6.88	6.53	1.0536	3
[illegible]	Limestone and Dolomite	1.56	1.54	1.0130	4
[illegible]	Coal	35.09	35.35	0.9926	5
[illegible]	Chemical Manures (fert.)	5.57	6.45	0.8636	6
7	Iron ore	4.44	5.34	0.8315	7
	Foodgrains	11.01	18.73	0.5878	8
	Salt	1.40	2.41	0.5809	9

RANKING BASED ON 1988-89 DATA

SL.NO. 1	COMMODITY NAME 2	% EARNINGS 3	% TKMS 4	RATIO 3/4 5	RANK 6
1	Mineral oils	12.33	6.36	1.9387	1
2	Iron and steel	8.63	5.97	1.4456	2
3	Cement	7.93	7.60	1.0434	3
4	Coal	36.59	37.19	0.9839	4
5	Limestone and Dolomite	1.70	1.76	0.9659	5
6	Iron ore	5.01	5.90	0.8492	6
7	Chemical Manures (fert.)	6.14	7.32	0.8388	7
8	Foodgrains	10.07	15.04	0.6695	8
9	Salt	1.35	2.46	0.5488	9

EXHIBIT 2.5

INTERMODAL SPLIT (tkms) FOR TOP NINE COMMODITIES

Commodities	1978-79*				1987-88@			
	Rail %	AVG.LEAD (KMS)	Road %	AVG.LEAD (KMS)	Rail %	AVG.LEAD (KMS)	Road %	
Salt	91.6	1427	8.4	320	88.31	1388	11.69	
Foodgrains	90.8	1278	9.2	277	76.31	1146	23.69	
Coal	95.2	691	4.8	408	90.56	717	9.44	
Iron ore	99.9	529	0.1	96	98.52	325	1.48	
Lime st & Dolomite	94.4	371	5.6	267	84.26	544	15.74	
Mineral oil	88.7	656	11.3	230	82.78	504	17.22	
Iron & Steel	84.2	1101	15.8	371	72.19	1191	27.81	
Fertiliser	90.9		9.1		84.35		15.65	
Cement	89.9	717	10.1	286	83.71	678	16.29	
ALL COMMODITIES	82.2	808	17.8	354	74.18	778	25.82	

Source: * NTPC Report 1980
@ RITES Report on Commodity Flows 1987

EXHIBIT 2.6

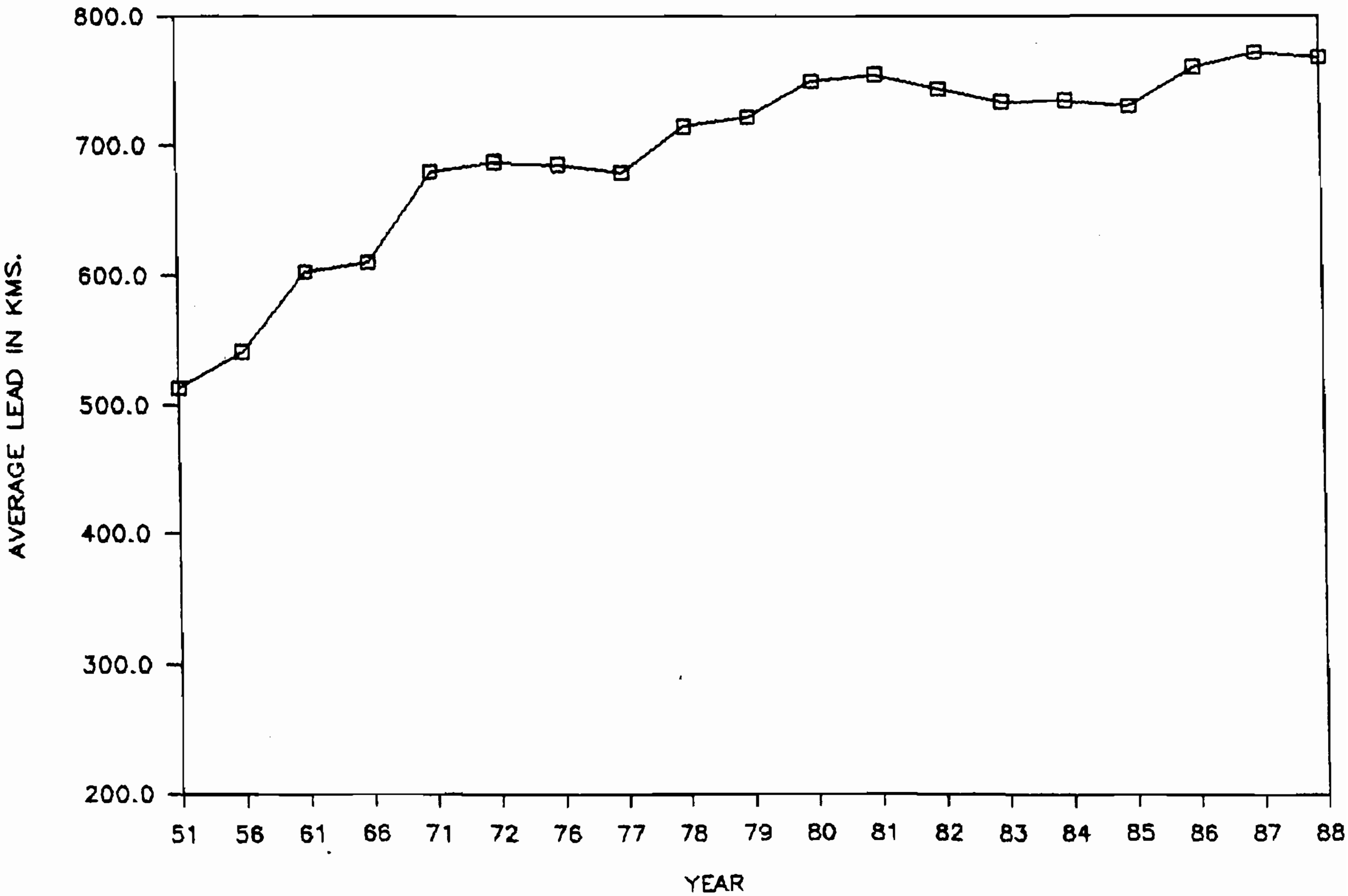
AVERAGE LEAD FOR TOP 9 COMMODITIES (KMS.)

YEAR	SALT	FOOD-GRAINS	IRON AND STEEL	FERTIL-ISERS	CEMENT	COAL	MINE. OILS	LIME ST. AND DOLOM.	IRON ORE	AVERAGE (ALL)
1950-51	-	512	-	-	-	558	-	-	-	513
1955-56	-	605	-	-	-	570	-	-	-	541
1960-61	-	760	874	-	372	664	554	-	-	603
1965-66	1034	808	821	752	456	571	598	-	-	611
1970-71	1267	961	993	811	633	581	594	218	-	-
1971-72	1186	1059	1021	832	617	605	593	-	-	687
1975-76	1407	956	1003	859	743	586	605	217	-	685
1976-77	1343	940	1000	930	669	575	609	277	-	679
1977-78	1414	1181	1062	991	676	586	631	274	-	714
1978-79	1464	1229	1097	1038	724	567	698	272	-	721
1979-80	1489	1340	1099	1126	757	551	718	-	-	749
1980-81	1441	1326	1042	1100	746	568	780	-	-	754
1981-82	1394	1290	1154	1013	748	580	731	-	-	743
1982-83	1457	1231	1207	969	781	582	647	-	-	733
1983-84	1520	1232	1217	1020	679	616	597	336	338	734
1984-85	1504	1227	1114	1098	656	618	563	326	337	730
1985-86	1611	1357	1111	1094	653	634	588	342	353	760
1986-87	1683	1370	1090	1073	651	654	588	363	366	771
1987-88	1760	1383	1105	1089	651	656	635	370	371	767
1988-89	1675	1344	1101	1010	652	646	625	375	380	736

SOURCE: (1) SAXENA RN., RAIL PRICING IN INDIA, 1984.
(2) INDIAN RAILWAYS YEAR BOOKS

EXHIBIT 2.7

AVERAGE LEAD



Chapter III

Salt

3.1 Introduction

The production of salt in 1987-88 is around 7.05 million tonnes. The major demand for salt is for human and animal consumption and for the manufacture of caustic soda and soda ash. The demand for salt is spread all over the country. Movement of salt takes place predominantly by rail. Salt for edible purposes is moved in bags by rail. Road movement is generally restricted to the movement from the salt works to the rail sidings.

The average lead for salt is the highest among all the nine commodities. The lead has been showing a fluctuating trend over the past twentyfive years (Exhibit 3.1). Since 1985, it has been increasing steadily though. Data about salt movement by road is not readily available. According to the RITES study of commodity flows, 35% of the total tonnage is moved by road. This involves quite a bit of double counting, since salt from the salt works to railway sidings takes place by road, and then by rail. The share in tkms (which is consequently a better measure of the movement effort) of salt movement by road is only 12%.

3.2 Supply, Demand and Distance Data

There are ten states producing salt. They are mostly coastal, except Rajasthan and Himachal Pradesh. Salt producing states are Gujarat, Tamil Nadu, Rajasthan, Maharashtra, Andhra Pradesh, Orissa, Karnataka, West Bengal, Goa and Himachal Pradesh in the order of importance of production. India exports salt from Gujarat and Tamil Nadu.

Production data, statewise, for 1969 to 1979 is available in the Report of the High Level Salt Enquiry Committee. Taking the annual growth rate for 10 years, the production for 1988 was estimated. This is divided statewise using the proportion of production in 1979. Consumption figures are given statewise from 1969 and 1979. There is a lot of variation in consumption between 1969 to 1972. Hence, we have taken the growth rate from 1972 to 1979, when the variation in consumption is not much, to estimate the consumption pattern in 1988. Export figures which were available as a total for the country, were divided between Tamil Nadu and Gujarat, according to the proportion of production from these states. After adjusting for the intra-state consumption, there are fifteen deficit states and five surplus states, with supply and demand quantities as given in Exhibit 3.2. Exhibit 3.3 gives a map showing the supply and demand points. The distance matrix used for the transportation model is given in Exhibit 3.4.

3.3 Model Output

The optimal allocation pattern as per the transportation model is shown in Exhibit 3.5. The northern states are served by Rajasthan and Gujarat. The major supply point is Gujarat, serving nine out of fifteen deficit states. Rajasthan serves six states, Tamil Nadu serves two and Andhra Pradesh and Goa serve one state each. The average lead as per this optimal allocation is 910 kms.

As per the data published by Railways for 1987-88, the tonnes carried by Railways are 3.04 million tonnes. The tonne kms are 5362 million. Average lead, as per this, works out to be 1764 kms. As per the optimal allocation, the tonnes originating are 4.23 million tonnes, and tonne kms. are 3849 million. This results in an average lead of 910 kms. The actual tonne kilometers are less than the model, presumably because there is interstate road movement. This would also partly explain the actual lead being nearly twice the model value. Inefficiency in allocation and not considering salt as multiple commodities may account for the rest.

3.4 Empty Wagon Movement

In the first scenario, we have assumed the average lead as 910 kms, the tonnes originating as 4.23 million and the empty movement as 34.4%. According to this the empty wagon movement will be 100.41 million wkms/yr. In the second scenario, the average lead and tonnes originating remain the same as in the first scenario, with an empty movement of 50%, resulting in 191.48 million wkms/yr. In the third scenario, we have assumed the average lead as 1764 kms. (1987-88 actual) with 3.04 million tonnes as tonnes originatng and 34.4% empty movement. Empty movement in this scenario will be 139.90 million wkms/year. Empty movement in the fourth scenario is 50% with the average lead and tonnes originating the same as in the third scenario. Empty wagon movement in this case is 266.79 million wkms/year. Wagon movement under the different scenarios is given in the following table:

Scen-ario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	4.23	191.48	910	34.4	100.41	477	291.89
2	4.23	191.48	910	50.0	191.48	910	382.96
3	3.04	266.79	1764	34.4	139.90	925	406.69
4	3.04	266.79	1764	50.0	266.79	1764	533.58

EXHIBIT 3.1

AVERAGE LEAD FOR SALT

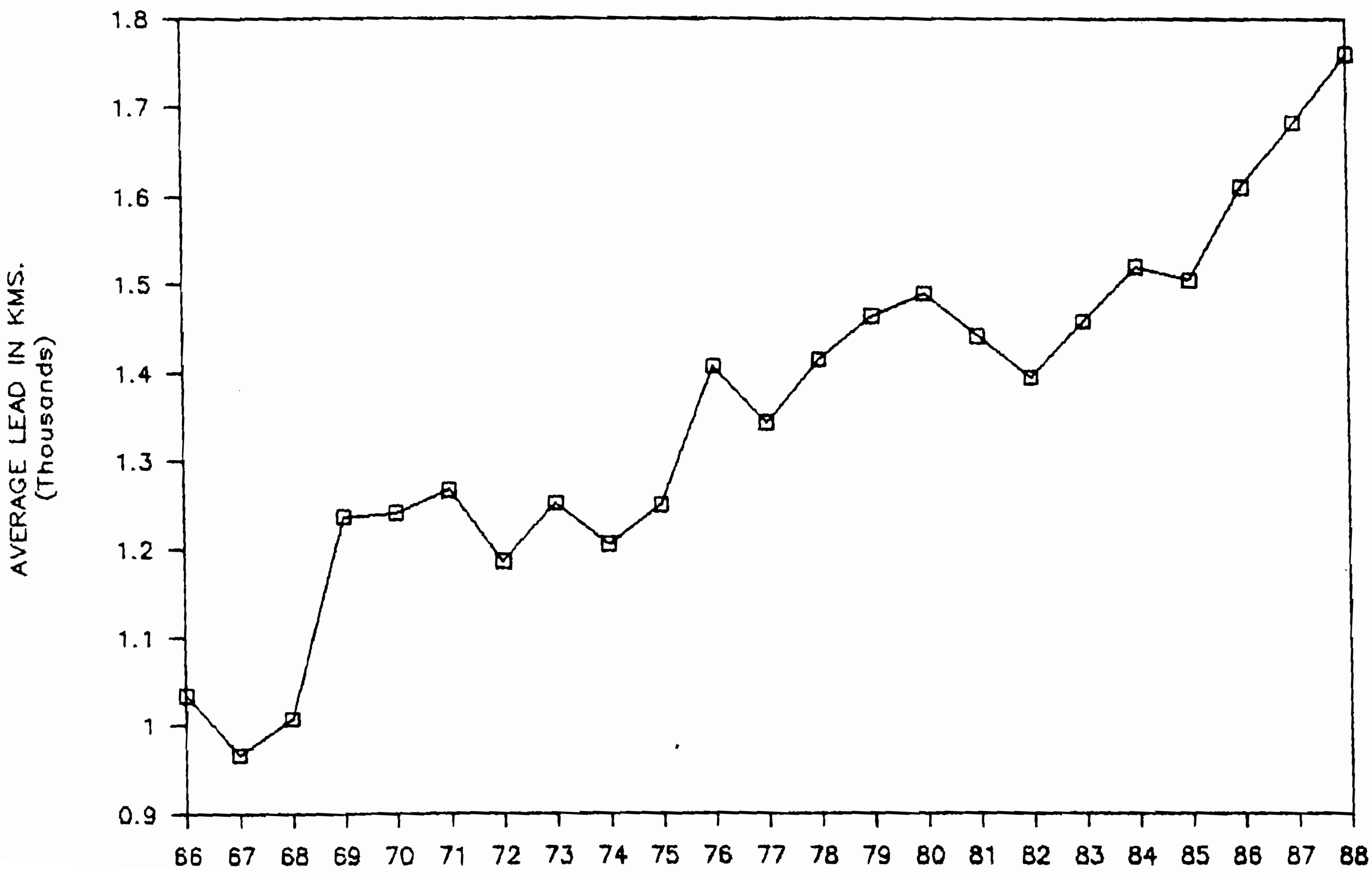


EXHIBIT 3.2

SUPPLY AND DEMAND PATTERN OF SALT (1987-88)
(000'TONNES)

Sl.No.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	ANDHRA PRADESH	424.15	249.73	174.42	
2	BIHAR	0.00	992.15		992.15
3	CHANDIGARH	0.00	1.74		1.74
4	DELHI	0.00	203.61		203.61
5	GOA	15.81	7.12	8.69	
6	GUJARAT	4976.52	1899.83	3076.69	
7	HARYANA	0.00	138.48		138.48
8	HIMACHAL PRADESH	5.27	6.09		0.82
9	JAMMU & KASHMIR	0.00	7.83		7.83
10	KARNATAKA	35.57	423.01		387.44
11	KERALA	0.00	156.37		156.37
12	MAHARASHTRA	684.96	1399.67		714.71
13	MADHYA PRADESH	0.00	343.59		343.59
14	NORTH EAST	0.00	192.19		192.19
15	ORISSA	96.16	448.06		351.91
16	PUNJAB	0.00	23.81		23.81
17	RAJASTHAN	956.31	298.21	658.11	
18	T.NADU & POND.	2070.69	1756.95	313.74	
19	UTTAR PRADESH	0.00	459.49		459.49
20	W. BENGAL & SIKKIM	17.12	274.62		257.50
	TOTAL	9282.56	9282.56	4231.65	4231.65

Source: Derived from the Report of The Salt Enquiry Committee, Govt of India, 1980.

Exhibit 3.3

Map Showing Demand and Supply Points
Commodity - Salt

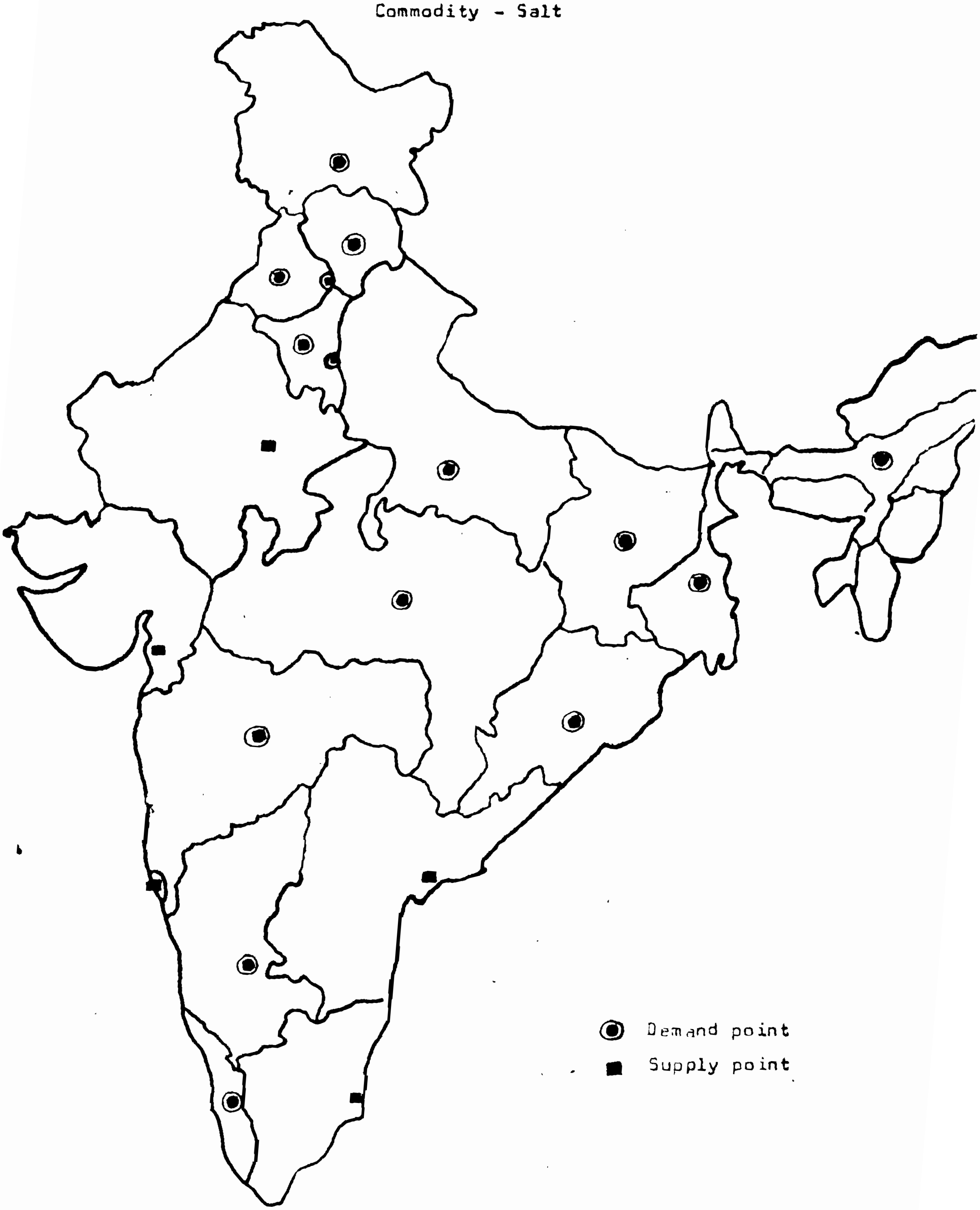


EXHIBIT 3.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF SALT (KMS)

SL.NO.	DEFICIT STATES	SURPLUS STATES A.P	GOA	GUJARAT	RAJASTHAN	T.NADU
1	BIHAR	1095	1590	1350	1050	1725
2	CHANDIGARH	1695	1710	1125	495	2295
3	DELHI	1395	1485	930	285	2055
4	HARYANA	1530	1515	930	285	2123
5	HIMACHAL PRADESH	1785	1830	1260	600	2400
6	JAMMU & KASHMIR	2025	2040	1455	810	2625
7	KARNATAKA	540	270	795	1350	600
8	KERALA	810	690	1230	1860	330
9	MAHARASHTRA	615	450	390	825	1050
10	MADHYA PRADESH	780	1020	720	600	1395
11	NORTH EAST	1830	2385	2100	1695	2520
12	ORISSA	1080	1230	1410	1185	1230
13	PUNJAB	1740	1695	1095	1110	2325
14	UTTAR PRADESH	1140	1380	960	525	1785
15	W.BENGAL & SIK.	1125	1710	1485	1290	1770

Chapter IV

Foodgrains

4.1 Introduction

Foodgrain movement is important as far as freight movement by railways is concerned since it has the second highest average lead of 137Ø kms in 1987-88. In terms of tonnes originating (3Ø.13 million) it ranked third in 1987-88. The distribution of foodgrains to a large extent is controlled by Food Corporation of India (FCI). Movement of foodgrains outside the control of FCI is not much, as far as movement by rail is concerned. Since production is seasonal, the demand for wagons to transport foodgrains reaches a peak during harvesting seasons. Procurement at the state level is done by state agencies and/or by FCI and stored in the godowns to be released later depending on need.

