CHAPTER 8 ISSUES ON INTERMODAL TRANSPORTATION

8.1 INTRODUCTION

The Indian Government has substantially invested in the development of a comprehensive highway network in the Golden Quadrilateral and with this investment near to completion, plans to initiate a multi-billion dollar investment to create dedicated railway corridors for cargo transport from Delhi towards the east and the west on that same Golden Quadrilateral.

However, the development of new transport infrastructure is not enough to guarantee efficient cargo transportation. Transportation systems should be considered as complex sets of relationships between demand, the locations transport services, and the networks that support cargo movements. These structural conditions define the commercial environment from which are derived operational attributes such as transportation costs, capacity, efficiency, reliability and speed. Transportation systems are also defined by a complex set of relationships between transport supply defined by the operational capacity of the network, and transport demand defined by the purchase capacity and personal mobility of an economy.

International transportation of freight takes place at different scales involving intercontinental, inter-regional and regional movements and is therefore subject to cross-border considerations such as control, competition and cooperation. Globalization dramatically stimulated a growing need for international transportation, notably because of economic integration replacing the earlier fragmentation of production systems. The growing level of integration between production, distribution and consumption generated an increasing need for transport integration and - efficiency and the establishment of modern logistics.

With cargo transport acting as a catalyst and critical component of a strong and sustainable economy, capable of producing significant financial and economic benefits, appropriate transport policies need to be formulated which maximize the benefits and minimize the nuisances. One part of this policy is to correctly allocate, design and construct the necessary transport infrastructure, subject to careful planning. Although planning and policy are not always interlinked, it is preferable that they are closely related and follow the same integrated perception.

The constantly growing impact of the above summarized conditions is particularly notable for strong performing economies such as India. Transport policies generally follow the identification of a perceived problem or an opportunity and therefore shape the kinds of actions considered which in term influences transport planning. In formulating a coherent transport policy, many problems exist than policy makers formally address meaning that several sometimes critical issues remain unaddressed. In the context of the dedicated freight railway line, the same trend can be observed. There is a strong focus on assessing the feasibility of the dedicated freight corridor development without simultaneously considering in detail the needs to ensure that the planned investment also generates anticipated benefits. In particular, the efficiency of the dedicated freight railway corridor highly depends upon the forward and backward feeder movements, with the ports and inland (container) depots as critical interlinking infrastructure to the road sector, in an optimized corridor vision acting as feeder transport mode to transport the goods between the corridor transit points and the origin and final destination.

In this context, this chapter studies the current conditions of the freight transport in India in terms of its level of service and identifies the arising issues that can be generated from the complex transport system including ICD, port, rail and road.

8.2 ISSUES ON INLAND CONTAINER DEPOT (ICD)

CONCOR's service is currently focused on delivery between the western ports (Nhava-Sheva) and ICDs in the Delhi and surrounding areas. Providing quick and punctual service is essential element for customer satisfaction. Although CONCOR does not provide fixed rail freight service based on timetables, it provides on-schedule service so that basically freight arrives within the promised time.

Although the level of service is less satisfactory than a service according to a timetable-based service, CONCOR is eager to provide the best service possible via a cargo tracing service via Internet. The CONCOR service is therewith far more advanced than railway services in many developing countries where there is a constant stream of dissatisfaction with service because customers "don't know when the freight will depart (or arrive)" or "the freight cannot be traced while in transit."

Based upon interviews conducted during the Study, there are little complaints about delayed delivery as compared to promised time which allows concluding that transportation services offered by CONCOR are generally on schedule.