Since surplus production is concentrated in a few states, transportation to demand points involve movement over large distances. As production depends entirely on the weather conditions there is lot of uncertainty regarding the wagon requirement. During a good cropping season, the procurement will be more but during an adverse cropping season the release from buffer stock will be very high.

The average lead has increased considerably, from 512 kms in 195Ø-51, to 1383 kms in 1987-88. During this period, there was a marginal decline until 1976-77. The growth pattern of average lead since 195Ø-51 is shown in Exhibit 4.1

4.2 Supply, Demand and Distance Data

Though the production of foodgrains takes place in all the states, most of the states do not have sufficient production for their own consumption. There are only three states which have surplus production. Purchase and sales of foodgrains by FCI, statewise, is taken from the 1986-87 FCI annual report. Since the sales figure is less than the purchase figure, the difference has been proportionately added to the sales figures to arrive at the consumption figure. The surplus states are Punjab, Haryana, and Uttar Pradesh. Total supply through FCI amounts to 22.25 million tonnes. Production and demand pattern of food grains is given in Exhibit 4.2.

Since it is difficult to identify the exact location of demand and supply points, we have taken the geographical center of every state as the demand and supply point (Exhibit 4.3). The distance between the demand and supply points is given in Exhibit 4.4.

4.3 Model Output

The allocation pattern as per the model is given in Exhibit 4.5. Supply from Punjab meets the entire demand of Jammu & Kashmir, Delhi, Rajasthan, Himachal Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Bihar, Orissa, West Bengal and part of the demand of NEF. Supply from Haryana meets the demand of Kerala, Madhya Pradesh and Maharashtra. Uttar Pradesh meets a part of the demand of NEF.

The average lead as per the optimal allocation is 1477 kms and the tonnes originating is 16.03 million tonnes. As per the Railway data in 1986-87, the tonnes originating was 29.00 million tonnes with an average lead of 1370 kms. The difference could be due to the assumptions that all the intra state movement takes place by road. A lower actual average lead than what the model gives and a higher tonnes originating show that to a certain extent intra state movement too takes place by rail. Further, double counting due to rail movement of foodgrains from the procurement center to godowns and again from the godowns to the markets is possible. Some non-FCI short distance movement by rail is also likely.

4.4 Empty Wagon Movement

In the first scenario the average lead is 1477 kms and the tonnes originating are 16.03 million (model data). The empty wagon movement as per this scenario assuming an average empty movement of 34.4% works out to be 617.69 million wkms. In the second scenario the empty movement, assumed to be 50%, works out to 1177.92 million wkms. In the third and fourth scenarios, we have taken the average lead and the tonnes originating as per the actual data given by Railways, and empty movement at 34.4% and 50% respectively. The empty wagon movement works out to be 1036.52 million wkms. and 1976.62 million wkms. respectively:

Scen-ario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	16.03	1177.92	1477	34.4	617.69	775	1795.61
2	16.03	1177.92	1477	50.0	1172.92	1477	2355.84
3	29.00	1976.62	1370	34.4	1036.52	718	3013.14
4	29.00	1976.62	1370	50.0	1976.62	1370	3953.24

EXHIBIT 4.1

AVERAGE LEAD FOR FOODGRAINS

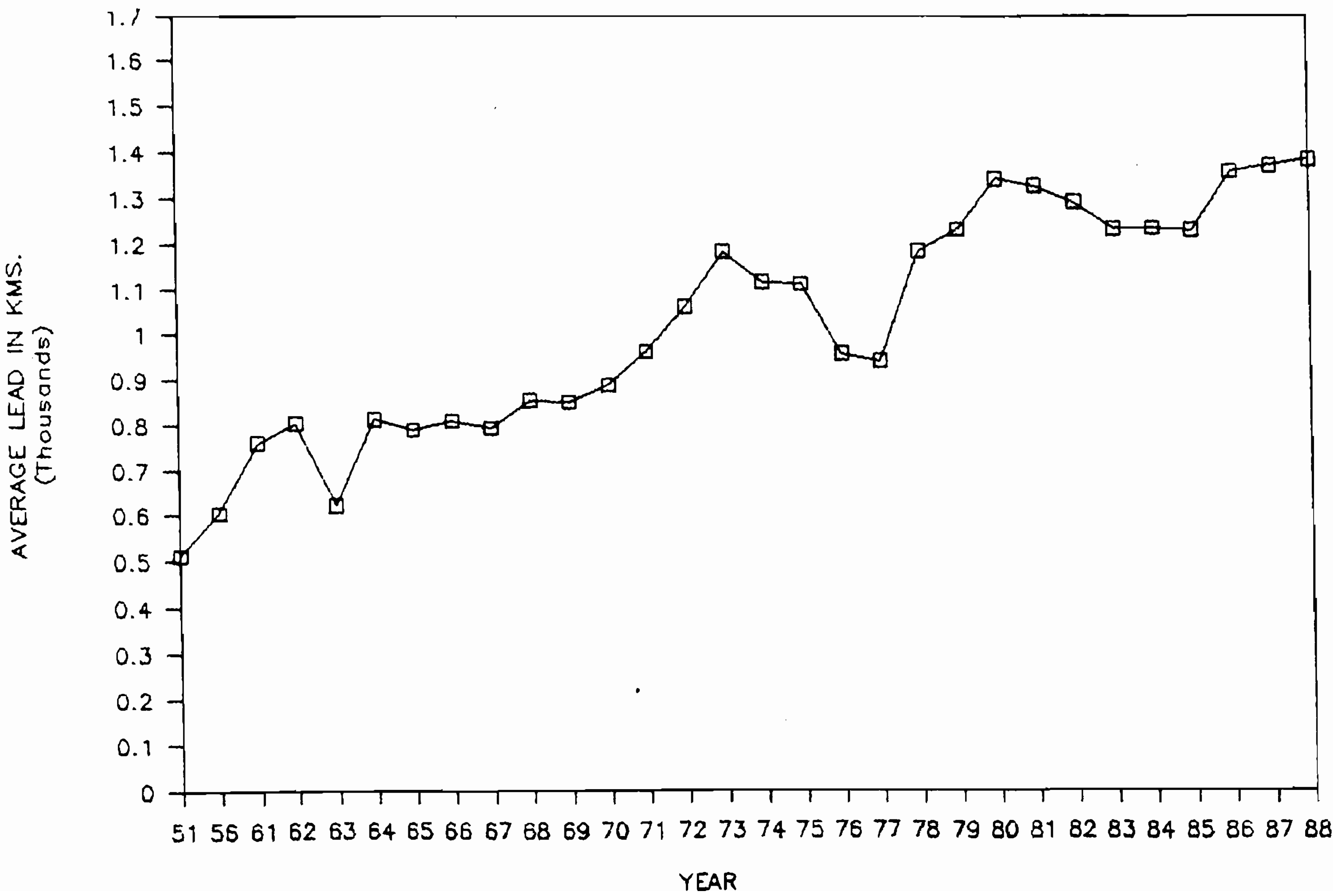


EXHIBIT 4.2

SUPPLY AND DEMAND PATTERN OF FOODGRAINS (1986-87)
(000'TONNES)

SL.NO.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	JAMMU & KASHMIR	0.000	413.791		413.791
2	DELHI	192.233	988.386		796.153
3	RAJASTHAN	134.985	1147.192		1012.207
4	HIMACHAL PRADESH	2.179	100.073		97.894
5	ANDHRA PRADESH	1617.769	1974.725		356.956
6	TAMILNADU	131.433	1310.404		1178.971
7	KARNATAKA	112.640	1398.799		1286.159
8	KERALA	19.004	1980.717		1961.713
9	MADHYA PRADESH	547.008	985.731		438.723
10	MAHARASHTRA	1016.700	2441.985		1425.285
11	GUJARAT	242.673	1368.227		1125.554
12	BIHAR	142.898	1498.654		1355.756
13	ORISSA	145.738	539.317		393.579
14	NORTH EAST	14.959	1694.976		1680.017
15	WEST BENGAL	176.248	2683.443		2507.195
16	PUNJAB	11701.802	200.714	11501.088	
17	HARYANA	3164.542	182.949	2981.593	
18	UTTAR PRADESH	2885.501	1338.228	1547.273	
	TOTAL	22248.312	22248.312	16029.954	16029.954

Source: FCI Annual Report, 1986-87

Exhibit 4.3

Map Showing Demand and Supply Points
Commodity - Foodgrains

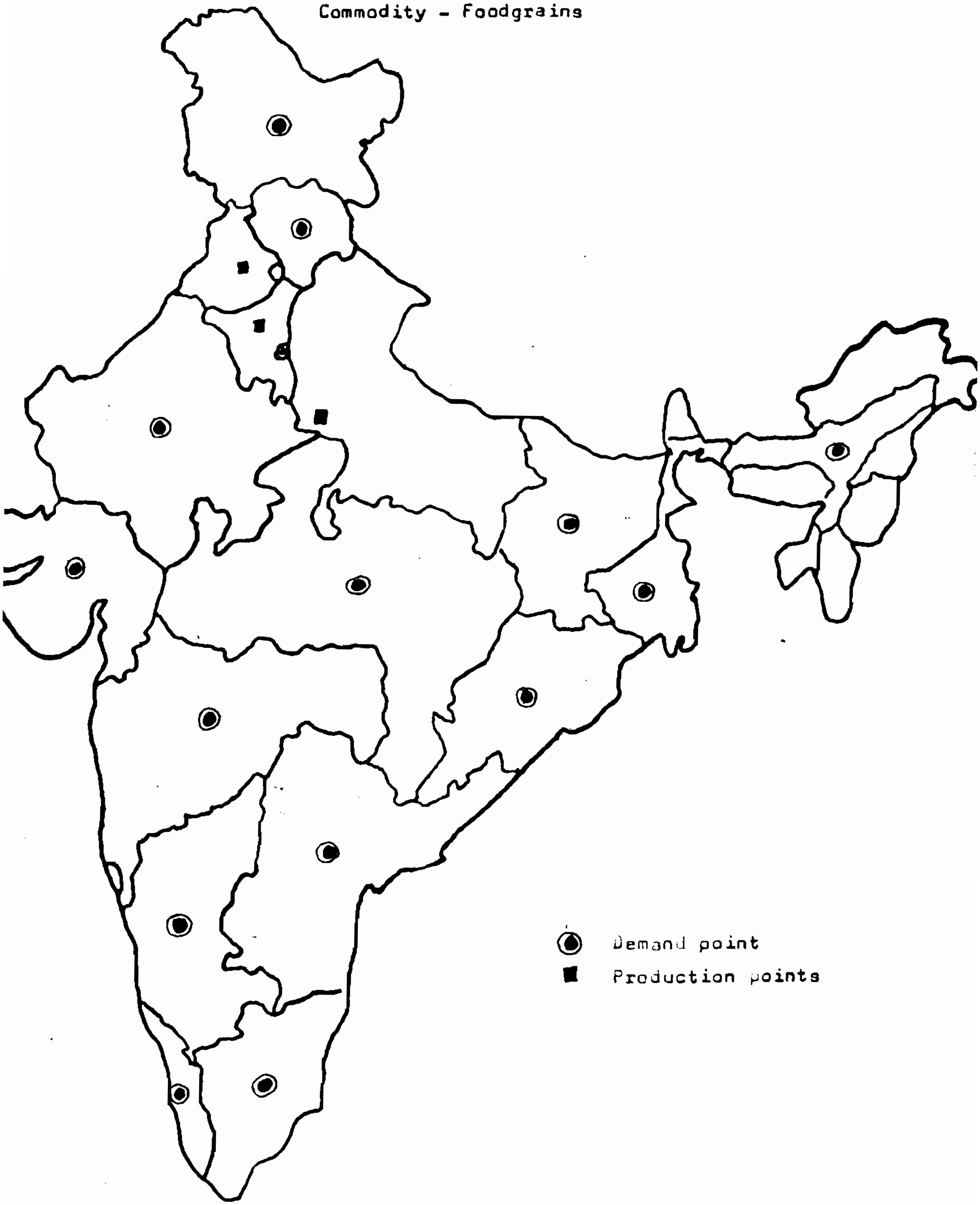


EXHIBIT 4.4

DISTANCE BETWEEEN SUPPLY AND DEMAND POINTS
OF FOODGRAINS
(KMS)

SL. NO.	DEFICIT STATES	SURPLUS STATES		
		PUNJAB	HARYANA	U.P
1	J & K	433	633	866
2	DELHI	166	366	483
3	RAJASTHAN	533	383	500
4	H.P	250	350	567
5	A.P	1433	1217	1067
6	T.NADU	1883	2283	2083
7	KARNATAKA	2016	1783	1633
8	KERALA	2567	2333	2150
9	M.P	1083	833	567
10	MAHARASHTRA	1433	1200	1067
11	GUJARAT	1133	950	1000
12	BIHAR	1333	1167	833
13	ORISSA	1633	1417	1100
14	N.EAST	2216	2050	1683
15	W.BENGAL	1600	1414	1133

EXHIBIT 4.5

OPTIMAL ALLOCATION OF FOODGRAINS
(000' TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES PUNJAB	HARYANA	U.P	TOTAL DEMAND
1	J&K	413.791			413.791
2	DELHI	796.153			796.153
3	RAJASTHAN	1012.207			1012.207
4	H.P	97.894			97.894
5	A.P	356.956			356.956
6	T.NADU	1178.971			1178.971
7	KARNATAKA	705.002	581.157		1286.159
8	KERALA		1961.713		1961.713
9	M.P		438.723		438.723
10	MAHARASHTRA	1425.285			1425.285
11	GUJARAT	1125.554			1125.554
12	BIHAR	1355.756			1355.756
13	ORISSA	393.579			393.579
14	N.EAST	132.744		1547.273	1680.017
15	W.BENGAL	2507.195			2507.195
	TOTAL SUPPLY	11501.087	2981.593	1547.273	16029.953

TOTAL TKMS : 23676 million.
AVG. LEAD : 1477 kms.

Chapter V

Iron and Steel

5.1 Introduction

Due to the high requirement of raw materials like coal and iron ore, which are primarily available in the eastern part of the country, the steel plants are also located in the eastern part. Being a core sector product, iron and steel products are freight equalized which affects the demand pattern and consequently the distribution pattern. In terms of the average lead (1987-88), iron and steel ranks third, among the nine commodities.

The average lead of iron and steel shows a fluctuating trend since 1960-61. From 877 kms in 1960-61, the lead increased to 1021 kms in 1970-71, then decreased to 1000 in 1976-77, again increased to 1099 in 1979-80. During 1983-84, the average lead reached an all time peak of 1217 kms and has been decreasing since then. In 1987-88 the average lead was 1105 kms. The trend of average lead since 1960-61 is shown in Exhibit 5.1.

5.2 Supply, Demand and Distance Data

Steel is produced by six major steel plants, five under public sector and one under private sector, and a few mini steel plants. Plantwise despatch of iron and steel to different states is given in the 'Statistical Outline of Steel Industry' by Steel Authority of India Ltd. (SAIL). Despatch data from mini steel plants is not available statewise. Hence, this data is not taken into account in the analysis. Despatch from mini steel plants amounts to only about 2%. The six major steel plants are located in Bhilai in Madhya Pradesh, Rourkela in Orissa, Bokaro and Jamshedpur in Bihar and Durgapur and Burnpur in West Bengal. In 1986-87 the production of iron and steel from these six plants was 8.77 million tonnes.

Current despatch (1986-87) from all major steel plants to a state is taken as the demand from that state. The demand for steel shows a large scale disparity among states. This, by and large is determined by the industrialization and urbanisation. More than 50% of the demand is from five states, viz., West Bengal, Uttar Pradesh, Madhya Pradesh, Maharashtra and Punjab. Plant wise despatch and demand at the states is given in Exhibit 5.2.

The major stockyard in each of the state is considered as the demand point. Actual location of the steel plants are taken as supply points. Exhibit 5.3 shows the demand and supply points. The distance between the demand and supply points is given in Exhibit 5.4.

5.3 Model Output

Bhilai supplies the entire quantity required by Goa, Maharashtra, Madhya Pradesh and part of the demand from Andhra Pradesh and Gujarat. Bokaro meets the entire demand of Bihar, Chandigarh, Delhi, Himachal Pradesh, Jammu & Kashmir, Punjab and part of the demand from Uttar Pradesh. Part of demand from West Bengal and the entire demand from the Northeast are met by the supply from Durgapur. Rourkela meets the entire demand from Karnataka and Tamil Nadu and part of the demand from Andhra Pradesh. The Burnpur plant meets the entire demand from Haryana and Rajasthan and part of the demand from Gujarat. The plant in Jamshedpur meets the entire demand from Kerala, Orissa and part of the demand from Andhra Pradesh, Uttar Pradesh and West Bengal. As per the model, the quantum of steel movement is 6994.57 million tonne kilometers. The optimal allocation pattern as per the model is given in Exhibit 5.5.

According to the optimal allocation given by the model the average lead is 798 kms and originating tonnes are 8.77 million. As per the actual data given by Railways, the average lead in 1986-87 is 1090 kms and originating tonnes are 12.33 million. The larger originating tonnes could be due to import traffic and the output from mini steel plants, not considered by the model. The larger lead reported by the railways could be due to the fact that steel, not being a single commodity, requires allocations at a disaggregate level. Thus, hot rolled coils move from Bokaro to Maharashtra, while rails move from Bhilai to Bihar, a cross movement that the model in its aggregate nature would avoid.

5.4 Empty Wagon Movement

In the first two scenarios for empty wagon movement calculations, we have assumed that the average lead is 798 kms and the tonnes originating as 8.77 million (as per the model). The empty movement in the first scenario (34.4% empty) is 182.48 million wkms/year. In the second scenario (50% empty), the empty movement is 347.99 million wkms/year. In the third and fourth scenarios, we have taken the actual average lead of 1090 kms and originating tonnes of 12.33 tonnes as given by the Railways, and empty movement at 34.4% and 50% respectively.. The empty movement in the third and fourth scenarios are 350.63 million and 668.64 million wkms/year respectvely. The wagon movement details under the four scenarios are given in the following table:

Scenario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	8.77	347.99	798	34.4	182.48	418	530.47
2	8.77	347.99	798	50.0	347.99	798	695.98
3	12.33	668.64	1090	34.4	350.63	572	1019.27
4	12.33	668.64	1090	50.0	668.64	1090	1337.28

EXHIBIT 5.1

AVERAGE LEAD FOR IRON AND STEEL

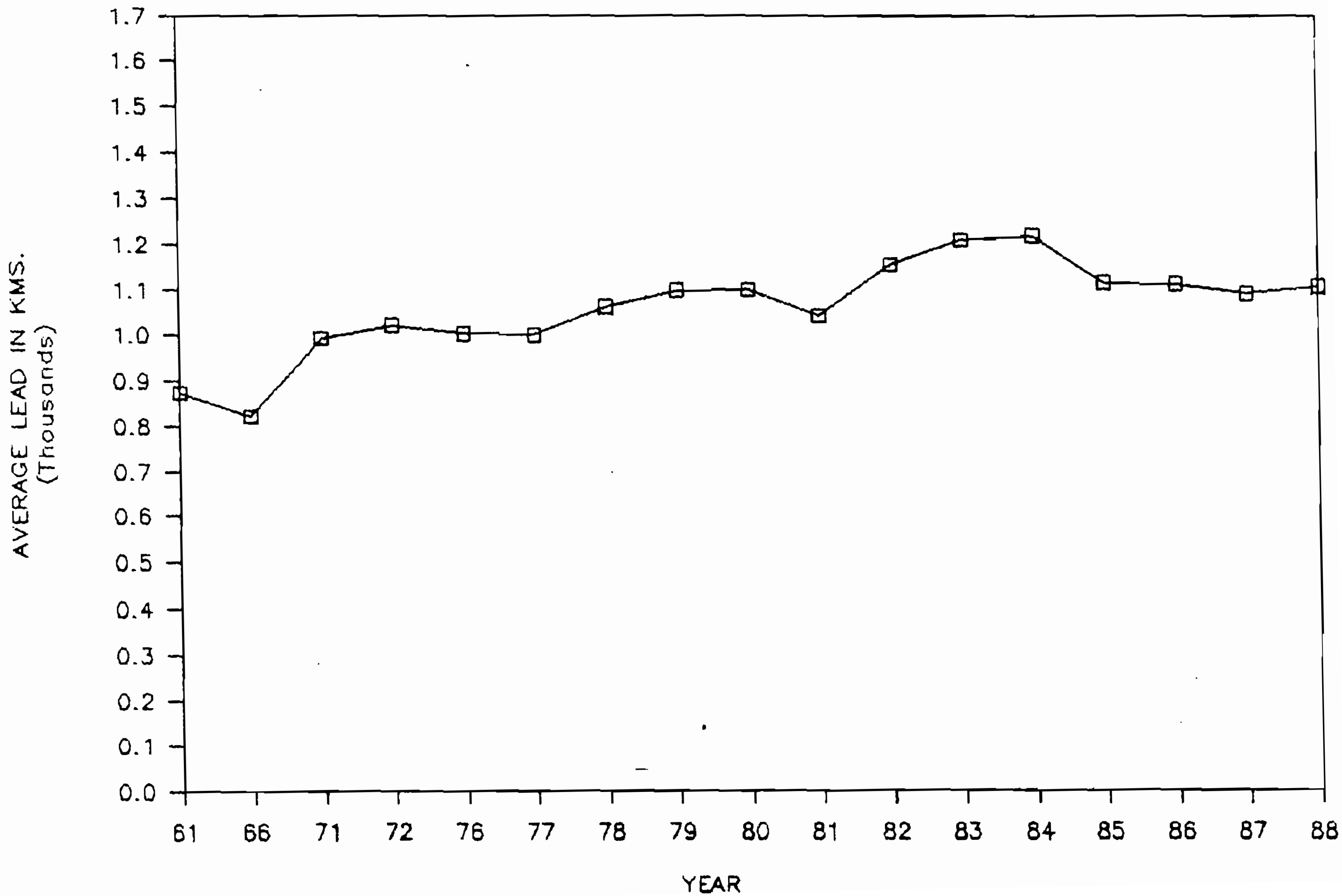


EXHIBIT 5.2

SUPPLY AND DEMAND PATTERN OF STEEL (1986-87)
(000' TONNES)

SOURCE	SUPPLY
BHILAI SP	2169
BOKARO SP	2199
DURGAPUR SP	818
ROURKELA SP	1090
IISCO	595
TISCO	1899
TOTAL	8770

STATES	DEMAND
A.P	432.27
BIHAR	366.83
CHANDIGARH	38.22
DELHI	387.14
GOA	2.40
GUJARAT	546.24
HARYANA	411.06
H.P	0.20
J&K	39.62
KARNATAKA	269.87
KERALA	51.53
MAHARASHTRA	1156.33
M.P	419.76
N.EAST	57.04
ORISSA	324.90
PUNJAB	1069.07
RAJASTAN	168.51
T.NADU	664.52
U.P	988.62
W.BENGAL	1375.86
TOTAL	8770.00

Source: Statistics about Steel, SAIL, 1987-88

Exhibit 5.3

Map Showing Demand and Supply Points
Commodity - Iron and Steel

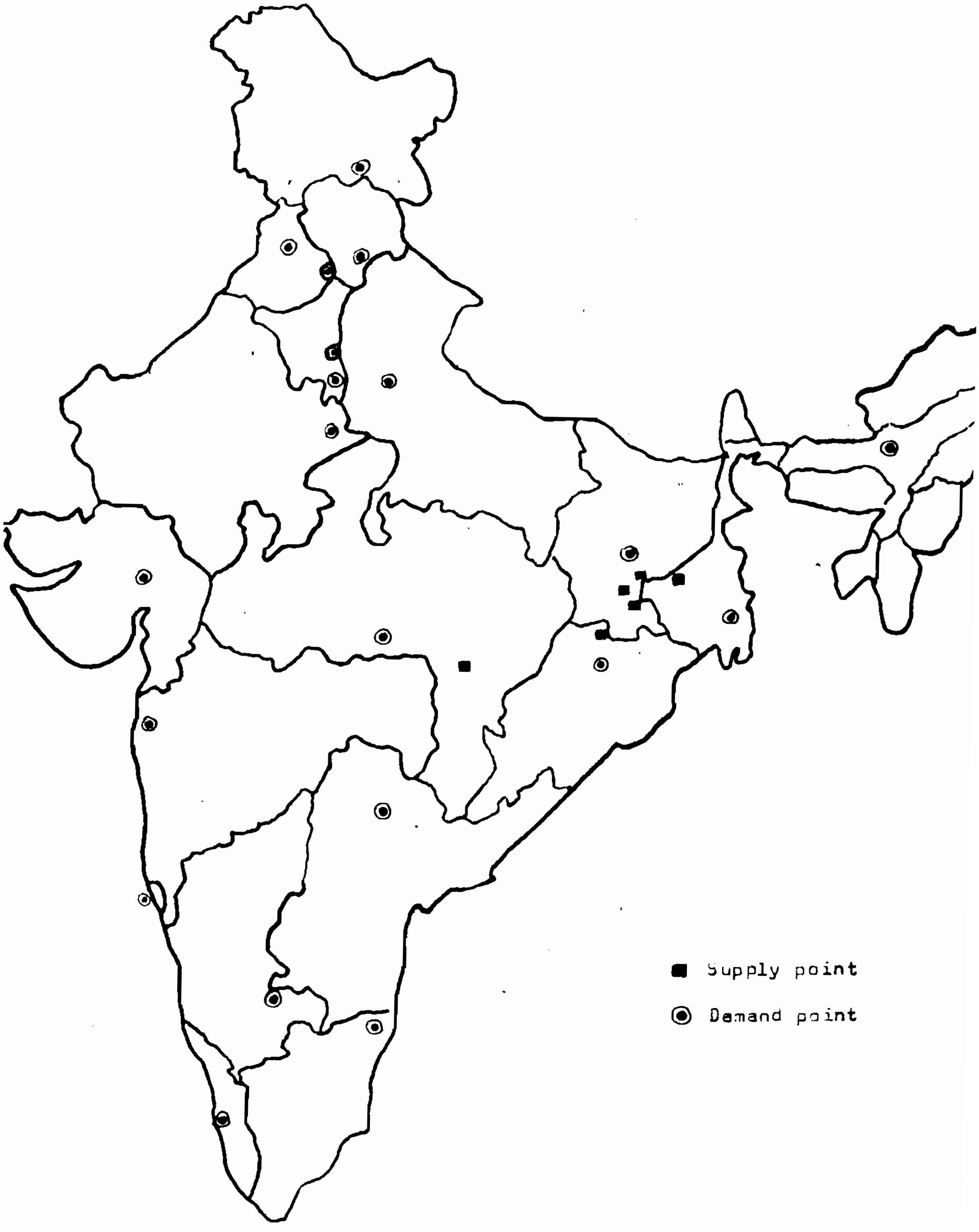


EXHIBIT 5.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF STEEL
(KMS)

SL.NO.	STATES	BHILAI	BOKARO	DURGAPUR	ROURKELA	IISCO	TISCO
1	A.P	535	915	990	712	870	870
2	BIHAR	555	75	150	240	105	150
3	CHANDIGARH	1170	1230	1305	1275	1215	1275
4	DELHI	930	1035	1125	1065	1020	1080
5	GOA	1020	1545	1635	1380	1500	1515
6	GUJARAT	900	1335	1440	1245	1290	1350
7	HARYANA	878	1020	1095	1020	990	1050
8	H.P	1170	1200	1320	1260	1200	1245
9	J&K	1410	1395	1470	1500	1380	1440
10	KARNATAKA	1005	1470	1545	1245	1425	1425
11	KERALA	1395	1860	1935	1680	1800	1800
12	MAHARASHTRA	855	1380	1485	1245	1320	1365
13	M.P	225	705	810	600	660	690
14	N.EAST	1305	825	735	1065	855	900
15	ORISSA	390	255	300	345	210	180
16	PUNJAB	1260	1350	1425	1395	1335	1395
17	RAJASTHAN	750	945	1035	930	915	975
18	T.NADU	1005	1425	1485	1230	1380	1725
19	U.P	810	900	975	930	885	930
20	W.BENGAL	735	270	180	360	300	255

EXHIBIT 5.5

OPTIMAL ALLOCATION OF STEEL
(000' TONNES)

SL.NO.	DEFICIT STATES	BHILAI	BOKARO	DURGAPUR	ROURKELA	IISCO	TISCO	TOTAL DEMAND
1	A.P	59.70			155.61		216.96	432.0
2	BIHAR		366.83					367.0
3	CHANDIGARH		38.22					38.0
4	DELHI		387.14					387.0
5	GOA	2.40						2.4
6	GUJARAT	530.81				15.43		546.0
7	HARYANA					411.06		411.0
8	H.P		0.20					0.2
9	J&K		39.62					40.0
10	KARNATAKA				269.87			270.0
11	KERALA						51.53	52.0
12	MAHARASHTRA	1156.33						1156.0
13	M.P	419.76						420.0
14	N.EAST			57.04				57.0
15	ORISSA						324.90	325.0
16	PUNJAB		1069.07					1069.0
17	RAJASTHAN					168.51		169.0
18	T.NADU				664.52			665.0
19	U.P		297.92				690.70	989.0
20	W.BENGAL			60.96			614.90	1376.0
	TOTAL SUPPLY	2169.00	2199.00	818.00	1090.00	595.0	1899.00	8770.0

TOTAL TKMS : 6995 million.
AVG. LEAD : 798 kms.

Chapter VI

Fertiliser

6.1 Introduction

Fertiliser movement by railways is gaining importance which is reflected in the relatively higher rank of this commodity in terms of tonnes originating, tonne kms and earnings during 1987-88 as compared to 1983-84. In terms of average lead, this ranks fourth. Fertilizer production and distribution is shared jointly by the public sector, cooperatives and private retail trade. Production and distribution of fertilizer is controlled by various regulations like the Essential Commodities Act (ECA), Fertilizer Control Order (FCO) and Fertilizer Movement Control Order.

The difficulty in the distribution of fertilizer at the appropriate time arises out of the seasonal demand for this commodity and the market spread in rural areas with inadequate means of transportation. This market spread over time and space makes the logistics of fertilizer more complicated. It is estimated that 62% of the tonnes originating move by rail. The tkms share by Railways is about 85%. This difference is due to the movement from the rail head to rural areas and from the production sites to rail heads by road. Till the mid seventies, Railways allowed piecemeal movement of fertilizer but later on they insisted on point to point rake movement.

The average lead since 1965-66 shows that from 752 kms, it reached a low of 630 kms in 1968-69 and increased steadily to 1126 kms in 1979-80, except for a small decrease during 1973-74. During 1979-80 to 1982-83, the lead decreased by 157 kms to 969 kms and then increased to 1098 kms in 1984-85. In 1987-88, the average lead was 1089 kms. Exhibit 6.1 shows the lead pattern.

6.2 Supply, Demand and Distance Data

During 1986-87, the production of fertilizer was around 20.18 million tonnes. Fertilizer is produced in almost all the states but there is large scale variation in the quantity produced. The surplus states identified are Andhra Pradesh, Kerala, Tamil Nadu, North east, Gujarat, Maharashtra, Goa, Rajasthan and Haryana. Of these, 52% of the surplus is concentrated in the southern states. The deficit states are Karnataka, Pondichery, Bihar, Orissa, West Bengal, Madhya Pradesh, Chandigarh, Punjab, Himachal Pradesh, Jammu & Kashmir, Delhi and Uttar Pradesh. Out of these 12 states, three eastern states, viz. Bihar, Orissa and West Bengal together account for 62% of the deficit.

Despatch data is available nutrient-wise and material-wise. Statewise consumption data is given nutrient-wise. Material quantity to nutrient ratio obtained from the despatch data, is used to convert the nutrient-wise consumption data for each state into material quantity. The total consumption data so obtained is less than the actual despatch data by 978000 tonnes. This difference is added to the consumption figure statewise using the proportion of original consumption figure. Movement of imported fertilizer is not taken into account. The data regarding despatch (used for supply), consumption (used for demand), surplus and deficit, statewise are given in Exhibit 6.2.

The supply point in a state is the location which has the maximum number of fertilizer plants. The demand point in a state is the center of the predominant agricultural region. Exhibit 6.3 gives the statewise location of the demand and supply points. The distances between demand and supply points are given in Exhibit 6.4.

6.3 Model Output

The optimal allocation pattern given by the model is as follows: Kerala meets the entire demand from Karnataka. Supply for Pondichery comes from Tamil Nadu. Demand at Bihar is met by the supply from Tamil Nadu and Maharashtra. The supply for Orissa comes from Andhra Pradesh, Kerala and Tamil Nadu. Demand at West Bengal is satisfied by the supply from Andhra Pradesh and Northeast. Supply to Madhya Pradesh comes from Gujarat, Maharashtra and Goa. Demand at Punjab is met by the supply from Tamil Nadu. The entire demand from Chandigarh is met by the supply from Rajasthan and Haryana meets the entire demand from Himachal Pradesh, Jammu & Kashmir and Delhi. The demand at Uttar Pradesh is met by the supply from Gujarat, Goa and Haryana. The optimal allocation pattern as per the model is given in Exhibit 6.5.

The originating tonnes for rail movement as per the optimal allocation pattern are 1.22 million. The tonne kilometers are 1192.13 million. As per this the average lead works out to be 979 kms. The actual originating tonnes as per the Railways in 1986-87 are 14.50 million. The tonne kilometers are 15558.4 million. The lead is 1073 kms. There is a significant difference between the originating tonnes that the model considers and the actual reported by railways. This could be due to (i) intrastate movement also taking place by rail, and (ii) double counting of fertiliser movement by rail as it moves from factory to stocking point and then from stocking point to wholesale warehouses. Such considerations should reflect in a smaller lead for the actual data, which is not true. This is possibly due to (i) the multicommodity nature of fertiliser, requiring allocations at the disaggregate level, (ii) forced cross movements due to government control on fertiliser distribution and (iii) rail movement distances being longer than straight line distances.

6.4 Empty Wagon Movement

The empty wagon movement under the first scenario (model data and 34.4% empty movement) is 31.10 million wkms/year. Under the second scenario (model data and 50% empty movement) the empty movement will be 59.31 wkms/year. The empty movement in the third scenario (actual rail data and 34.4% empty movement) is 405.90 million wkms/year and in the fourth scenario (actual rail data and 50% empty movement) the empty movement is 774.05 wkms/year. The wagon movement details under the four scenarios are shown in the following table:

Scen-ario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	1.22	59.31	977	34.4	31.10	512	90.41
2	1.22	59.31	977	50.0	59.31	977	118.62
3	14.50	774.05	1073	34.4	405.90	563	1179.95
4	14.50	774.05	1073	50.0	774.05	1073	1548.10

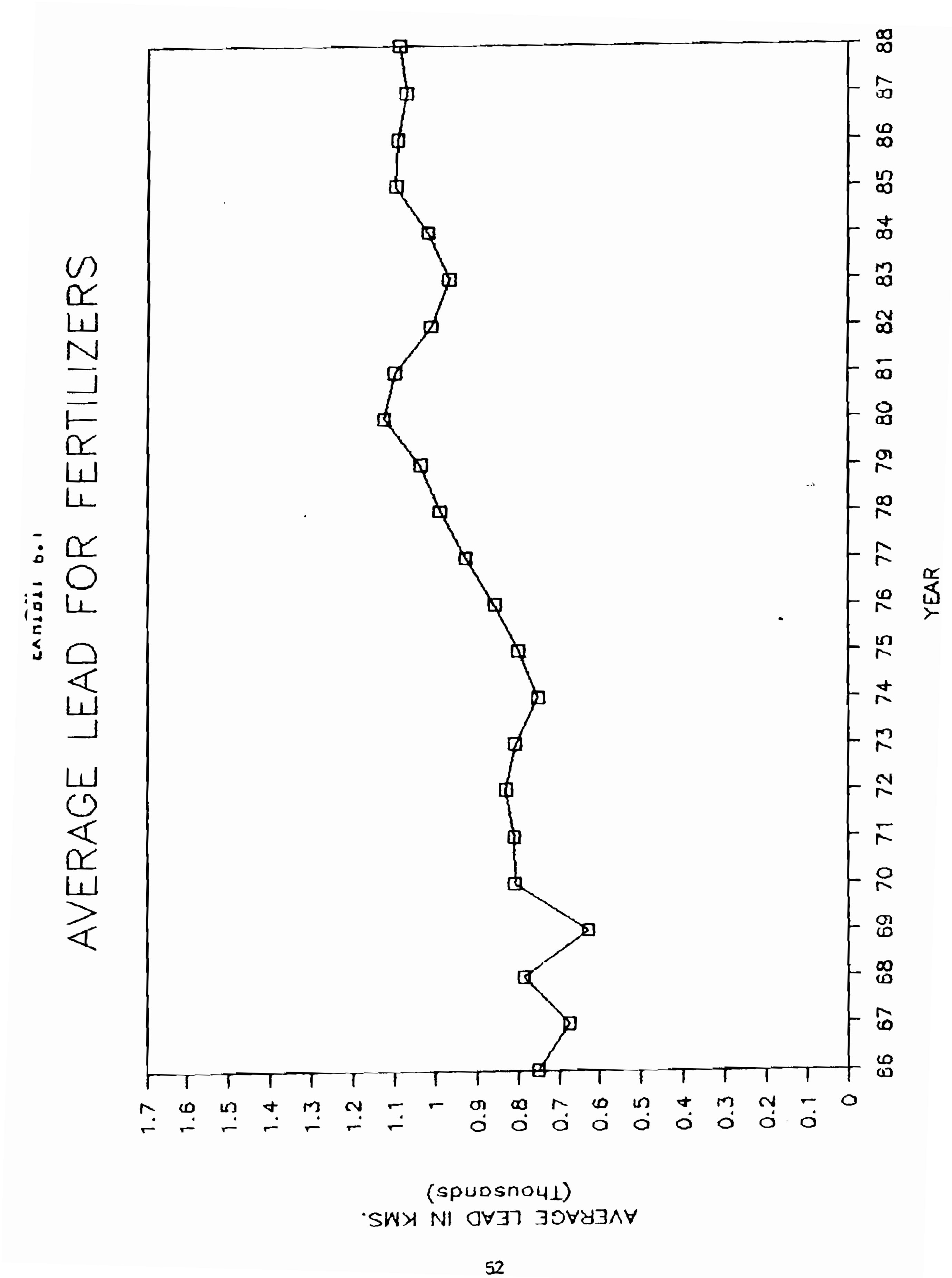


EXHIBIT 6.1
AVERAGE LEAD FOR FERTILIZERS
AVERAGE LEAD IN KMS.
(Thousands)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
YEAR

EXHIBIT 6.2

SUPPLY AND DEMAND PATTERN OF FERTILISER (1987-88)
(000' TONNES)

SL.NO.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	A.P	2227.881	2103.325	124.556	
2	KARNATAKA	1267.188	1295.618		28.430
3	KERALA	383.001	340.058	42.943	
4	TAMIL NADU	1954.863	1488.417	466.446	
5	PONDICHERY	22.808	37.859		15.051
6	BIHAR	860.838	1230.498		369.660
7	ORISSA	29.078	295.111		266.033
8	W.BENGAL & SIK	1007.096	1131.051		123.955
9	N.EAST	112.861	79.122	33.739	
10	GUJARAT	990.902	934.626	56.276	
11	M.P	1211.222	1322.827		111.605
12	MAHARASHTRA	1783.654	1577.837	205.817	
13	GOA	10.870	8.416	2.454	
14	RAJASTHAN	661.945	560.937	101.008	
15	HARYANA	1135.297	950.578	184.719	
16	CHANDIGARH	.113	2.076		1.963
17	PUNJAB	2587.997	2602.617		14.620
18	H.P	61.144	92.440		31.296
19	J & K	58.732	59.867		1.135
20	DELHI	11.736	23.127		11.391
21	U.P	3797.706	4040.524		242.818
TOTAL		20176.932	20176.932	1217.957	1217.957

Source: Fertiliser Statistics, 1988-89.