Looking at the ICDs in the Delhi region (see Table 8.1), the regular services are provided for:

- Nhava-Sheva port ~ TKD
- Nhava-Sheva ~ Dadari
- Pipovav ports ~ Dadari (1 run/week)

Table 8.1 Outline of Service for Main Northern ICDs and Nhava-Sheva Port

	Distance	Frequency	Time promised
TKD	1400 km	Daily (multiple)	42 hours
Ludhiana	1500 km	Daily	56 hours
Jaipur	1400 km	3 runs/week	72 hours
Jodhpur	900 km	3 runs/week	72 hours
Moradabad	1100 km	3 runs/week	60 hours
Dadri	1400 km	Daily	42 hours

Source: prepared using CONCOR website and MOL materials

In the east on routes to and from Kolkata, no weekly service are provided with.

8.3 ISSUES ON PORTS

It is assumed that the origin/destination ports for intermodal transportation in the eastern and western corridor are respectively Nhava-Sheva and Kolkata (Halida). Of these two key ports Nhava-Sheva is the principal gateway that accounts for nearly 60% of all the container freight handled in India. The volume of ocean containers handled is expected to further increase due to India's predicted economic growth, and the port is being expanded to handle 7.0 million TEU according to the JICA report.

In 2004, Nhava-Sheva port handled a total of 2.7 million TEU of freight, placing it 32nd in the world and port authorities expect to rapidly exceed 3.0 million TEU and climb in the top 30 ports in the world. This port is the gateway to all of India, and according to interviews, 30% in terms of TEU is for local needs in Mumbai area and delivered by road transportation while the remaining 40% is bound for other inland states, about 30% of that volume is carried by rail.

In contrast, the volume of containers handled in eastern ports is not impressive. Currently container transportation from Kolkata to Delhi is conducted on a spot basis, without any need for regular weekly runs. So focusing on Nhava-Sheva operation is an important issue to improve Indian intermodal transport.

Since Nhava-Sheva port is an extremely busy port that has been handling 2.7 million TEU with only two berths until starting operations on a third birth, the port is likely to be congested and unavoidably generate cargo throughput delays. However, the operational ability is not necessarily low. The loading and unloading capacity, for example in terms of hourly gantry crane operation, is about 25 TEU/hour, which is not at all low compared to other Asian countries. In spite of their relatively high operation performance, it is difficult for this port to cope with the sharply increasing volume of containerized freight, and in 2005, the port was forced to temporarily evacuate containers to the nearby Mumbai Port.

The condition of ship congestion at India's major ports over the past three years is summarized in Table 8.2. The congestion at Nhava-Sheva port is striking. Looking at the "Average Offshore Wait" at each port, Kandla Port and Nhava-Sheva port have required more than 10 days during the past three years, which shows that the waiting time for ships is very long at these ports.

Table 8.2 Port Congestion (unit: days)

	Average Offshore Wait			Average Loading/Unloading Time		
Port	2002-2003	2003-2004	2003-2004	2002-2003	2003-2004	2003-2004
Kolkata (Kolkata)	0.07	0.07	0	4.47	4.29	2.69
Kolkata （Halida）	3.51	3.36	6.05	3.02	2.87	3.02
Mumbai	3.60	3.60	5.73	5.06	4.1	4.37
Nhava-Sheva	11.45	9.36	10.56	2.28	2.04	2.32
Chennai	1.30	0.90	0.90	3.70	4.60	3.90
Kandla	16.8	10.8	15.6	5.94	5.06	4.65

Source: Ministry of Shipping

On the other hand and in sharp contrast, the "Average Loading/Unloading Time" (time from a ship's arrival at its berth until loading/unloading is complete) is rather short, conspicuously shorter than the average loading/unloading time at other ports in India.

In other words, the Figure 8.1 shows that the overcapacity at Nhava-Sheva has led to a phenomenon of ship's offshore waiting, but when ships arrive at berth, prompt service is provided that is not inferior to the level in other countries.