Exhibit 6.3

Map Showing Demand and Supply Points
Commodity - Fertilizer

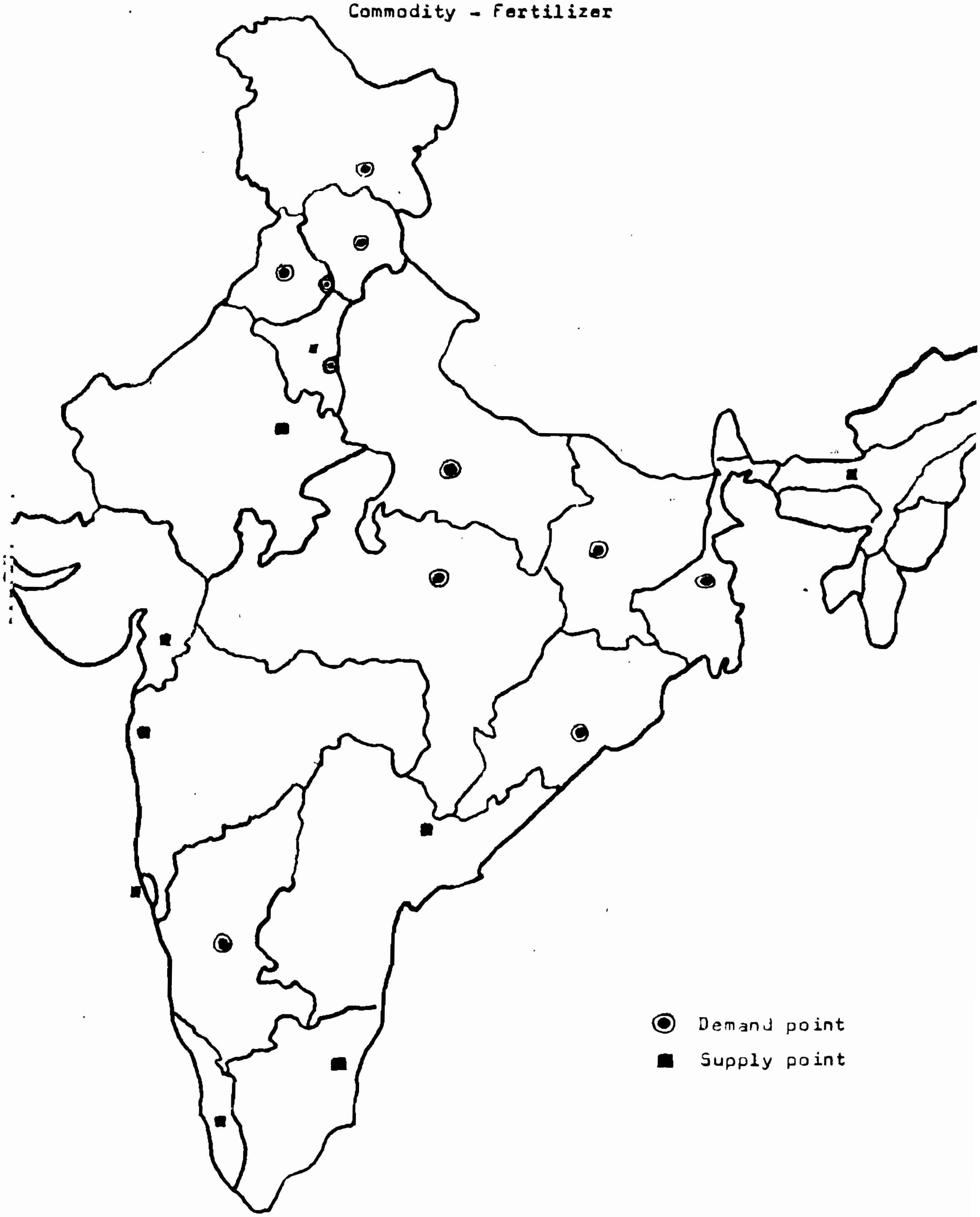


EXHIBIT 6.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF FERTILISER
(KMS)

SL.NO.	DEFICIT STATES	SURPLUS STATES								
		A.P	KERALA	T.NADU	N.EAST	GUJ-ARAT	MAHAR-ASHTRA	GOA	RAJA-STHAN	HAR-YANA
1	KARNATAKA	615	495	465	2190	1275	623	585	1425	1710
2	PONDICHERY	465	390	300	2190	1275	1095	1065	1800	2055
3	BIHAR	1140	1890	1560	720	1350	1350	1395	915	945
4	ORISSA	480	1140	1110	1140	170	1200	1215	1185	1305
5	W.BENGAL	1020	1980	1650	615	1500	1620	1635	1245	1245
6	M.P	675	1620	1350	1140	795	945	975	600	750
7	PUNJAB	1395	2370	705	1695	1020	1350	1410	450	225
8	CHANDIGARH	1560	2355	2160	1620	1110	1470	1410	450	165
9	H.P	1620	2445	2265	1695	1200	1485	1530	540	330
10	J & K	1860	2685	2490	1875	1440	1710	1740	765	465
11	DELHI	1320	2145	1935	1470	915	1185	1215	240	75
12	U.P	1005	1920	1665	1080	930	1125	1185	465	495

EXHIBIT 6.5

OPTIMAL ALLOCATION OF FERTILISER
(000'TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES									TOTAL DEMAND
		A.P	KERALA	T.NADU	N.EAST	GUJARAT	MAHARASHTRA	GOA	RAJASTHAN	HARYANA	
1	KARNATAKA		28430								28430
2	PONDICHERY			15051							15051
3	BIHAR			232252			137408				369660
4	ORISSA	34339	14513	217180							266032
5	W.BENGAL	90216			33739						123955
6	M.P					40743	68409	2454			111686
7	PUNJAB			1963							1963
8	CHANDIGARH								14620		14620
9	H.P									31296	31296
10	J & K									1135	1135
11	DELHI									11391	11391
12	U.P					15533		101008		126277	242818
	TOTAL SUPPLY	124555	42943	466446	33739	56276	205817	103462	14620	170099	1217957

TOTAL TKMS : 1192 million.
AVG. LEAD : 979 kms.

Chapter VII

Cement

7.1 Introduction

Cement, a major input in the construction activity is produced in areas which possess the basic raw material of cement grade limestone, mostly in the southern and western states. Cement production is heavily dependent on other major inputs like coal and power. More than 50% of the product is transported by Railways. Availability of wagons is very crucial for this industry since it affects both, the supply of coal as a input and despatch of cement.

As per the 1956 Industries Act, cement price and distribution was brought under Government control since it was a crucial input for defence and similar priority requirements. The producers did not have any involvement in the distribution pattern of cement. The average lead went up steadily till 1975-76 (Exhibit 7.1). During 1976-77, the average lead went down and then again it increased till 1982-83. In 1982, the government introduced partial decontrol of cement by which the producers were allowed to sell their products in the open market. The average lead dropped from 781 kms in 1982-83 to 651 kms in 1988-89. The sudden decrease in the average lead suggests that the distribution pattern has become more efficient due to partial decontrol.

In the current year (1988-89), the government has lifted all controls on pricing and distribution of cement. Due to this decontrol, the lead is likely to come down again since otherwise the transportation cost would reduce the manufacturer's profit. Of course, a few manufacturers may also move into distant markets, depending on their brand image and production capacity, though the effect on lead due to this is not expected to be significant. The trend in average lead for cement since 1960-61 is shown in Exhibit 7.1.

7.2 Supply, Demand and Distance Data

The major cement producing states are Madhya Pradesh, Rajasthan and Andhra Pradesh, together accounting for 50% of the production. Total production in the country in 1988 was about 40 million tonnes. Since the partial decontrol on cement in 1982, the production has increased considerably leading to excess supply at present (PTI Eco. Service, February 15, 1989). There are 94 cement manufacturing units in India. Companywise production and despatch data are published in the journal 'Cement' by Cement Manufacturers' Association (CMA). Statewise despatch data has been used to obtain statewise supply.

Demand details at a state level are not readily available. Since despatch is a function of demand, we have used the percapita despatch for the country as a norm to estimate statewise demand. This assumes that cement is uniformly consumed, as a function of population. Consequently, the major consumption points are Uttar Pradesh, Bihar, Maharashtra, West Bengal, Andhra Pradesh and Madhya Pradesh accounting for about 59% of the total demand. Exhibit 7.2 gives the statewise production and demand for cement along with the cement surplus and deficit states. The surplus states identified are Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Tamil Nady, Karnataka and Himachal pradesh. The deficit states are Uttar Pradesh, Bihar, West Bengal, North East, Kerala, Punjab, Maharashtra, Orissa, Delhi, Jammu & Kashmir, Haryana, Goa and Chandigarh.

There are many production centers scattered within a state. To calculate the distance, we have taken the center of major concentration of cement plants in every cement surplus state as the supply point. Similarly, we have taken a point closer to major concentration of urban centers as the demand point in a cement deficit state. Exhibit 7.3 gives a map which identifies these points. The distance between demand and supply points is given in Exhibit 7.4.

7.3 Model Output

The allocation pattern as per the model is given in Exhibit 7.4. The supply pattern is as follows:

- Karnataka supplies to Goa, Maharashtra and Orissa.
- Tamil Nadu supplies to Kerala and West Bengal.
- Madhya Pradesh supplies to Uttar Pradesh, Bihar, West Bengal and Chandigarh.
- Gujarat supplies to Haryana, Punjab and Chandigarh.
- Rajasthan supplies to Delhi and Uttar Pradesh.
- Himachal Pradesh supplies to Punjab, Chandigarh and Jammu & Kashmir.

The average lead as per the model is 573 kms whereas the actual lead recorded is 652 kms. This could be due to three reasons: (1) the allocation in this case is the most efficient; (2) the actual distance will be more - we had taken straight line distances; (3) actual consumption pattern may be different from what we have taken based on per capita consumption for the country.

As per the Indian Railways annual report for 1987-88 the tonnes originating is 22.32 million tonnes, about 6.83 million tonnes more than what the model estimate of 15.49 million tonnes. The actual rail despatch works out to be 59.7% of the total despatch (37.34 million tonnes). According to CMA estimates, 51.02% of the total despatch goes by rail. As per the model, 41.5% is sent by rail. To account for these differences, at least somewhere in between the Railways' and CMA estimates, we assumed that 50% of intrastate movement in large states (Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra and Uttar Pradesh) goes by rail, i.e. another 5.73 million tonnes. Taking this into account, the tonnes originating works out to 21.21 million tonnes.

The subsequent calculations on empty wagon kilometers were done using this figure of originating tonnes and a lead of 573 kilometers (since this lead is not unreasonable for the intrastate movement). Such an adjustment is done for cement, since in a deregulated market, it was felt that the industry estimates would be close to the desired effeciency.

7.4 Empty Wagon Movement

Based on the reported originating tonnes and lead of the Railways and the model estimated originating tonnes and lead, and the 34% and 50% empty movement assumptions, empty and total wagon movement kilometers per year for transportation of cement are calculated:

Scen-ario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	21.21	605.00	573	34.4	317.26	301	922.26
2	21.21	605.00	573	50.0	605.00	573	1210.00
3	22.32	723.48	652	34.4	379.39	342	1102.87
4	22.32	723.48	652	50.0	723.48	652	1446.96

EXHIBIT 7.1

AVERAGE LEAD FOR CEMENT

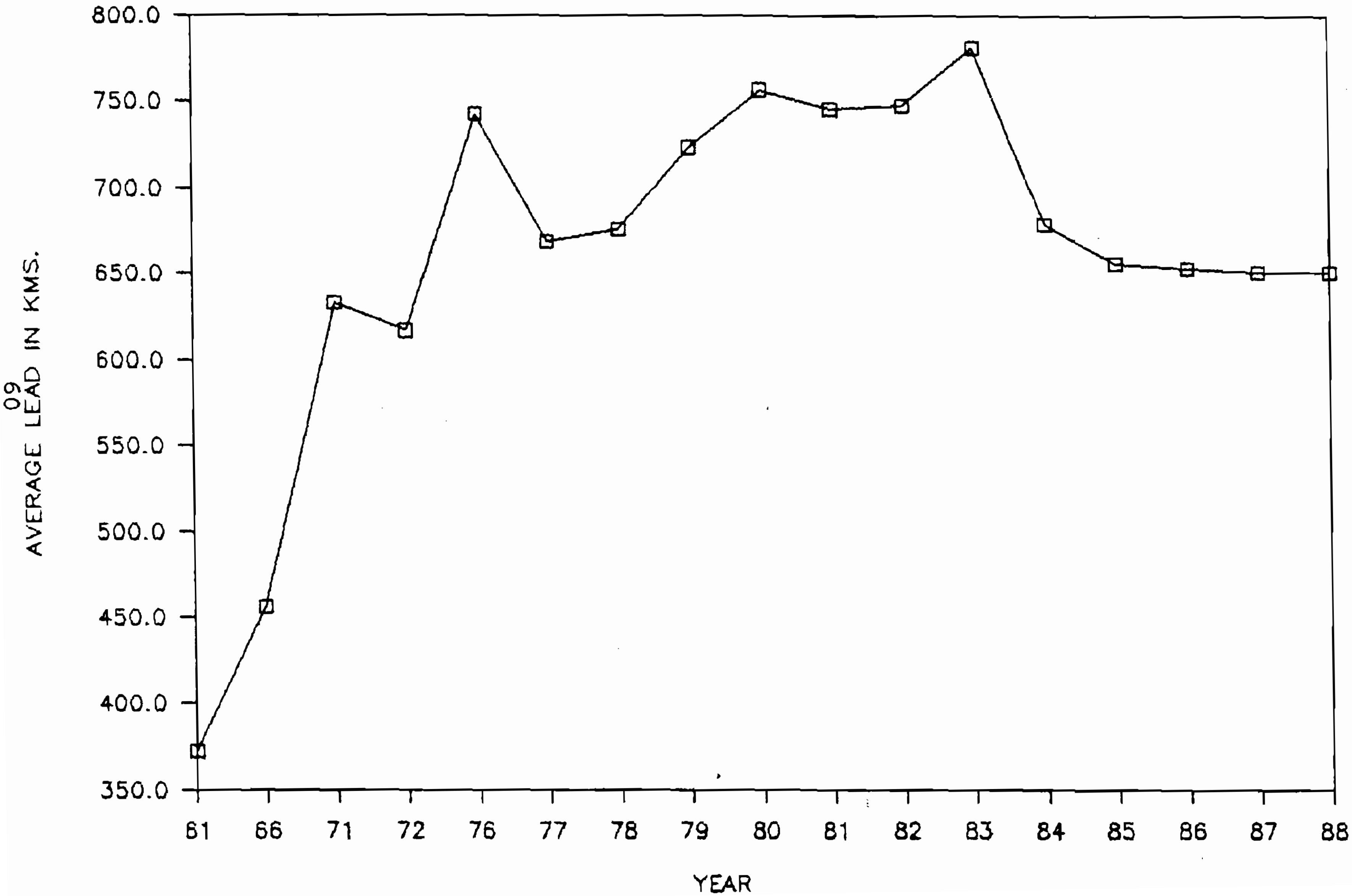


EXHIBIT 7.2

SUPPLY AND DEMAND PATTERN OF CEMENT (1987-88)
(000' TONNES)

SL.NO.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT	INTRA-STATE RAIL MOVMT
1	A.P	4617	2899	1718		1449
2	KARNATAKA	3203	2041	1162		1020
3	KERALA	386	1341		955	
4	TAMILNADU & Po	3773	2557	1216		
5	BIHAR	1191	3792		2601	
6	ORISSA	871	1393		522	
7	W.BENGAL & SIK	405	2962		2557	
8	N.EAST	267	1539		1272	
9	GUJARAT	3310	1879	1431		
10	M.P	9797	2852	6945		1426
11	MAHARASHTRA	2528	3416		888	1264
12	GOA		59		59	
13	RAJASTHAN	4301	1940	2361		
14	HARYANA	533	714		181	
15	CHANDIGARH		31		31	
16	PUNJAB		901		901	
17	H.P	875	228	647		
18	J & K	142	335		193	
19	DELHI		389		389	
20	U.P	1146	6077		4931	573
	TOTAL	37345	37345	15481	15481	5732

Source: Statistical Outline of India, CSO, 1987-88.

Exhibit 7.3

Map Showing Demand and Supply Points
Commodity - Cement

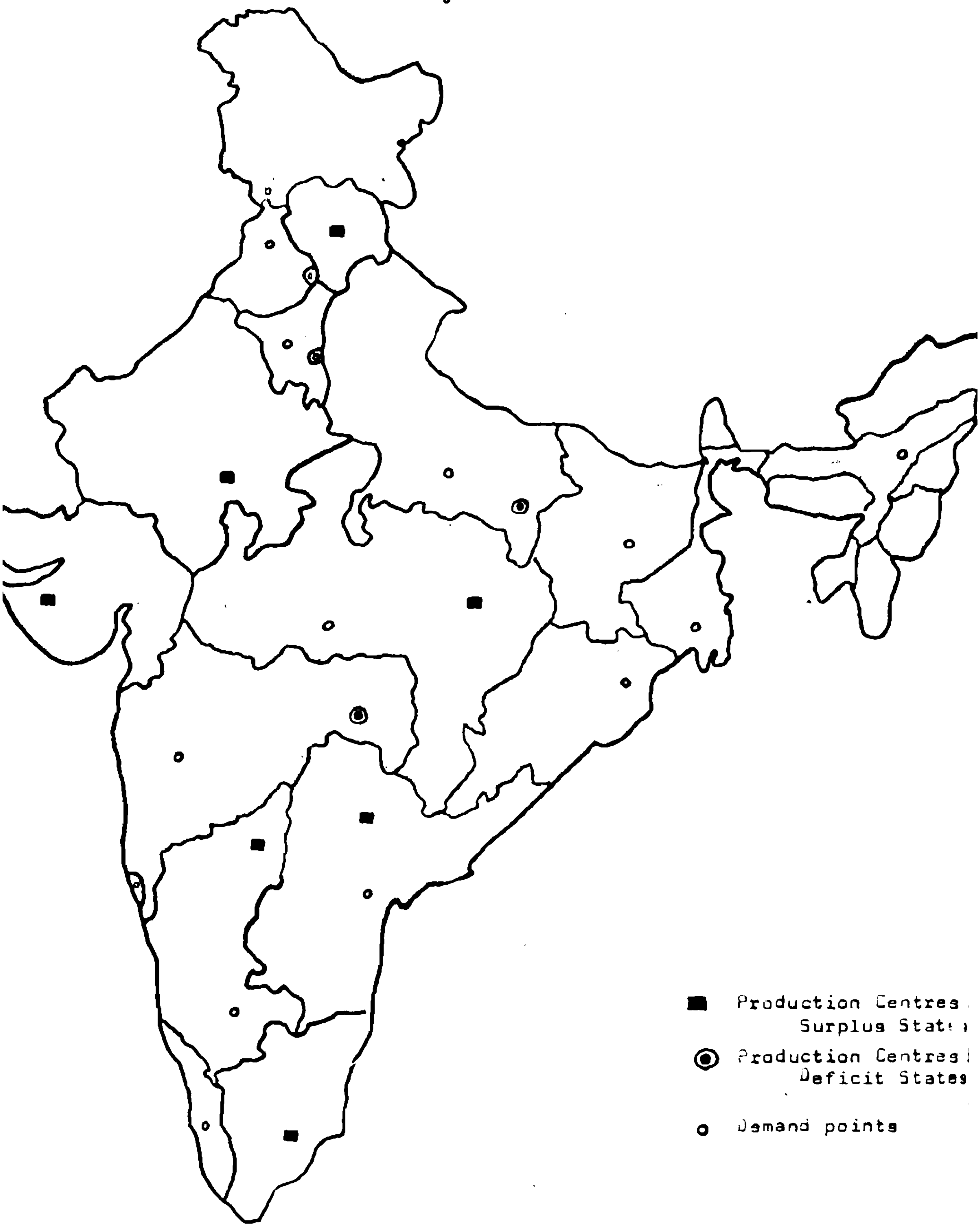


EXHIBIT 7.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF CEMENT
(KMS)

SL. NO.	DEFICIT STATES	SURPLUS STATES						
		KARNATAKA	A.P	T.NADU	M.P	GUJARAT	RAJASTHAN	H.P
1	KERALA	735	900	225	1545	1650	1710	2400
2	GOA	345	600	765	1155	975	1095	1815
3	MAHARASHTRA	345	525	1020	900	675	780	1500
4	ORISSA	1065	795	1530	495	1560	1200	1380
5	DELHI	1350	1260	2100	750	1005	435	330
6	HARYANA	1380	1290	2100	825	975	420	315
7	PUNJAB	1650	1575	2385	1080	1155	660	150
8	CHANDIGARH	1575	1485	2295	960	1140	600	120
9	U.P	1140	960	1815	360	1125	570	705
10	J & K	1800	1740	2550	1230	1290	825	210
11	BIHAR	1260	1020	1800	465	1575	1065	1155
12	W.BENGAL	1320	1035	1725	660	1770	1335	1545
13	NORTH EAST	2115	1860	2640	1290	2370	1815	1755

EXHIBIT 7.5

OPTIMAL ALLOCATION OF CEMENT
(000'TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES: KARNATAKA	A.P	T.NADU	M.P	GUJARAT	RAJASTHAN	H.P	TOTAL DEMAND
1	KERALA			955					955
2	GOA	59							59
3	MAHARASHTRA	888							888
4	ORISSA	215	307						522
5	DELHI						389		389
6	HARYANA					181			181
7	PUNJAB					478		422	901
8	CHANDIGARH							31	31
9	U.P				2188	772	1972		4931
10	J & K							193	193
11	BIHAR				2601				2601
12	WEST BENGAL		1411	261	885				2557
13	NORTH EAST				1272				1272
	TOTAL SUPPLY	1162	1718	1216	6945	1431	2360	646	15481

TOTAL TKMS : 8871 million.
AVG. LEAD : 573 kms.

Chapter VIII

Coal

8.1 Introduction

More than 40% of the originating tonnes of rail movement is due to coal in 1988-89. Coal also ranks first in terms of tonne kilometers and earnings. At the same time, due to the priority given to coal as an essential commodity for the country's development because of its use as a raw material for the steel industry and thermal power plants, the transport of coal by rail is subsidised.

The average lead of coal has increased from 558 kms in 1950-51 to 646 kms in 1988-89. It had registered a peak of 664 kms in 1960-61 and since then has been fluctuating marginally. Exhibit 8.1 shows the lead pattern graphically. Much of the coal is consumed in the region of the collieries, as can be seen in the lead data for the coal meant for the steel plants. The lead is not expected to increase since the future location of thermal power plants is planned closer to the collieries. This is because the transport of power is cheaper than the transport of coal, given the well developed power grid.

8.2 Supply, Demand and Distance Data

Production of coal in India takes place mainly in the eastern parts. Bihar, M.P. and West Bengal together account for 71% of the production. Andhra Pradesh, Maharashtra, Orissa, Uttar Pradesh and the Northeast are the other coal producing states. Tamil Nadu, Gujarat and J&K produce lignite and peat. To arrive at the surplus and deficit states, all forms of coal are considered as substitutable. Power plants are the major consumer of coal, followed by steel plants and cement industries. Steel plants are located close to the coal mines and hence the transportation effort needed is not much. Thermal power plants and cement factories, which also require coal, are spread all over the country. According to Coal India's assessment in 1987, about 63% of the total coal, which needs transportation, goes by Rail. The statewise supply, demand, surplus and deficit for 1986-87 are given in Exhibit 8.2. A map showing the supply and demand points is given in Exhibit 8.3.

The supply centre in each state is located considering the actual location of coal mines. The demand centre in a state is taken as the middle point of the most urbanised region except in cases where there are steel plants. In such situations, the demand centre is weighted towards the steel plant location. Exhibit 8.4 gives the distance matrix between the supply and demand centres.

8.3 Model Output

Bihar supplies coal to Punjab, Himachal Pradesh, and Delhi. Madhya Pradesh supplies to Haryana and Rajasthan. West Bengal supplies to the Northeast, Punjab and Chandigarh. Andhra Pradesh supplies to Rajasthan and Gujarat. Maharashtra supplies to Rajasthan. Orissa supply to Delhi and Rajasthan. Uttar Pradesh supplies to Punjab. Tamil Nadu supplies to Gujarat, Karnataka and Kerala. A small amount is supplied by J&K to Punjab. The supply from Tamil Nadu rather than to it (which is true in reality) is because lignite is treated as substitutable for coal. The allocation pattern is given in Exhibit 8.5.

Average lead as per railway data during 1986-87 is 659 kms, whereas as per the model, the average lead is 1445 kms. This is due to large quantities of short distance intra-state movement taking place by Rail, and the non-substitutablity of products like regular coal, coking coal and lignite/peat resulting in required cross movement, which the model does not consider. The tonnes originating as per the model is 25.28 million, while as per the Railway data, it is 109.50 million tonnes. The tonne kilometers transported as per the model is 36544.92 million, while according to the Railways, it is 71613.00 million.

8.4 Empty Wagon Movement

In the first two scenarios for empty wagon movement calculations, we have assumed that the average lead is 1445 kms and the tonnes originating as 25.28 million (as per the model). The empty movement in the first scenario (34.4% empty) is 953.02 million wkms/year. In the second scenario (50% empty), the empty movement is 1817.39 million wkms/year. In the third and fourth scenarios, we have taken the actual average lead of 659 kms and originating tonnes of 109.50 tonnes as given by the Railways, and empty movement at 34.4% and 50% respectively. The empty movement in the third and fourth scenarios are 1882.60 million and 3590.07 million wkms/year respectvely. The wagon movement details under the four scenarios are given in the following table:

Scenario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	25.28	1817.39	1445	34.4	953.02	758	2770.41
2	25.28	1817.39	1445	50.0	1817.39	1445	3634.78
3	109.50	3590.07	659	34.4	1882.60	346	5472.67
4	109.50	3590.07	659	50.0	3590.07	659	7180.14

EXHIBIT 8.1

AVERAGE LEAD FOR COAL

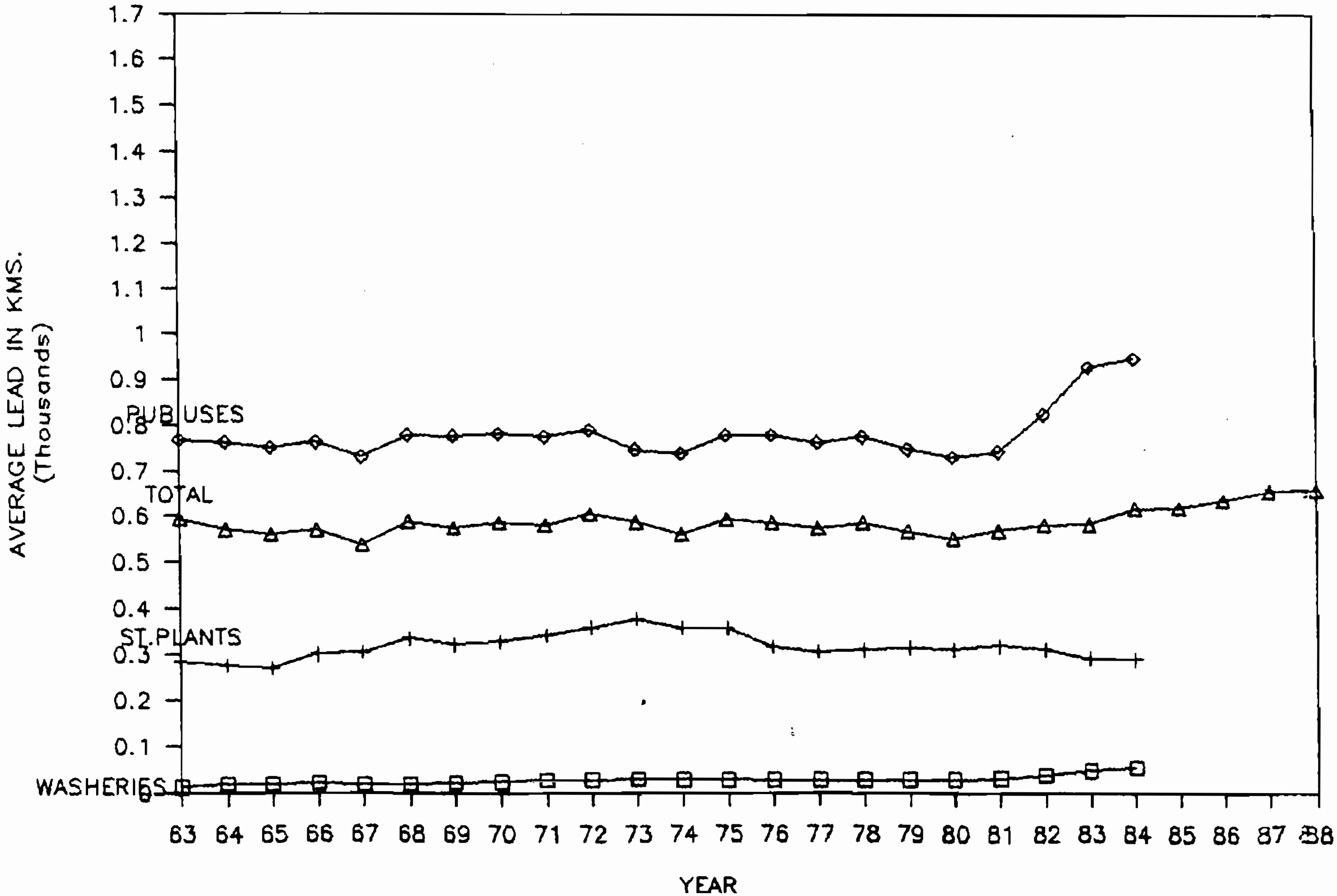


EXHIBIT 8.2

SUPPLY AND DEMAND PATTERN OF COAL (1986-87)
(000' TONNES)

SL.NO.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	A.P	16200	12277	3923	
2	BIHAR	58200	48907	9293	
3	CHANDIGARH		20		20
4	DELHI		5042		5042
5	GUJARAT	1000	2955		1855
6	HARYANA		1122		1122
7	H.P		231		231
8	J & K	28	20	8	
9	KARNATAKA		264		264
10	KERALA		189		189
11	MAHARASHTRA	11900	10264	1636	
12	M.P	41297	37938	3359	
13	N.EAST	900	2274		1374
14	ORISSA	6900	4428	2472	
15	PUNJAB		8091		8091
16	RAJASTHAN		7095		7095
17	T.NADU	6900	5676	1224	
18	U.P	4600	3421	1179	
19	W.BENGAL	20000	17812	2188	
	TOTAL	168025	168025	25282	25282

Source: Basic Statistics relating to Indian Economy, CMIE, Sept.1987.

Exhibit 8.3

Map Showing Demand and Supply Points
Commodity - Coal

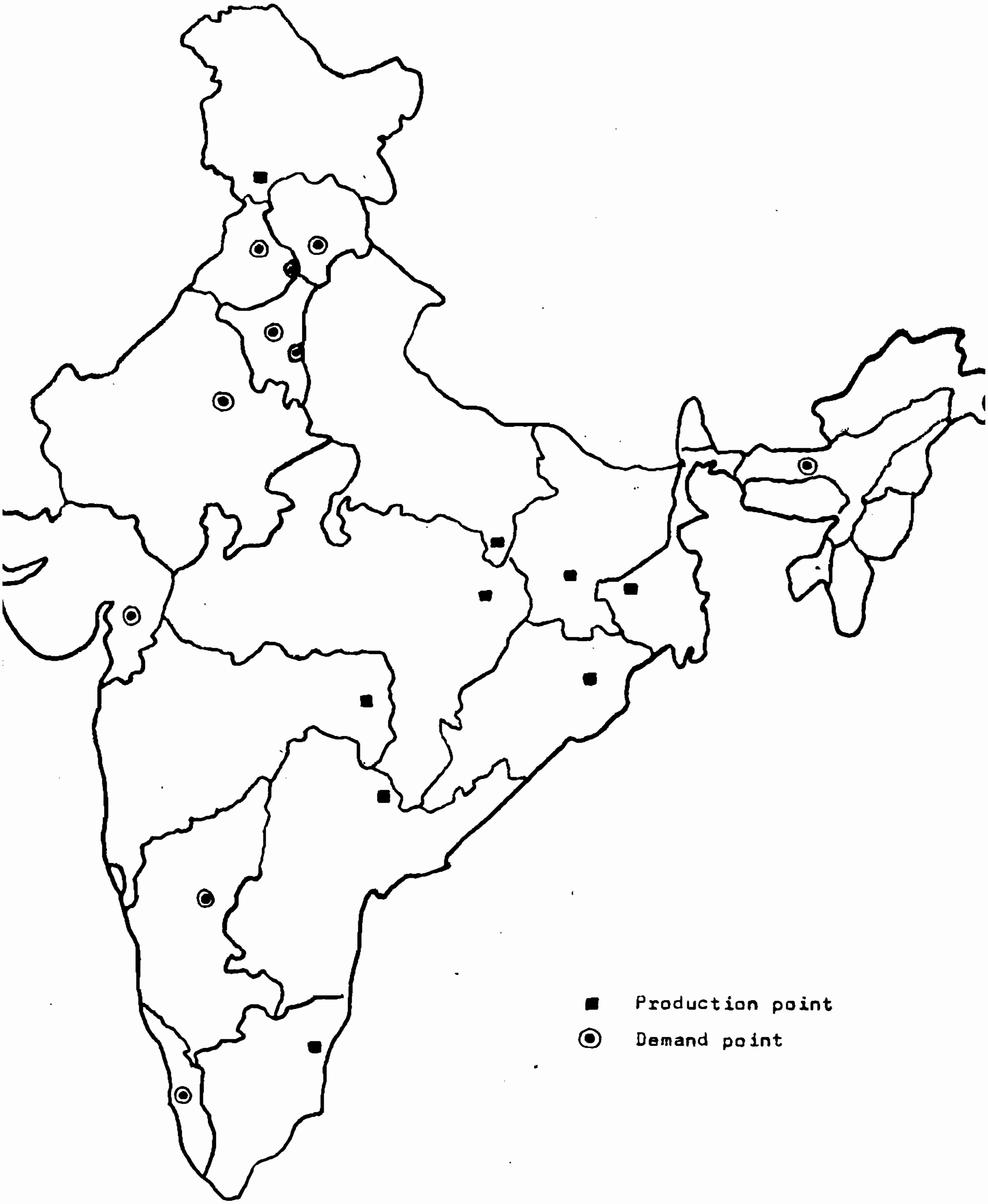


EXHIBIT 8.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF COAL
(KMS)

DEFICIT STATES	SURPLUS STATES								
	A.P	BIHAR	J&K	MAHARASHTRA	M.P	ORISSA	T.NADU	U.P	W.BENGAL
CHANDIGARH	2000	1560	380	1640	1420	1900	2880	1280	1720
DELHI	1680	1320	680	1360	1160	1640	2580	1040	1520
GUJARAT	1160	1640	1700	940	1300	1720	1740	1380	1840
HARYANA	1780	1440	580	1420	1260	1760	2640	1140	1620
H.P	2060	1560	340	1700	1460	1900	2960	1280	1760
KARNATAKA	760	1800	2700	940	1520	1620	680	1700	1940
KERALA	1340	2380	3400	1600	2140	2140	520	2340	2460
N.EAST	1980	960	2300	1840	1260	1100	2800	1160	760
PUNJAB	2100	1700	280	1740	1540	2020	2960	1400	1890
RAJASTHAN	1600	1460	840	1240	1220	1720	2420	1140	1660

EXHIBIT 8.5

OPTIMAL ALLOCATION OF COAL (1986-87)
(000' TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES A.P	BIHAR	J&K	MAHARASHTRA	M.P	ORISSA	T.NADU	U.P	W.BENGAL	TOTAL DEMAND
1	CHANDIGARH		20								20
2	DELHI		69			3211			1179	583	5042
3	GUJARAT	1084						771			1855
4	HARYANA		1122								1122
5	H.P								231		231
6	KARNATAKA							264			264
7	KERALA							189			189
8	N.EAST									1374	1374
9	PUNJAB		8082	8							8090
10	RAJASTHAN	2839			1636	148	2499				7122
	TOTAL SUPPLY	3923	9293	8	1636	3359	2499	1224	1410	1957	25309

TOTAL TKMS : 36545 million.
AVG. LEAD : 1445 million.

Chapter IX

Mineral Oils

9.1 Introduction

Among the nine bulk commodities, mineral oil earns 12.33% of the revenues for the Railways (after coal), though it carries only 6.36% of the tonne-kms. This is because it has the highest freight rate, and consequently is an attractive commodity for the Railways. The rail movement for this commodity is different since it requires special purpose wagons for transportation. Since the wagons (tankers) used are not suitable for the movement of other goods, it will have to go back empty to the origin, thus resulting in 50% empty movement. At present, Railways do not transport crude oil from the mines/ports to the refineries. The crude oil goes by pipeline, wherever required, since most refineries are near the ports. Movement of petroleum products from the refineries to various states takes place by rail and road. Railways carry about 50% of the total demand of petroleum products in the country.

The average lead for mineral oils shows a fluctuating trend since 1960-61. From 554 kms in 1960-61, it increased to a peak of 780 kms in 1980-81. Since then it decreased to 563 kms in 1984-85. In 1987-88, the average lead was 635 kms and in 1988-89 it was 625 kms. The average lead pattern is shown in Exhibit 9.1.

9.2 Supply, Demand and Distance Data

There are nine states with petroleum refineries. They are: Andhra Pradesh, Bihar, Gujarat, Kerala, Maharashtra, N. East, Tamil Nadu, U.P and West Bengal. The two western states of Gujarat and Maharashtra account for more than 43% of the production. Production of mineral oils during 1987-88 was 44.63 million tonnes. Among the refining states, all the states have surplus production, except West Bengal. The supply and demand details are given in Exhibit 9.2.

Demand for petroleum products is from all over the state and so we have taken the middle point of the state as the demand centre. The actual location of refineries is taken as the supply point. Exhibit 9.3 shows the demand and supply points. The distance matrix is shown in Exhibit 9.4

9.3 Model Output

As per the optimal allocation pattern given by the model, part of the supply to Orissa and West Bengal comes from Andhra Pradesh. Supply from Bihar meets part of the demand from West Bengal. Supply from Gujarat meets the entire demand from Chandigarh, Delhi, Haryana, J & K and part of the demand from Punjab. Entire demand from Goa and major part of the demand from Karnataka is met by the supply from Kerala. Part of the demand from M.P and Punjab and the entire demand from Rajasthan is met by the supply from Maharashtra. Supply from N. East meets a part of the demand from West Bengal. Tamil Nadu meets part of the demand from Karnataka, M.P and Orissa. U.P. meets the entire demand from Himachal Pradesh and a part of the demand from Delhi. The allocation pattern is shown in Exhibit 9.5

According to the Railway data, the tonne-kms registered during 1987-88 was 13778.00 million. The tonnes originating was 21.69 million tonnes and the average lead was 635 kms. According to the model, the tonnes originating is 13.39 million, with an average lead of 753 kms, resulting in a transport effort of 10079.00 million tonne-kms.

As per the actual data given by Railways, the tonnes originating and the tonne-kms are more than the figures obtained in the model. The average lead of 635 Kms is lower than the figure of 753 kms which is obtained through optimal allocation. This suggests that there is a certain amount of intra-state movement taking place by rail. According to previous estimates, Railways carry about 50% of the demand of the petroleum products in our country. As per the model, it accounts only for 30%. This confirms that rail is used for intra-state movement too.

Hence we consider that about 8 million tonnes of intra-state movement also takes place by rail with an average lead of 400 kms. The net lead then works out to be 620 kms.