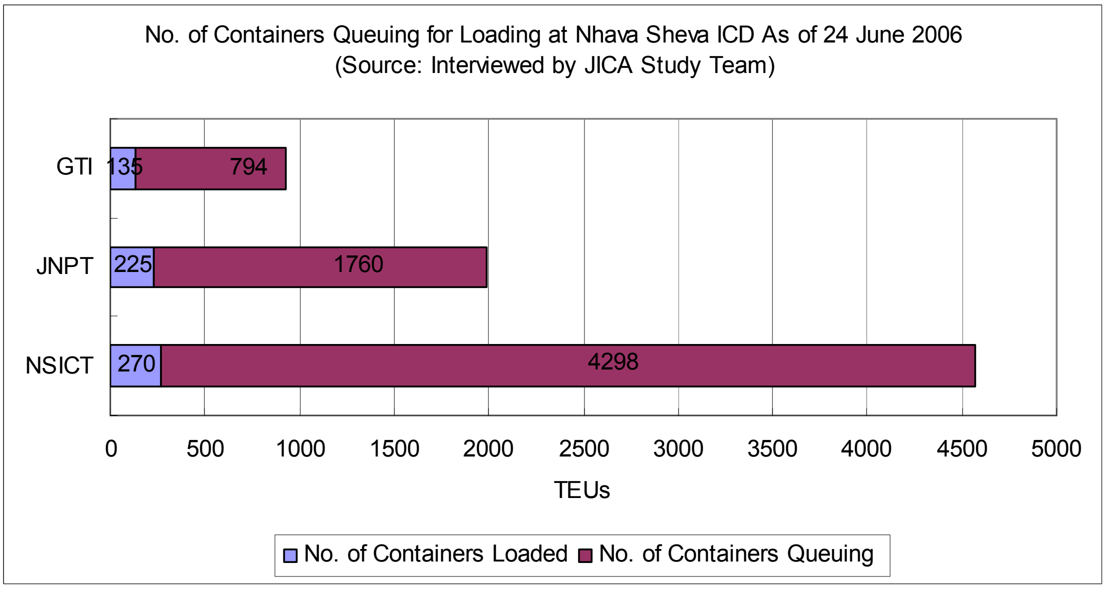


Figure 8.1 Container Queuing for Loading at Nhava Sheva

In spite of that, the long offshore waiting period lengthens the overall lead time before land transportation and is a factor hindering the delivery of freight as scheduled. There is a high possibility that the problem in the loading/unloading operation Nhava-Sheva port is a factor in the loss of reliability of not only ocean transportation but also inland transportation.

8.4 ISSUES ON PORT CONTAINER YARDS

The limited capacity of Nhava-Sheva port rapidly generates a hindering overflow of containers in container yards, in particular when containers are allowed to dwell for an extended period of time in the yard. Since much of the import containers at Nhava-Sheva are for local importers, backlogs of local containers lead to troublesome delays in particular disturbing rail transport. For that reason, this section will first investigate the workflow of operations for local containers, and next, follow up the operations for the transport of the containers by rail.

1) Local Freight

An efficient work pattern is implemented so that local containers pile up as little as possible within the port area. Containers off-loaded at the port are placed in the container yards areas designated to each shipping lines, then transported to the off-dock container yard (CY) outside the port where they are ready for customs clearance.

Due to the adoption of the off-dock CY system for customs clearance outside the port, Nhava-Sheva port succeeds in reducing backlogs for local containers inside the port area. In order to assist this system and to discourage importers to use the CY as a free storage area, the period of container storage free of charge is limited to only three days (as compared to for example one week in Japan). The limitation on free storage is a strong incentive to rapidly move containers to off-dock CY within 3days to avoid paying extra storage costs.

Not only ship companies but also warehouse companies are located in the off-dock CY, and a large number of containers (both full and empty) are positioned there. Developing off-dock CY avoids storage of containers in the port and makes it possible for local importers to pick up their containers relatively quickly.

2) Inland Freight

Six sidings are installed into the back area of the container storage are in the port. Containers for rail transport are moved to these sidings and loaded onto the freight cars. Daily reports are delivered to each shipping line concerning the container stockpile in the yard, containers loaded that day, and containers scheduled to be loaded the next day. According to these reports, the current backlog is notable.