9.4 Empty Wagon Movement:

Since the type of tanks used for movement of petroleum products cannot be used for transportation of other commodities, the empty movement in this case will be 50%. We have constructed two scenarios, one based on optimal allocation and the other based on actual movement. The empty movement as per the two scenarios is as follows:

Scenario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
2	21.39	659.79	620	50.0	659.79	620	1319.58
4	21.69	685.23	635	50.0	685.23	635	1370.46

EXHIBIT 9.1

AVERAGE LEAD FOR MINERAL OILS

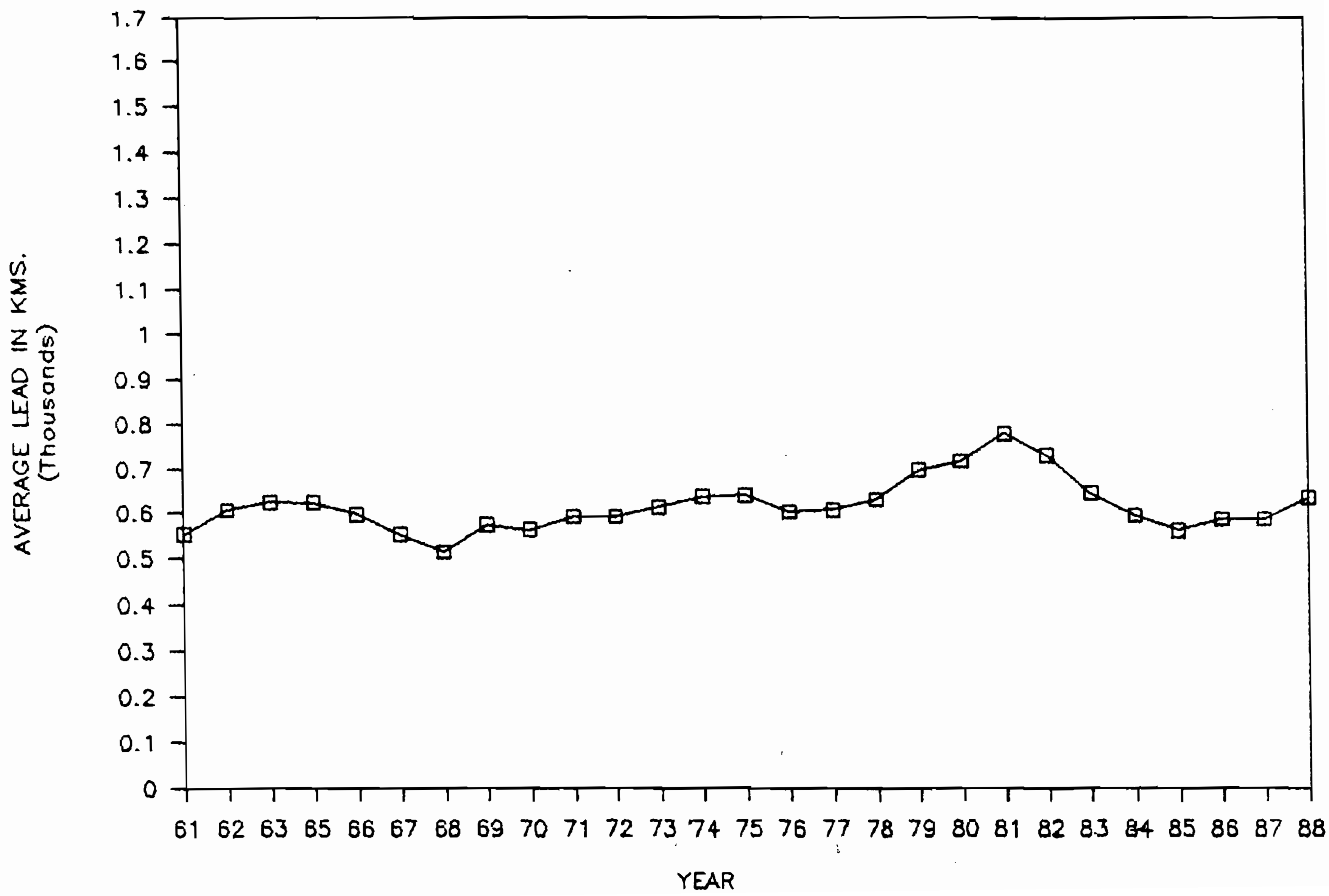


EXHIBIT 9.2

SUPPLY AND DEMAND PATTERN OF MINERAL OILS (1987-88)
(000'TONNES)

SL.NO.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	A.P	3351	2515	836	
2	BIHAR	2394	2213	181	
3	CHANDIGARH		154		154
4	DELHI		1836		1836
5	GOA		551		551
6	GUJARAT	7936	5305	2631	
7	HARYANA		1263		1263
8	H.P		126		126
9	J&K		244		244
10	KARNATAKA		1928		1928
11	KERALA	3946	1471	2475	
12	MAHARASHTRA	11348	7694	3654	
13	M.P		2009		2009
14	N.EAST	2179	1060	1119	
15	ORISSA		832		832
16	PUNJAB		2294		2294
17	RAJASTHAN		1667		1667
18	T.NADU	4751	4164	587	
19	U.P	6202	4295	1907	
20	W.BENGAL	2527	3014		487
	TOTAL	44634	44634	13391	13391

Source: Annual report of the Ministry of Petro--leum, 1987-88

Exhibit 9.3

Map Showing Bemand and Supply Points
Commodity - Mineral Oils

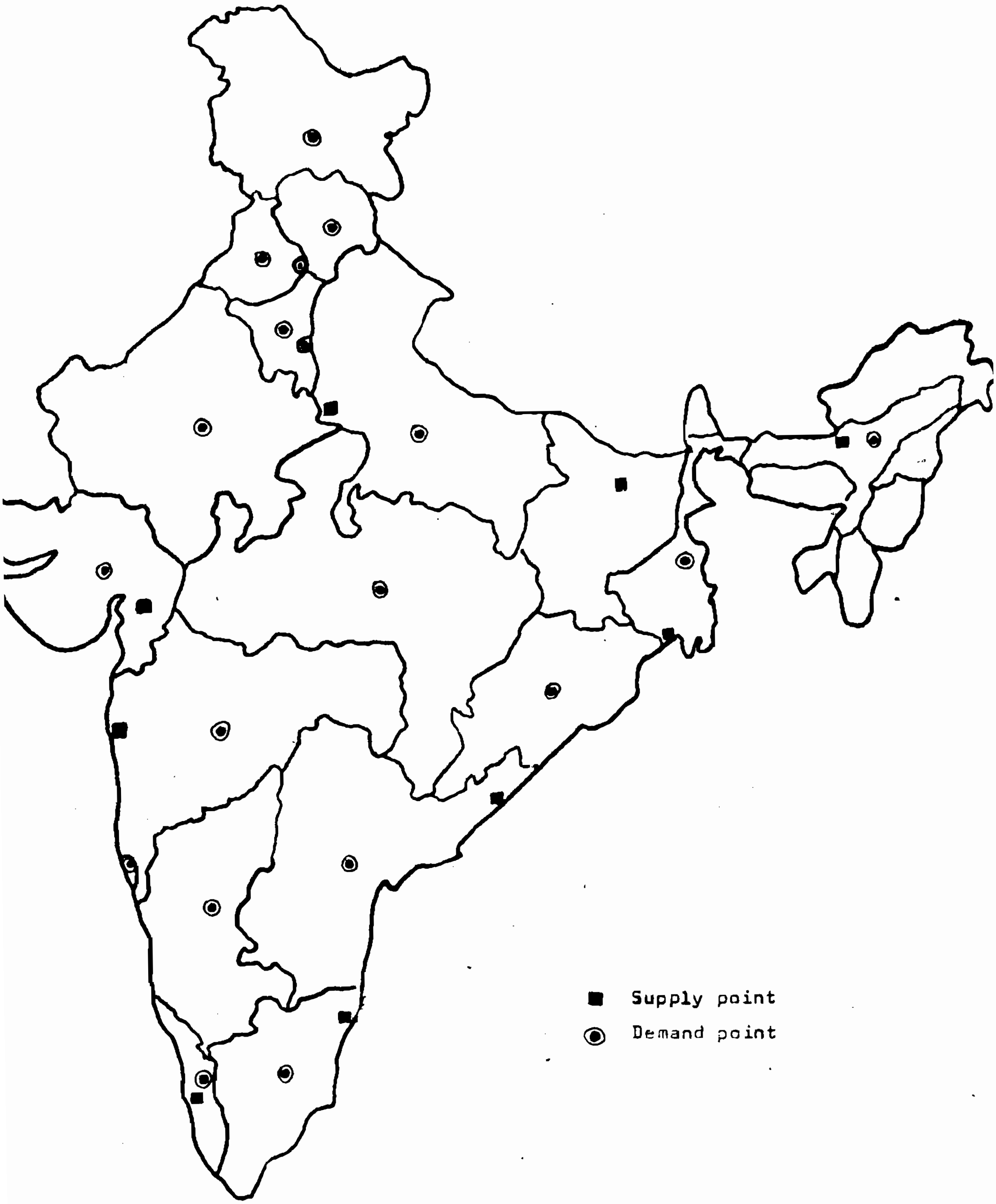


EXHIBIT 9.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF MINERAL OIL
(KMS)

SL.NO	DEFICIT STATES	SURPLUS STATES							
		A.P	BIHAR	GUJARAT	KERALA	MAHARA-SHTRA	NORTH EAST	TAMIL NADU	U.P
1	CHANDIGARH	1590	1095	990	2355	1380	1665	2070	420
2	DELHI	1365	960	840	2130	1185	1560	1830	180
3	GOA	1050	1710	735	660	330	2340	720	1410
4	HARYANA	1440	1050	855	2160	1200	1650	1890	255
5	H.P	1650	1110	1170	2475	1515	1560	2175	495
6	J & K	1920	1350	1395	2715	1740	1830	2430	780
7	KARNATAKA	870	1620	855	555	540	2235	495	1425
8	M.P	675	728	645	1515	825	1365	1155	525
9	ORISSA	300	600	1155	1500	1215	1185	1050	1005
10	PUNJAB	1650	1200	1020	2355	1365	1785	2100	465
11	W.BENGAL	795	263	1500	2025	1635	735	1560	1065
12	RAJASTHAN	1320	1185	525	1875	855	1785	1665	360

EXHIBIT 9.5

OPTIMAL ALLOCATION OF MINERAL OILS
(000'TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES: A.P	BIHAR	GUJARAT	KERALA	MAHARA-SHTRA	NORTH EAST	TAMIL NADU	U.P	TOTAL
1	CHANDIGARH			154						154
2	DELHI			55					1781	1836
3	GOA				551					551
4	HARYANA			1263						1263
5	H.PRADESH								126	126
6	J & KASHMIR			243						243
7	KARNATAKA				1924			4		1928
8	M.PRADESH					1784		220		2004
9	ORISSA	469						363		832
10	PUNJAB			916		1378				2294
11	W. BENGAL	367	181				1119			1667
12	RAJASTHAN					487				487
	TOTAL SUPPLY	836	181	2631	2475	3649	1119	587	1907	13385

TOTAL TKMS : 10079 million.
AVG. LEAD : 753 kms.

Chapter X

Limestone and Dolomite

10.1 Introduction

Limestone and dolomite are among the prime raw materials used in the cement and iron and steel industry. The location of these industries are based on the easy availability and proximity to the sources of limestone and dolomite. This is reflected in the low lead. However the average lead has been increasing steadily from 218 kms in 1965-66 to 427 kms in 1988-89. The trend in average lead for limestone and dolomite since 1965-66 is shown in Exhibit 10.1.

10.2 Supply, Demand and Distance Data

During 1986, the production of limestone and dolomite was around 60.88 million tonnes. The major limestone and dolomite producing states are Maharashtra, Madhya Pradesh, Andhra Pradesh, Rajasthan, Gujarat, Tamilnadu and Orissa. Maharashtra and Madhya Pradesh together account for 40% of the production. Consumption of limestone and dolomite by the iron and steel industry was 5.01 million tonnes. Consumption by the cement industry is about 1.33 tonnes per tonne of cement produced. According to this, the consumption by cement industry is around 44.7 million tonnes. Calculating the statewise consumption, the net surplus and demand for interstate movement works out to be 25.07 million tonnes (Exhibit 10.2).

Limestone and dolomite seem to be predominantly transported by conveyor belts and other inplant modes. According to the RITES study (1987-88), the modal split between rail and road is 84.26% and 15.74% with an average lead of 544 kms and 293 kms respectively. As per the data given by Railways, the tkms for limestone and dolomite in 1987-88 is 3425 million and tonnes originating is 9.13 million. Going by the RITES figures of modal split, the tonnes originating by road is 2.18 million tonnes (3425/0.8426 - 3425)/293. This means about 49 million out of the total production of 60 million is either transported by conveyor belts or by inplant transportation modes. This appears right, since otherwise, if we assume that out of 60.08 million tonnes, 9 million tonnes goes by rail and the remaining 51.08 million tonnes by road with a tkms split of 84.26 and 15.24 respectively, the average lead by road works out to only 12.55 kms whereas it is actually 293 kms.

For the calculation of distances between the consumption and production points, the demand points are taken considering the location of iron and steel and cement industries, while the supply points are based on the locations of the limestone and dolomite reserves in the respective states. Exhibit 10.3 gives a map which shows the location of supply and demand points. The distances are given in Exhibit 10.4.

10.3 Model Output

The allocation pattern as per the model is given in Exhibit 10.5. The model gives that the supply from each of the states, Madhya Pradesh, Orissa and Andhra Pradesh, and Tamilnadu goes to Bihar, West Bengal and Kerala respectively. Supply from Maharashtra caters to the demand from Uttar Pradesh, North East and Bihar. Rajasthan supplies a major part of Punjab's demand, the total demand of Haryana and Delhi, and a small portion of the demand from Uttar Pradesh. The supply from Himachal Pradesh serves the full demand from J & K and Chandigarh and also a small amount to Punjab. Karnataka serves the complete demand of Goa and the requirements of Bihar and Kerala partially.

According to the optimal allocation given by the model the total tonne-kms are 25786.64 million, and the tonnes originating are 25.07 million. These figures give an average lead of 1029 kms. As per the actual data given by the railways in 1988-89, the tonne-kms and tonnes originating are 3908 million and 9.16 million. The average lead recorded by the railways is 427 kms. This indicates a major discrepancy in that the model indicates both a significantly higher originating tonnes and lead for rail movement. If this were true, in actual practice long lead movements are not taking place by rail. The distance data could also be contributing to the error since aggregate rather than specific locations are being considered for supply and demand. In any case, it has been decided to proceed with the empty wagon calculations as per the model data, for methodological continuity.

10.4 Empty Wagon Movement

In the first two scenarios for empty wagon movement calculations, we have assumed that the average lead is 1029 kms and the tonnes originating as 25.07 million (as per the model). The empty movement in the first scenario (34.4% empty) is 672.94 million wkms/year. In the second scenario (50% empty), the empty movement is 1283.28 million wkms/year. In the third and fourth scenarios, we have taken the actual average lead of 427 kms and originating tonnes of 9.16 tonnes as given by the Railways, and empty movement at 34.4% and 50% respectively. The empty movement in the third and fourth scenarios are 102.03 million and 194.57 million wkms/year respectvely. The wagon movement details under the four scenarios are given in the following table:

Scenario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	25.07	1283.28	1029	34.4	672.94	540	1956.22
2	25.07	1293.28	1029	50.0	1283.28	1029	2566.56
3	9.16	194.57	427	34.4	102.03	224	296.60
4	9.16	194.57	427	50.0	194.57	427	389.14

EXHIBIT 10.1

AVERAGE LEAD FOR LIMESTONE AND DOLOMITE

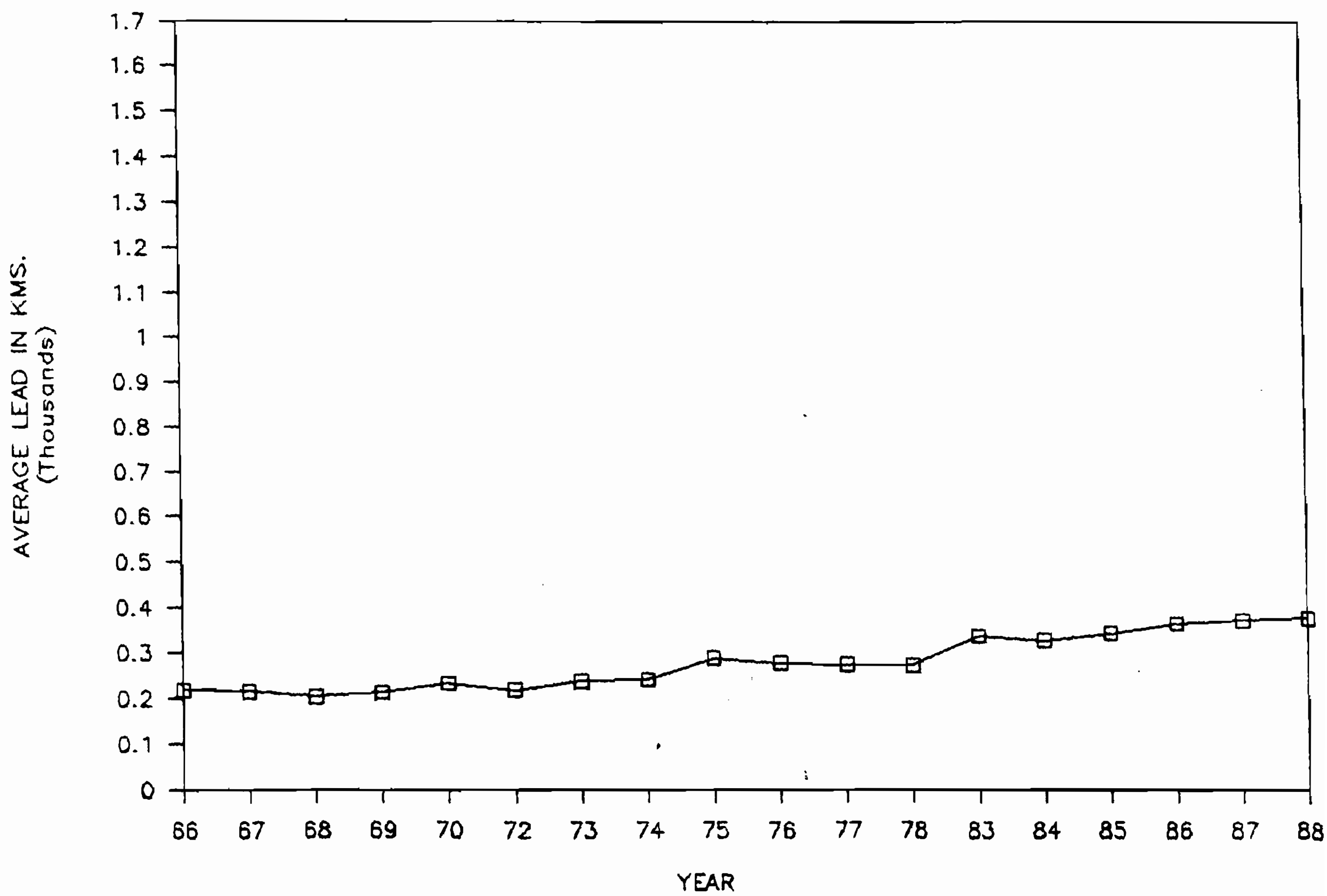


EXHIBIT 10.2

SUPPLY AND DEMAND PATTERN OF LIMESTONE AND DOLOMITE (1986)
(000'TONNES)

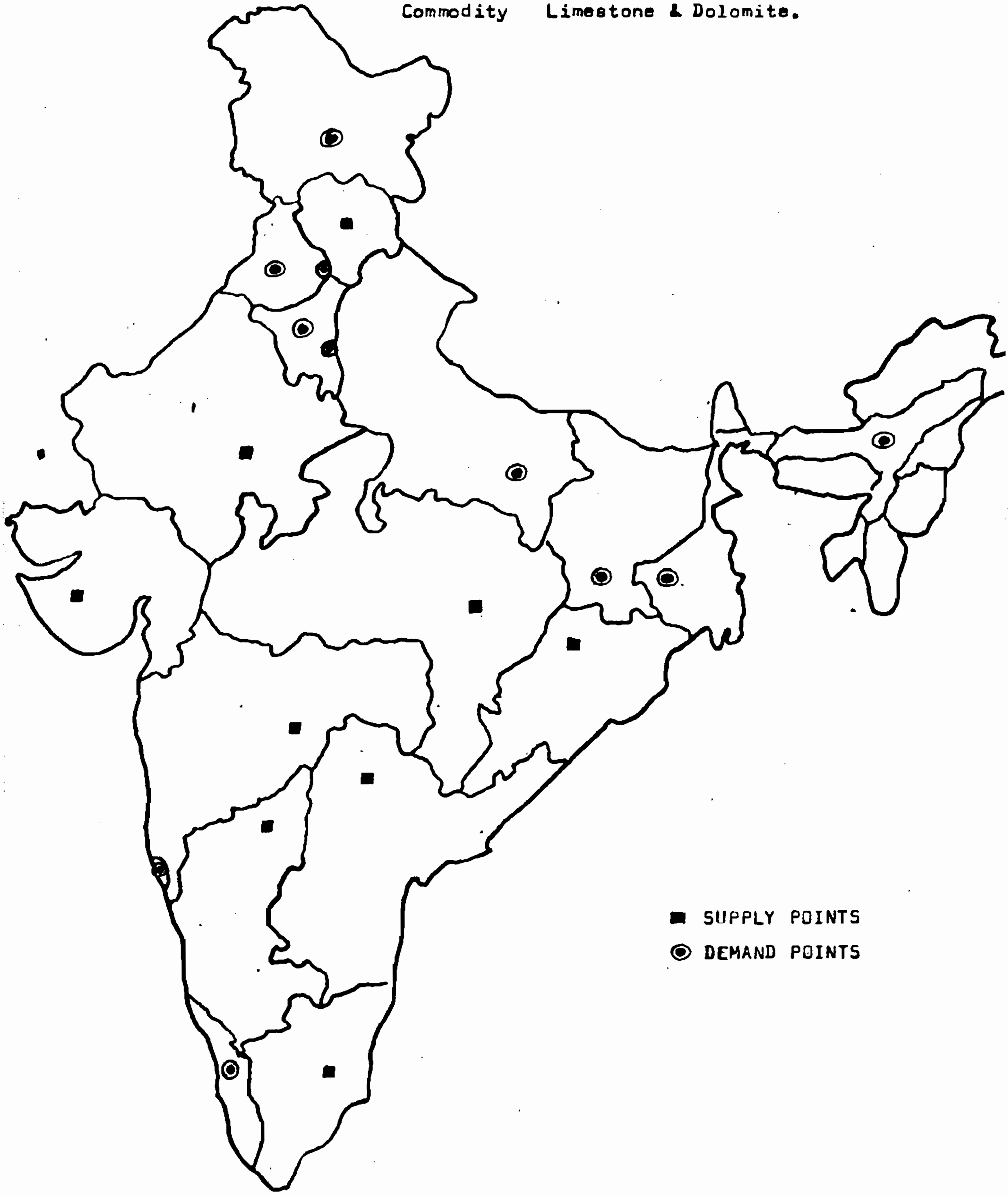
SL.NO.	STATES	LIMESTTONE		DOLOMITE		LIMESTONE & DOLOMITE			
		PRODUCTION	DEMAND	PRODUCTION	DEMAND	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	A.P	7304	4086	3		7307	4086	3221	
2	BIHAR	1928	8040	205	1438	2133	9478		7345
3	CHANDIGARH	38	45			38	45		7
4	DELHI	218	548			218	548		330
5	GOA	2	84			2	84		82
6	GUJARAT	4173	2648	266		4439	2648	1791	
7	HARYANA	496	1007			496	1007		511
8	H.P	683	322			683	322	361	
9	J&K	139	472			139	472		333
10	KARNATAKA	3835	2916	2		3837	2916	921	
11	KERALA	242	1892			242	1892		1650
12	MAHARASHTRA	11755	4814	23		11778	4814	6964	
13	M.P	11735	5651	704	351	12439	6002	6437	
14	N.EAST	402	2169			402	2169		1767
15	ORISSA	3204	2623	922	345	4126	2968	1158	
16	PUNJAB		1270			0	1270		1270
17	RAJASTHAN	5322	2735	10		5332	2735	2597	
18	TAMILNADU	5221	3604			5221	3604	1617	
19	U.P	1939	8566	59		1998	8566		6568
20	W.BENGAL	7	5151	41	101	48	5252		5204
	TOTAL	58643	58643	2235	2235	60878	60878	25067	25067

Source: Statistical Abstract , CSO, (1986).