Using the data of June 24 as example, the following observations could be made:

- The maximum number of departure trains around 10 a day (the shipping lines understand this to be due to the limitations of the rail capacity). Given that only 90 TEU can be loaded onto one train, making it possible to transport a maximum of 900 TEU per day, then looking at Table 8.3, an average of 12 days worth of containers are backlogged.

- The container stockpile exceeds 10,000 TEU see Table 8.4.

- In addition to the train departure schedule (actual figures) for the investigated day (nine trains departed this day), the schedule for the following day is also reported. Schedules for subsequent days are not available.

- Scheduled trains do not necessarily depart as expected. In this case, 16 trains are scheduled the next day, but the actual number will be reduced to around 10. Such reductions and alterations of the original schedule are common practice.

Table 8.3 Number of Trains, by Destination, Scheduled to Depart from the Terminals

	Today's Departures			Tomorrow's Departures		
	JNPT	NSCT	GTI	JNPT	NSCT	GTI
TKD	1			3	3	1
Ludhiana	1				1	1
Mulund	1				1	
Sabarmati	1				1	1
Baroda			1			
Ratlam		1				
Dadri		1	1		1	
Moradabad		1		1		
Nagpur				1		1
Total	4	3	2	5	7	4

Source: Materials provided by MOL (6/24/06)

Table 8.4 Number of Containers Stored at Terminals as of June 2006 (unit: TEU)

	Number of Containers Waiting at Each Berth				
	NSCT	JNPT	GTI	**Total to Destination**	**Percentage**
Agra	22	7	2	31	0%
Aurangabad	30	88	88	206	2%
Jodhpur	80	42	30	152	1%
Baroda	54	188	11	253	2%
Faidabad	218	8	7	233	2%
Chinchwad	12	38	0	50	0%
Kanpur	74	9	45	128	1%
Ludhiana	772	165	398	1,335	11%
Dadri	515	205	167	887	8%
GDH	1	0	0	1	0%
Jaipur	2	10	39	51	0%
Malanpur	1	0	1	2	0%
Moradabad	180	274	201	655	6%
MCT	1	0	6	7	0%
Nagpur	612	268	123	1,003	9%
Mulund	171	195	15	381	3%
Pithampur	32	10	8	50	0%
Rewari	12	0	0	12	0%
Sabarmati	252	191	125	568	5%
Hyderabad	178	103	103	384	3%
New Delhi (TKD)	3,281	1,615	364	5,260	45%
Total from Terminal	6,500	3,416	1,773	11,649	100%

Source: Materials provided by MOL (6/24/06)

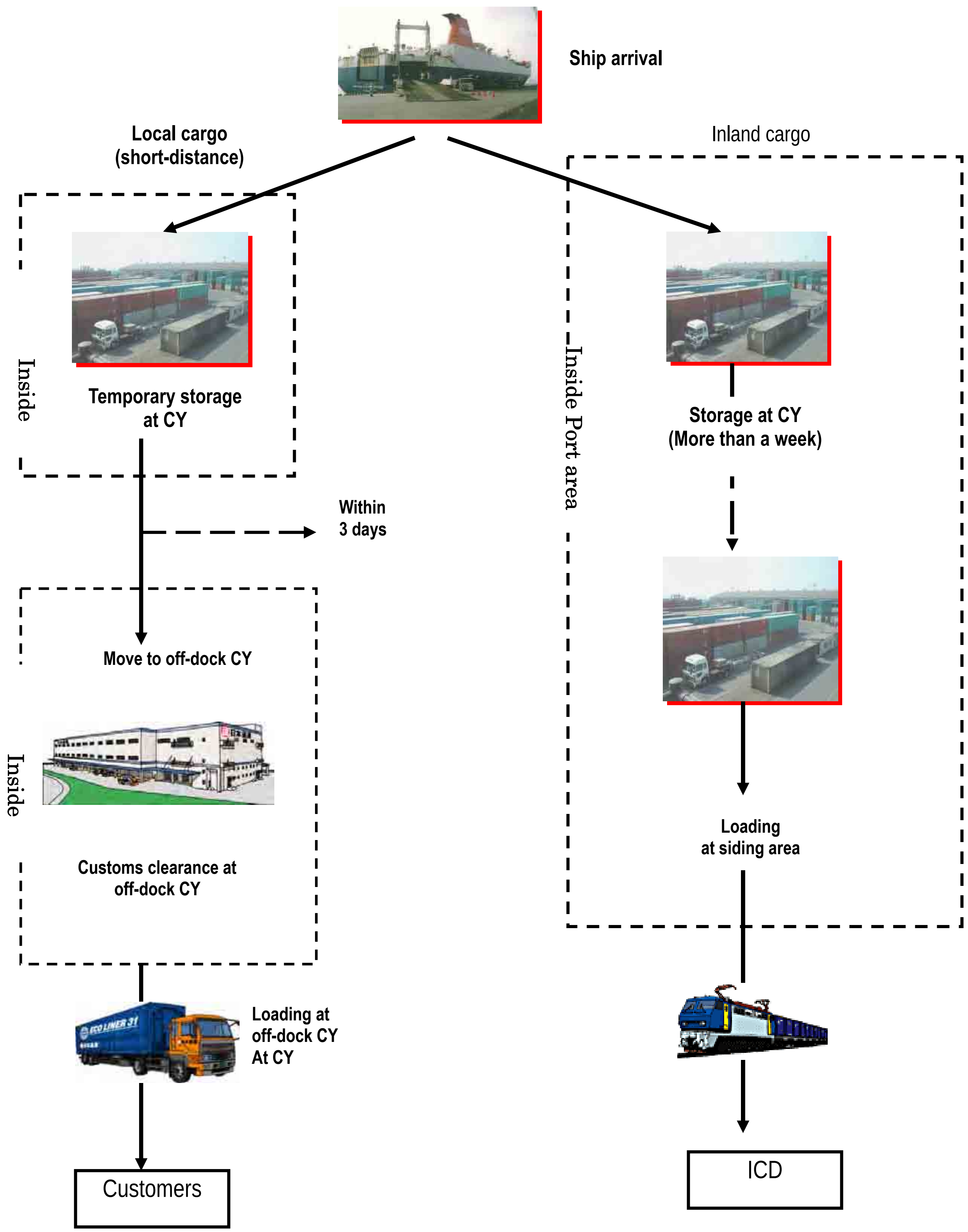


Figure 8.2 Flow of Local & Inland Cargo

8.5 ISSUE ON TRUCK TRANSPORTATION

8.5.1 Road Conditions

It is clear that transportation by railway will continue competing with door-to-door truck transportation. From a truly intermodal perspective, railway transport must not only be "competitive" with truck transport but will in time also have to "cooperate" with road transport as feeder mode. A similar phenomenon can be observed globally where railways' share has continued to decline together with the development of road transport, and India is no exception. For that reason, it is important to understand the situation of truck transport which at present only competes with railway transport without providing support as feeder mode.

According to India's 10th national plan, vehicles are estimated to have an 87% share of passenger transport and a 65% share of freight transport, road transport thus claiming a high percentage of freight transport. In addition, with the expectation that freight volume will grow at an annual rate of 7% to 10%, a large portion of the national budget and foreign funds are being invested into the improvement of road infrastructure, best demonstrated with the development of the Highway network in the Golden Quadrilateral, see Table 8.5.

As for railway transport more recently, the development of the "golden quadrilateral" highway network was considered much earlier as an extremely important factor for sustainable economic development because the national highways make up only National highways carry 2% of all roads in India, but 40 % of the transport volume.