EXHIBIT 10.3

Map Showing Demand & Supply Points

Commodity Limestone & Dolomite.



■ SUPPLY POINTS

◎ DEMAND POINTS

EXHIBIT 10.4

DISTANCE BETWEEN DEMAND AND SUPPLY POINTS OF LIMESTONE & DOLOMITE
(KMS)

SL.NO.	DEFICIT STATES	SURPLUS STATES: A.P	GUJARAT	H.P	KARNATAKA	MAHARASHTRA	M.P	ORISSA	RAJASTHAN	T.NADU
1	BIHAR	1140	1940	1720	1520	1280	480	280	1400	2100
2	CHANDIGARH	1920	1500	200	2080	1720	1400	1700	740	2880
3	DELHI	1620	1300	480	1420	1420	1100	1440	500	2700
4	GOA	840	1860	2500	440	740	1540	1740	1560	1000
5	HARYANA	1700	1300	440	1840	1500	1480	1560	520	2680
6	J&K	2400	1920	340	2540	2200	1840	2100	1200	3430
7	KERALA	1200	1860	3160	900	1280	1940	2000	2300	380
8	N.EAST	2300	3060	2280	2700	2420	1620	1380	2380	3100
9	PUNJAB	1940	1400	300	2080	1720	1500	1800	700	3120
10	U.P	1260	1700	1160	1600	1260	500	680	1020	2320
11	W.BENGAL	1340	1940	1800	1740	1500	700	400	1620	2200

EXHIBIT 10.5

OPTIMAL ALLOCATION OF LIMESTONE AND DOLOMITE
(000'TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES: A.P	GUJARAT	H.P	KARNATAKA	MAHARASHTRA	M.P	ORISSA	RAJASTHAN	T.NADU	TOTAL DEMAND
1	BIHAR				806	102	6437				7345
2	CHANDIGARH			7							7
3	DELHI								330		330
4	GOA				82						82
5	HARYANA								511		511
6	J&K			333							333
7	KERALA				33					1617	1650
8	N.EAST					1767					1767
9	PUNJAB			21					1249		1270
10	U.P		966			5095			507		6568
11	W.BENGAL	3221	825					1158			5204
	TOTAL SUPPLY	3221	1791	361	921	6964	6437	1158	2597	1617	25067

TOTAL TKMS : 25787 million.
AVG. LEAD : 1029 kms.

Chapter XI

Iron Ore

11.1 Introduction

The production of iron ore in 1986-87 amounts to 441 million tonnes. The major sector which consumes iron ore is the iron and steel industry. Hence the demand is concentrated in the eastern parts of the country. Iron ore movement to steel plants is predominantly done by rail. In terms of the tonnes originating, iron ore ranks second among the nine commodities.

According to the RITES study (1987-88), 98.5 % of the iron ore movement is by rail with an average rail lead of 325 kms. The average lead of iron ore has more or less remained constant over the years. The lead since 1982-83 is given in Exhibit 11.1. This low figure of lead is due to the fact that the major consumer, the iron and steel industry, is located near the iron ore reserves. The non-fluctuating trend in the lead is because the supply and demand pattern has remained more or less constant.

11.2 Supply, Demand and Distance Data

There are eight states producing iron ore. Most of the production is from Goa, M.P., Bihar, Orissa and Karnataka, which account for about 90% of the total production. After accounting for intrastate consumption, the surplus states identified are Goa, Karnataka, Maharashtra, M.P., Orissa, and Rajasthan.

The demand of iron ore is only from seven states, and that too mainly from Bihar and Orissa. The deficit states identified are A.P., Bihar and Tamil Nadu. The demand and supply pattern is given in Exhibit 11.2.

For calculating the distances between the supply and demand points for the inter-state movement of iron ore, the supply points are taken as the location of iron ore reserves in the respective states and the demand points are the location of iron and steel industry since this is the major consumer of iron ore. The locations of these points are shown in the Exhibit 11.3. The straight line distances are given in the matrix form in Exhibit 11.4.

11.3 Model Output

The allocation pattern given by the model is given in Exhibit 11.5. It shows that the total supply from Goa, Maharashtra and Orissa, go to A.P. Madhya Pradesh also supplies a part of the demand from A.P. and Bihar. The supply from Karnataka goes to Tamilnadu and the rest of the demand of A.P. The supply from Rajasthan caters to the remaining demand from Bihar.

According to the model, the tonnes originating and the tonne-kms are 11.76 million and 8487.93 million respectively. This results in an average lead of 722 kms. The tonnes originating and tonne-kms as recorded by the Railways in 1988-89 are 33.01 million and 13131 million respectively, with an average lead of 369 kms. The discrepancy is due to the fact that even short distance intrastate movement takes place by rail.

11.4 Empty Wagon Movement

In the first two scenarios for empty wagon movement calculations, we have assumed that the average lead is 722 kms and the tonnes originating as 11.76 million (as per the model). The empty movement in the first scenario (34.4% empty) is 221.51 million wkms/year. In the second scenario (50% empty), the empty movement is 422.42 million wkms/year. In the third and fourth scenarios, we have taken the actual average lead of 369 kms and originating tonnes of 33.01 tonnes as given by the Railways, and empty movement at 34.4% and 50% respectively. The empty movement in the third and fourth scenarios are 317.81 million and 606.06 million wkms/year respectvely. The wagon movement details under the four scenarios are given in the following table:

Scenario	Tonnes Origin. Million	Loaded Wkms Million	Loaded Lead Kms	% Empty Mvmt.	Empty Wkms Million	Empty Lead Kms	Total Wkms Million
1	11.76	422.42	722	34.4	221.51	379	643.93
2	11.76	422.42	722	50.0	422.42	722	844.84
3	33.01	606.06	369	34.4	317.81	194	923.87
4	33.01	606.06	369	50.0	606.06	369	1212.12

EXHIBIT 11.1

AVERAGE LEAD FOR IRONORE

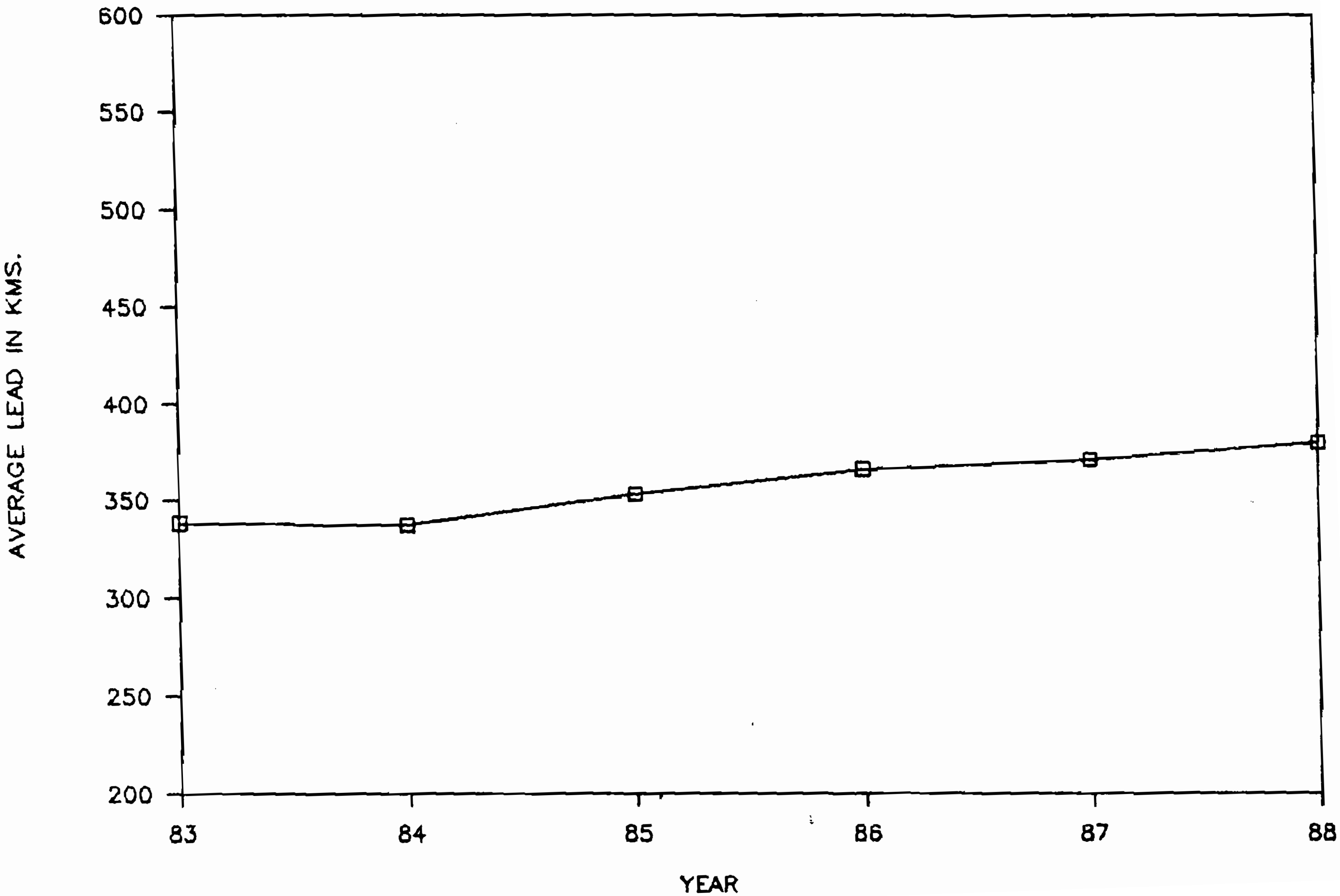


EXHIBIT 11.2

SUPPLY AND DEMAND PATTERN OF IRONORE (1986-87)
(000' TONNES)

SL.NO.	STATES	SUPPLY	DEMAND	SURPLUS	DEFICIT
1	A.P	140	10070		9930
2	BIHAR	6988	8314		1326
3	GOA	14166	11078	3088	
4	KARNATAKA	6234	3493	2741	
5	MAHARASHTRA	1077		1077	
6	M.P	8744	4136	4608	
7	ORISSA	6815	6591	224	
8	RAJASTHAN	22		22	
9	T.NADU		504		504
	TOTAL	44186	44186	11760	11760

Source: Statistical Abstract of India, CSO, 1987.

Exhibit 11.3

Map Showing Demand and Supβly Points
Commodity - Iron Ore

EXHIBIT 11.4

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF IRONORE
(000' TONNES)

SL.NO.	DEFICIT STATES	SURPLUS STATES					
		GOA	KARNATAKA	MAHARASHTRA	M.P	ORISSA	RAJASTHAN
1	A.P	900	825	795	555	405	1475
2	BIHAR	1770	1830	1530	600	705	1260
3	T.NADU	810	540	915	1200	1125	1980

EXHIBIT 11.5

OPTIMAL ALLOCATION OF IRONORE
(000'TONNES)

SL.NO.	DEFICIT STATES	GOA	KARNATAKA	MAHARASHTRA	M.P	ORISSA	RAJASTHAN
		SURPLUS STATES					
1	A.P	3089	2237	1077	3304	224	
2	BIHAR				1304		22
3	T.NADU		504				
	TOTAL SUPPLY	3089	2741	1077	4608	204	22

TOTAL TKMS : 8488 million.
AVG. LEAD : 722 kms.

Chapter XII

Empty Wagon Movement

12.1 Introduction

In 1987-88, the empty wagon kilometers were 34% of the total wagon kilometers, up from a low of 26.8% in 1955-56. In absolute terms, the empty wagon kilometers in four wheeler units (FWUs) were 6052 million in 1987-88 while it was 1486 million in 1955-56. This (6052 million wkms) works out to four trains of nearly 67 FWUs travelling empty the entire Railway system of 62000 kms, every day!

The empty wagon lead has been increasing from 220 kms in 1950-51 to 395 kms in 1987-88, but for a dip to 198 kms in 1955-56, and from 378 kms in 1983-84 to 353 kms in 1985-86. The data regarding the calculation of empty wagon lead is given in Exhibit 12.1. A graphical representaion of the changing pattern of empty lead is shown in Exhibit 12.2.

12.2 Supply, Demand and Distance Data

To calculate the supply and demand of empty wagons, the statewise surplus and deficit of each of the nine commodities (except mineral oils) are considered. Mineral oils is considered separately because the wagons used for its transportation cannot be used for other commodities. Exhibit 12.3 shows statewise net surplus and deficit for rail movement of all commodities except mineral oils. The state which is a net surplus in a commodity will become a demanding state for empty wagons for that commodity and similarly, a state which is a net deficit in a commodity will become a supplying state for empty wagons for that commodity.

Intrastate Movement: It is assumed that in each state the empty wagons generated are first used for the demand of empty wagons within that state and the surplus is then available for allocations to other states. The four wheeler equivalent units of the supply and demand of empty wagons based on the total commodity surplus/deficit and the intrastate allocation of empty wagons is given in Exhibit 12.4. The lead for the intrastate movement of empty wagons given in Exhibit 12.4 is calculated as the distance between the two bi-centres in each state.

Interstate Movement: After making the intrastate allocation, there are ten states having surplus empty wagons and an equal number having a deficit (Exhibit 12.4). Uttar Pradesh has the highest number of empty wagons. Other states which are surplus in empty wagons are W.Bengal, Delhi, North East, Kerala, Rajasthan, A.P., J&k, Bihar and Chandigarh. Among the deficit states, Madhya Pradesh demands the highest number of empty wagons, which is slightly more than 50% of the total surplus of empty wagons. Orissa, Maharashtra, Goa, Gujarat, Karnataka, Tamilnadu, Haryana, H.P. and Punjab are the other states which have a deficit of empty wagons. The pattern of supply and demand of empty wagons is given in Exhibit 12.4.

For the calculation of distances between the supply and demand points for interstate movement of empty wagons, the supply points are taken as the weighted mean location of the consumption points of all the commodities. This is based on the fact that the empty wagon is generated at the unloading point i.e. the demand point of the commodity. Similarly, the demand points are marked as the mean location of the production points of the commodities. The location of supply and demand points in different states is shown in Exhibit 12.5. The matrix showing the distances between the supply and demand points is given as Exhibit 12.6.

12.3 Model Output

Intrastate: The intrastate allocation of empty wagons and the resulting empty wagon-kilometers are given in Exhibit 12.7. The total number of originating empty wagons for this movement is 3.49 million for the year. The total empty wkms generated due to the intrastate movement is 1207.02 million with an average lead of 346 kms.

Interstate: The optimal allocation of empty wagons for the interstate movement as per the model is given in Exhibit 12.8. The model shows that the empty wagons generated from W.Bengal and Bihar, Rajasthan and Chandigarh are moved to Madhya Pradesh, Goa, and Haryana respectively. Wagons emptied in Kerala are moved to the neighbouring states of Tamilnadu and Karnataka. North East supplies empty wagons to Madhya Pradesh and Orissa. The supplies from Uttar Pradesh are destined towards Madhya Pradesh and Maharashtra. The supply from Delhi goes to Maharashtra, Goa, Haryana and Gujarat. Andhra Pradesh supplies to the demand from Goa and Karnataka. The surplus wagons from J&K are supplied to Himachal Pradesh, Haryana and Punjab. The total number of originating empty wagons for this movement is 2.16 million for the year. The total empty wkms due to interstate movement (excluding mineral oils) is 2132.67 million with an average lead of 988 kms.

12.4 Empty Wagon Movement

According to the model, the total empty wagon-kms generated are obtained by adding the respective figures for intrastate (1207.02 million), interstate (2132.67 million) and mineral oils (659.79 million), i.e. 3999.48 million. Similarly, the total originating wagons are 6.71 million (3.49 + 2.16 + 1.06 million). These figures give an average lead of 596 kms. The figure recorded by Railways in 1988-89 for empty wkms is 5308.81 wkms/year for the nine bulk commodities (6052 wkms/year for all commodities). The average empty lead recorded by the Railways for these nine commodities is 392 kms (for all commodities is 395 kms).

Four different scenarios are used in this paper for empty wagon movement calculation. Scenario I and II give the model output and are based on the assumption that there is no intrastate rail movement for commodities. Scenario I takes the empty movement of

34.4% whereas scenario II takes 50% empty movement. Scenario III and IV are the recordings of the Railways with 34.4% and 50% empty movement respectively. Exhibits 12.9 to 12.12 give the commodity-wise calculations of the loaded and empty wagon kilometers. Scenario V takes the model output and the empty movement considered is a result of the netflow analysis which optimally allocates the empty wagons generated for both intrastate and interstate movements. The summary of all the five scenarios is presented in the table below:

Scenario	Tonnes Orign. Mill.	Loaded Wkms mill.	Loaded Lead Kms.	% Empty Mvmt.	Empty Wkms mill.	Empty Lead Kms.	Total Wkms mill.
1	134.96	6564.58	978	34.4	3442.40	513	10006.98
2	134.96	6564.58	978	50.0	6564.58	978	13129.16
3	254.55	9485.51	749	34.4	4970.11	393	14459.62
4	254.55	9485.51	749	50.0	9485.51	749	18971.02
5	134.96	6564.58	978	37.9	3999.48	596	10564.06

12.5 Conclusions

a) The originating tonnes as predicted by the model is just over 50% of the actual originating tonnes carried by Railways for these nine bulk commodities. This is primarily due to the assumption that intrastate movement is by road. Double counting by the Railways due to two movements by rail between the production centre and consumption centre is also a reason. The double movement could be either due to the distribution arrangements or transhipment at break of guage points. The multiple commodity nature of each commodity also reflects a higher net surplus/deficit than what the model assumes for each state, thus understating the originating tonnes for rail movement.

b) The loaded wagon kilometers as predicted by the model is about two thirds of the actual stated by Railways. The average loaded lead predicted by the model is 978 kms as against a lower lead of 749 kms claimed by the Railways. This is due to short distance traffic also going by rail (intrastate,traffic with double movement not recognised by the model, etc)

c) The empty wagon-kms predicted by the model, under the assumption of 34.4% empty movement, is about 70% of the actual empty wagon-kms currently incurred by Railways. The empty lead as per the model is 513 kms whereas the Railways claim their actual empty lead as 392 kms.

d) Under the scenario of 50% empty movement, the empty wagon-kms predicted by model is about 70% of the actual empty-wkms as stated by Railways. The empty lead as per the model under this scenario is 978 kms whereas the Railways state their actual figure as 749 kms.

e) The netflow analysis for the empty wagon movement calculation predicts a scenario which gives a 38% empty movement. This is quite close to the current empty movement percentage of 34.4%

f) All the above figures for empty and loaded wagon kilometers account for about 90% of the rail traffic.