Already a substantial amount of funds have been invested into the "golden quadrilateral" and a basic level of road infrastructure including two-lane roads has been installed as can be observed in Table 8.6. Regionally, basic infrastructure development in the western corridor of Delhi/Mumbai is nearly complete, and network quality improvements are emerging such as doubling existing two-lane roads to four lane roads. However, in the eastern corridor, there are undeveloped sections between Kolkata and Bihar, and the opening of all routes is still a distant realization and the overall condition of the road infrastructure in the west remains better than in the east.

Table 8.5 Development of National Highways

	Targeted Routes		
	Golden Quadrilateral	East/West and North/South Corridors	Connections to Ports, Others
Distance of Extension (㎞)	5,846	7,300	1,133
Completed	4,480	675	263
Under Construction	1,366	857	2,678
Cumulative Expenditure (10 million rupees)	20,115	2,131	1,928

Table 8.6 Development Plan for National Highways

Content	Planned and Actual	
Expansion to 2 lanes(Km)	Planned	832
	Completed	719
Expansion to 4 lanes(Km)	Planned	2,944
	Completed	2,386
Improvement of 2 lanes(Km)	Planned	3,535
	Completed	2,981
Bypass(No.)	Planned	12
	Completed	5
Bridges and Overpasses(No.)	Planned	232
	Completed	105

The development is planned to enable travel at speeds over 100 km/hour on national highways, see Picture 8.1.

Environs of Nhava-Sheva Port

Delhi Environs (National Highway

Picture 8.1 Current Condition of Satisfactory National Highways

However, although development of roads is certainly progressing, it is not yet possible to drive at the aimed-for high speeds on all national highways. Transportation companies also point out that the following factors hinder speedy delivery, see Picture 8.6.2.

- Even on national highways, there are bumps and holes that hinder smooth travel.
- There are few cases where the lanes are clearly marked, and so vehicles cannot travel smoothly.
- Traveling through towns, villages, etc., requires time, because few bypass roads for such areas forces drivers to slow down their vehicles for passing through.

- On the roads, there is a diverse assortment of farm equipment such as tractors as well as animals, including cattle and bicycles.

Even on the most recent four-lane roads, the lanes are not clearly marked, and the roads are not built to prevent entry from both sides of the road. So, it is likely that slow vehicles and animals will continue to mingle with rapid cars and trucks on the roads.

Farm tractor intruding on a national highway (going through the regular gate)

Motorbike going the wrong direction on a national highway.

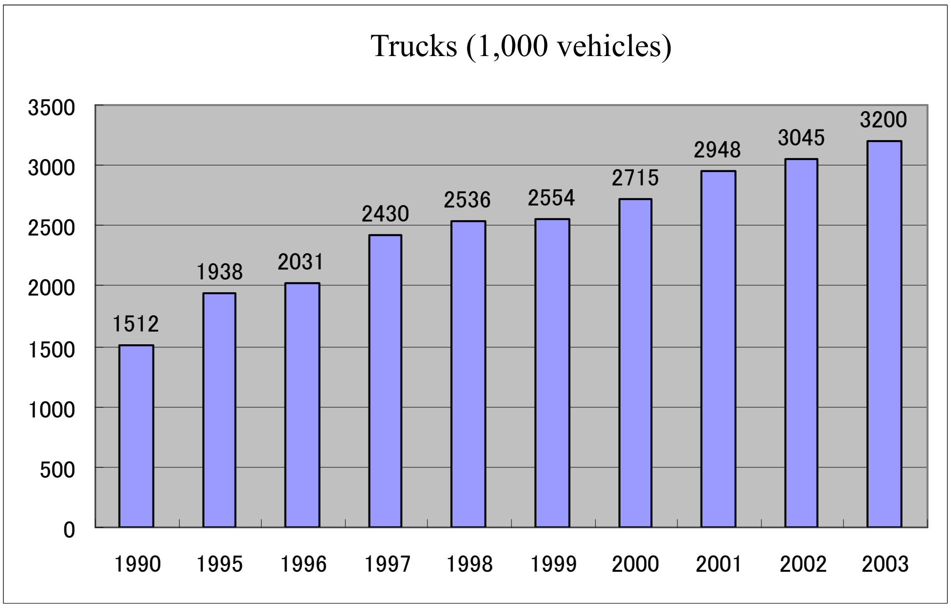
Picture 8.2 Examples of conditions that hinder travel on national highways