EXHIBIT 12.1

AVERAGE LEAD CALCULATIONS FOR EMPTY WAGONS

YEAR	AVG. LOADED LEAD (KMS) 1	% EMPTY 2	EMPTY WAGON LEAD (KMS) 3
1950-51	513	30.00	220
1955-56	541	26.80	198
1960-61	603	29.50	252
1965-66	611	30.70	271
1970-71	680	30.30	296
1975-76	685	31.70	318
1979-80	749	29.80	318
1980-81	754	30.50	331
1981-82	743	30.80	331
1982-83	733	31.90	343
1983-84	734	34.00	378
1984-85	730	33.30	364
1985-86	760	31.70	353
1986-87	771	32.20	366
1987-88	767	34.00	395
1988-89	736	34.60	389

Source: Indian Railways Year Books.
Col 3 = Col 1*(Col 2/(100-Col 2))

AVERAGE LEAD FOR EMPTY WAGONS

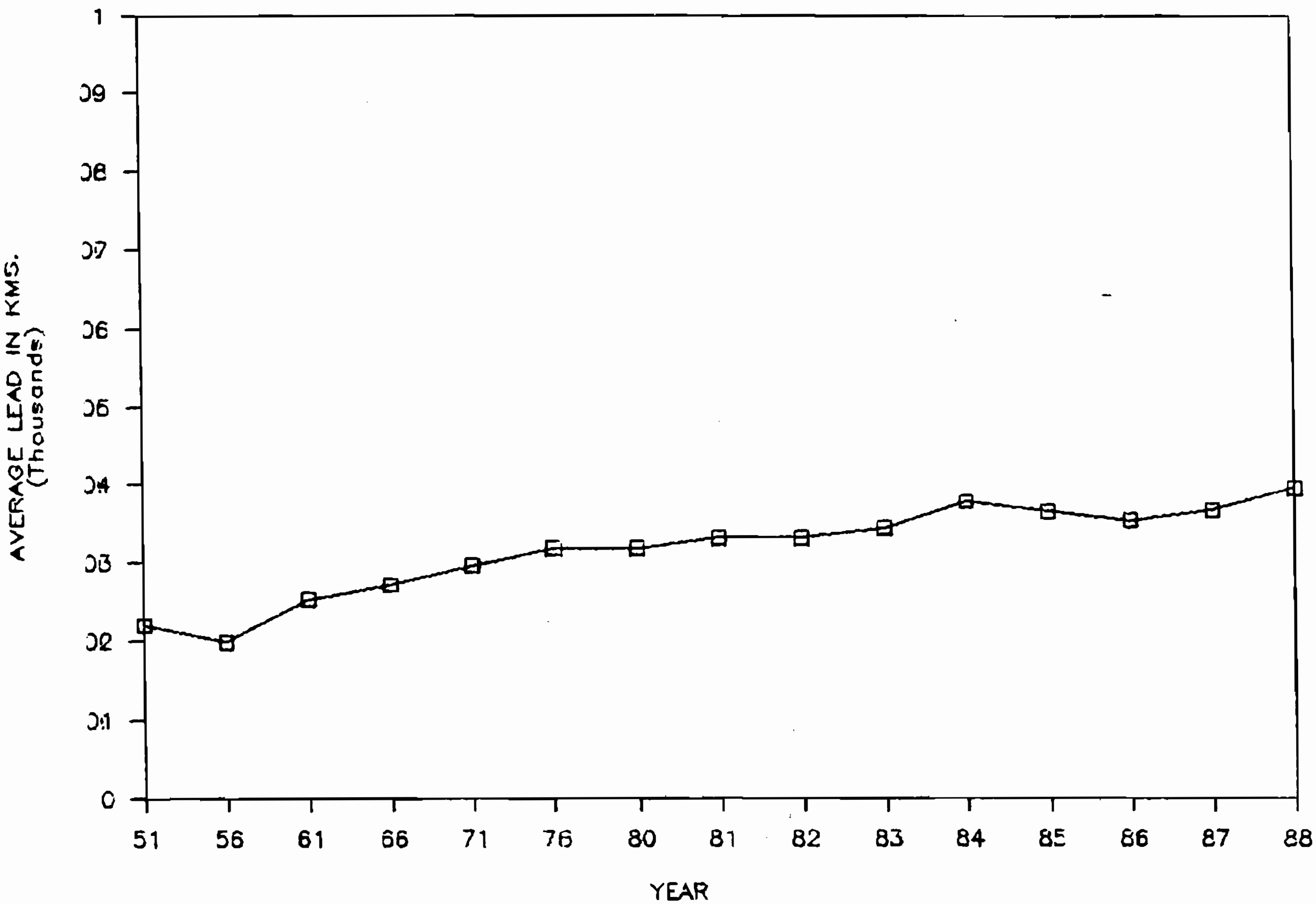


EXHIBIT 12.3

NETFLOW OF COMMODITIES FROM STATES
('000' TONNES)

	CEMENT		FERTILIZER		FOODGRAINS		COAL		SALT		IRONORE		STEEL		L & DOLO.		ALL COMM.	
STATES	SUR	DEF	SUR	DEF	SUR	DEF	SUR	DEF	SUR	DEF	SUR	DEF	SUR	DEF	SUR	DEF	SUR	DEF
A.P	3167	1449	125			357	3923		174			9931		432	3221		10610	12169
BIHAR		2601		370		1356	9294			992		1326	4693	367		7345	13987	14357
CHANDIGARH		31		2				20		2				38		7	0	100
DELHI		389		11		796		5042		204				387		330	0	7159
GOA		59	2						9		3089			2		82	3100	143
GUJARAT	1431		56			1126		1855	3076					546	1791		6354	3527
HARYANA		181	185		2982			1122		138				411		511	3167	2363
H.P	647			31		98		231		1				0	361		1000	361
J&K		193		1		414	8			8				40		333	8	989
KARNATAKA	2182	1020		28		1286		264		387	2741			270	921		5844	3255
KERALA		955	43			1962		189		156				52		1650	43	4964
MAHARASHTRA	1264	2152	206			1425	1636			715	1077			1156	6964		11147	5448
M.P	8371	1426		112		439	3359			344	4608		2169	420	6437		24944	2741
N.EAST		1272	34			1679		1374		192				57		1767	34	6341
ORISSA		522		266		394	2472			352	224		1090	325	1158		4944	1859
PUNJAB		901		15	11501			8091		24				1069		1270	11501	11370
RAJASTHAN	2361		101			1012		7095	658		22			168	2597		5739	8275
T.NADU	1216		466	15		1179	1224		314			504		665	1617		4837	2363
U.P	573	5504		243	1547		1179			459				989		6560	3299	13763
W.BENGAL		2557		124		2507	2138			257			810	1376		5204	3806	12025
TOTAL	21212	21212	1218	1218	16030	16030	25283	25283	4231	4231	11761	11761	8770	8770	25067	25067	113572	113572

EXHIBIT 12.4
NETFLOW OF EMPTY WAGONS
(000'NOS.)

		EMPTY WAGONS (FWUs)		INTRASTATE ALLOCATION		NET EMPTY WAGONS (FWUs)	
SL.NO.	STATES	SUPPLY	DEMAND	WAGONS	LEAD	SURPLUS	DEFICIT
1	A.P	605	528	528	480	78	0
2	BIHAR	714	696	696	300	18	0
3	CHANDIGARH	5	0	0	0	5	0
4	DELHI	356	0	0	0	356	0
5	GOA	7	154	7	50	0	147
6	GUJARAT	175	316	175	220	0	141
7	HARYANA	118	158	118	160	0	40
8	H.P	18	50	18	60	0	32
9	J&K	49	0	0	50	49	0
10	KARNATAKA	162	291	162	380	0	129
11	KERALA	247	2	2	380	245	0
12	MAHARASHTRA	271	555	271	500	0	284
13	M.P	136	1241	136	620	0	1105
14	N.EAST	315	2	2	400	314	0
15	ORISSA	92	246	92	300	0	153
16	PUNJAB	566	572	566	160	0	7
17	RAJASTHAN	412	286	286	440	126	0
18	T.NADU	118	241	118	300	0	123
19	U.P	685	164	164	480	521	0
20	W.BENGAL	598	150	150	300	449	0
	TOTAL	5650	5650	3490	346	2160	2160

EXHIBIT 12.5

Map Showing Demand & Supply Points

Commodity - Empty Wagons

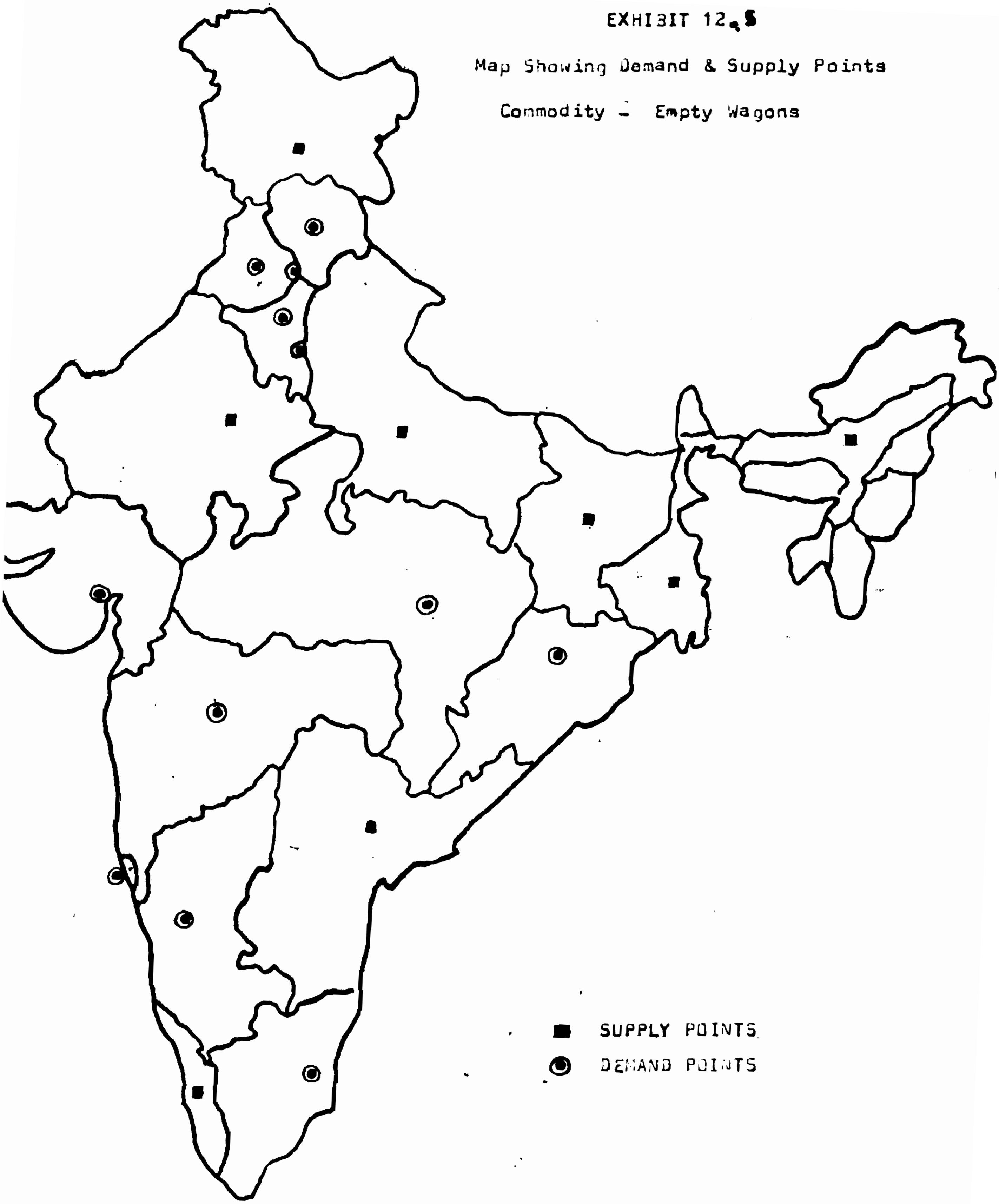


EXHIBIT 12.6

DISTANCE BETWEEN SUPPLY AND DEMAND POINTS OF EMPTY WAGONS
(KMS)

SL.NO.	DEFICIT STATES	SUPPLYING STATES: A.P	BIHAR	C'GARH	DELHI	J & K	KERALA	N.EAST	R'THAN	U.P	W.BENGAL
1	GOA	900	2140	2300	2040	2750	860	3120	1720	1920	2380
2	GUJARAT	1340	1940	1400	1180	1800	1900	2650	820	1280	2150
3	HARYANA	1940	1390	180	130	620	2900	2160	420	620	1700
4	H.P	2270	1500	130	460	300	3250	2130	760	840	1900
5	KARNATAKA	770	2120	2450	2160	2900	650	3050	1800	2000	2200
6	MAHARASHTRA	770	1580	1680	140	2140	1440	2540	1100	1240	1760
7	M.P	870	680	1360	1080	1780	2080	1780	1020	660	920
8	ORISSA	950	520	1760	1500	2150	2100	1360	1520	1030	520
9	PUNJAB	2150	1560	120	350	460	3100	2320	770	840	1960
10	T.NADU	950	2300	3000	2600	3460	490	3100	2400	2420	2230

EXHIBIT 12.7
INTRASTATE ALLOCATION OF EMPTY WAGONS

SL.NO.	STATES	WAGONS (Th.)	LEAD (KMS)	WKMS (MILLION)
1	A.P	528	480	253.37
2	BIHAR	696	300	208.76
3	CHANDIGARH	0	0	0.00
4	DELHI	0	0	0.00
5	GOA	7	50	0.36
6	GUJARAT	175	220	38.60
7	HARYANA	118	160	18.81
8	H.P	18	60	1.08
9	J&K	0	50	0.02
10	KARNATAKA	162	380	61.54
11	KERALA	2	380	0.81
12	MAHARASHTRA	271	500	135.52
13	M.P	136	620	84.55
14	N.EAST	2	400	0.68
15	ORISSA	92	300	27.75
16	PUNJAB	566	160	90.51
17	RAJASTHAN	286	440	125.63
18	T.NADU	118	300	35.27
19	U.P	164	480	78.78
20	W.BENGAL	150	300	44.87
	TOTAL	3490	346	1207.02

EXHIBIT 12.8

OPTIMAL ALLOCATION OF EMPTY WAGONS
(Thou. Wagons)

SL.NO.	DEFICIT STATES	SURPLUS STATES										TOTAL
		A.P	BIHAR	C'GARH	DELHI	J & K	KERALA	N.EAST	R'THAN	U.P	W.BENGAL	DEMAND
1	GOA	70			77				126			273
2	GUJARAT				14							14
3	HARYANA			5	25	10						40
4	H.P					32						32
5	KARNATAKA	7					122					129
6	MAHARASHTRA				240					43		283
7	M.P		18					160		477	449	1104
8	ORISSA							153				153
9	PUNJAB					7						7
10	T.NADU						123					123
	TOTAL SUPPLY	77	18	5	356	49	245	313	126	520	449	2150

EMPTY WAGON-KMS = 2132.67 million
AVG.EMPTY LEAD = 988 kms.

EXHIBIT 12.9
SCENARIO I

MODEL BASED ALLOCATION, (34.4% EMPTY)

COMMODITIES	TONNES ORIG. MILLION.	LOADED WKMS MILLION.	LOADED LEAD KMS.	EMPTY WKMS MILLION.	EMPTY LEAD KMS.	TOTAL WKMS MILLION.
SALT	4.23	191.48	910	100.41	477	291.89
FOODGRAINS	16.03	1177.92	1477	617.69	775	1795.61
IRON & STEEL	8.77	347.99	798	182.48	418	530.47
FERTILIZERS	1.22	59.31	977	31.10	512	90.41
CEMENT	21.21	605.00	573	317.26	301	922.26
COAL	25.28	1817.39	1445	953.02	758	2770.41
MINERAL OILS	21.39	659.79	620	345.99	325	1005.78
LIME.& DOLO.	25.07	1283.28	1029	672.94	540	1956.22
IRONORE	11.76	422.42	722	221.51	379	643.93
BULK COMM.	134.96	6564.58	978	3442.40	513	10006.98

EXHIBIT 12.10
SCENARIO II

MODEL BASED ALLOCATION, (50% EMPTY)

COMMODITIES	TONNES ORIG. MILLION.	LOADED WKMS MILLION.	LOADED LEAD KMS.	EMPTY WKMS MILLION.	EMPTY LEAD KMS.	TOTAL WKMS MILLION.
SALT	4.23	191.48	910	191.48	910	382.96
FOODGRAINS	16.03	1177.92	1477	1177.92	1477	2355.84
IRON & STEEL	8.77	347.99	798	347.99	798	695.98
FERTILIZERS	1.22	59.31	977	59.31	977	118.62
CEMENT	21.21	605.00	573	605.00	573	1210.00
COAL	25.28	1817.39	1445	1817.39	1445	3634.78
MINERAL OILS	21.39	659.79	620	659.79	620	1319.58
LIME.& DOLO.	25.07	1283.28	1029	1283.28	1029	2566.56
IRONORE	11.76	422.42	722	422.42	722	844.84
BULK COMM.	134.96	6564.58	978	6564.58	978	13129.16

EXHIBIT 12.11
SCENARIO III

ACTUAL RAIL MOVEMENT, (34.4% EMPTY)

COMMODITIES	TONNES ORIG. MILLION.	LOADED WKMS MILLION.	LOADED LEAD KMS.	EMPTY WKMS MILLION.	EMPTY LEAD KMS.	TOTAL WKMS MILLION.
SALT	3.04	266.79	1764	139.90	925	406.69
FOODGRAINS	29.00	1976.62	1370	1036.52	718	3013.14
IRON & STEEL	12.33	668.64	1090	350.63	572	1019.27
FERTILIZERS	14.50	774.05	1073	405.90	563	1179.95
CEMENT	22.32	723.48	652	379.39	342	1102.87
COAL	109.50	3590.07	659	1882.60	346	5472.67
MINERAL OILS	21.69	685.23	635	359.33	333	1044.56
LIME.& DOLO.	9.16	194.57	427	102.03	224	296.60
IRONORE	33.01	606.06	369	317.81	194	923.87
BULK COMM.	254.55	9485.51	749	4974.11	393	14459.62

EXHIBIT 12.12
SCENARIO IV

ACTUAL RAIL MOVEMENT, (50% EMPTY)

COMMODITIES	TONNES ORIG. MILLION.	LOADED WKMS MILLION.	LOADED LEAD KMS.	EMPTY WKMS MILLION.	EMPTY LEAD KMS.	TOTAL WKMS MILLION.
SALT	3.04	266.79	1764	266.79	1764	533.58
FOODGRAINS	29.00	1976.62	1370	1976.62	1370	3953.24
IRON & STEEL	12.33	668.64	1090	668.64	1090	1337.28
FERTILIZERS	14.50	774.05	1073	774.05	1073	1548.10
CEMENT	22.32	723.48	652	723.48	652	1446.96
COAL	109.50	3590.07	659	3590.07	659	7180.14
MINERAL OILS	21.69	685.23	635	685.23	635	1370.46
LIME.& DOLO.	9.16	194.57	427	194.57	427	389.14
IRONORE	33.01	606.06	369	606.06	369	1212.12
BULK COMM.	254.55	9485.51	749	9485.51	749	18971.02

Chapter XIII

Conclusions and Limitations

1. This paper has developed a methodology to analyse the wagon utilisation by examining the wagon cycle. Wagon utilisation has been improved significantly in the past decade by bringing down the yard times (wagon cycle has come down from 15.2 days in 1980-81 to 11.4 days in 1988-89). The policy of a train load as the unit of traffic instead of the wagon load has led to this by avoiding the need for marshalling at yards. Wagon utilisation can still be improved at the terminals, to reduce the wagon cycle further by 25%, from the present 11.4 days. Increase in speeds may not lead to significant reduction in wagon cycle, though it would improve throughput.

2. This research has helped in developing a methodology to estimate the loaded wagon kms and empty wagon kms needed to move the traffic offered to the Railways. The operations research transportation model forms the core of the methodology. Since nine commodities alone account for about 90% of the traffic in terms of tonnes originating, or tonne kilometres or revenue earned, the model could be applied to just these nine commodities.

3. A lot of data limitations were encountered. Ideally, the data for the origin-destination demand of each of the commodities should be at the railway divisional level. This was not easily available. The same could have been aggregated by obtaining data based on commodity-wise station loadings, but with a lot of effort which may not be commensurate with the aggregate planning nature of the exercise. Finally, statewise supply and demand data for each commodity was obtained, from a variety of sources.

4. While using the transportation model, modal split assumptions between rail and road were made. Intrastate movement was assumed to be by road and interstate movement by rail, except in the case of cement and mineral oil where specific modal split data was available to justify some intrastate movement by rail also. The assumptions were primarily reflecting the short distance economics of road movement as also interstate tax "hassles" which are more applicable to road movement.

5. Since the data was aggregated to a state level (except steel production), this has resulted in inaccuracies in location, and distance data.

6. Another assumption which understates the rail movement is the single commodity nature of each bulk commodity, which is not true in reality. For example, steel is really about 200 different commodities, coal could be coking or non-coking, etc.

7. At an aggregate level, it appears that loaded rail movement demand is not likely to go up in terms of tkms or wkms. This is because road movement is ready absorb traffic growth and with a better spread of (new industry) locations, lead is likely to go

down. The only way railways would maintain their market is to aggressively seek it.

8. Empty wagon movement is quite efficiently done. Special purpose wagons or unit train movement is likely to increase empty wkm by 40% (ie from about 35% to 50% of total wkm)

9. Further work needs to be done at the Railway divisional level or even at the major station level. Data availability, and cleaning up may be a problem.

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