8.5.2 Trucking Companies

Together with road infrastructure, another critical factor for the trucking service is the quality of trucking companies that provide the service.

a. Transportation Industry

In the Indian trucking industry, nearly 85% of the operators work as individuals (owner drivers). Large trucking companies do exist, but many of them do not own their own trucks for transportation but act as "brokers", coordinating traffic via small and medium-size operators who own their trucks. Because the number of vehicles is steadily increasing (Figure 8.3) and more operators enter the industry every year, total capacity supply is growing with a rapid tempo, intensifying competition which in turn leads to lower transport fees. This whole chain of events creates an environment where very competitive transport fees are offered in contrast to rail transport where prices are notably higher. Meanwhile, it should be pointed out that lower fees reduce profits, making investments in modern equipment difficult if not impossible and over time negatively affects operational quality of the truck services in India. This indicates that, when it comes to service, the rail transport industry can easily differentiate itself from the trucking industry.



Source: Central Statistical Organization, Ministry of Statistics and Implementation

Figure 8.3 Trends in Number of Trucks Registered (unit: 1,000 vehicles)

A recent World Bank report presents an international comparison of transport fees (see Table 8.7), and according to it, the trucking fees in India are the most competitive in the world. This indicates the possibility that trucking fees may be cheaper than rail fees. Moreover, according to the same study, there are many advertisements of trucks looking for cargo in trade publications, etc., and looking at those, the fee for a nine-ton truck from Delhi to Mumbai is stated at approximately 15,000 rupees. (Since this was stated in a trade publication, there is a strong possibility that the actual fee is lower.). Regarding long-haulage domestic transport, it is not difficult for us to get cheaper truck deliver fee than rail.

Table 8.7 International Comparison of Trucking Fees per Ton Cost Price

Country	Ton Cost Price (US $)
India	0.019-0.027
Brazil	0.025-0.048
Pakistan	0.015-0.021
Central Asian Countries	0.035-0.085
China	0.040-0.060
US	0.025-0.050
Australia	0.036

Source: November 1,2005 "India road transport service efficiency study "WB South Asia regional office Energy & Infrastructure division

b. Quality of Service

Due to improved road infrastructure the speed of truck transportation has greatly improved. According to a study by the Japan Federation of Freight Industries in the year 2000, with an average daily travel distance of 100 km to 200 km, between 8 to 10 days would be necessary to travel 1400km between Nhava-Sheva and Delhi.

However, interviews in present year 2006 Study suggest that even if it is impossible to achieve travel speeds of 100 km/hour, assuming that the daily distance traveled steadily increases to 350 km/day, then an estimated travel time of approximately 3 days from Delhi to Nhava-Sheva would not be impossible. As a matter of fact, a Japanese motorbike manufacturer assigns transport operations between Nhava-Sheva and Delhi under a contract that stipulates a required transport time of 4 days with 10 hours of driving time per day at 35 km/hour. Local transport operators say that driving distances of 500 km/day are no problem, and longer distances are possible if there are two drivers. These examples suggest that the Delhi to Nhava-Sheva route can be covered in two days.

The above mentioned World Bank Report (page 13) which estimates the time required for the Mumbai-Delhi route at three days supports the PCI study on travel times for the Delhi to Nhava-Sheva route. Together with the installation of infrastructure, the swiftness of road transport is steadily increasing and is becoming increasingly competitive with the time of 42 hours that is provided by rail transport.

However, truck transport also shows several shortcomings:

- Although an average travel speed of 100 km/hour is planed in the infrastructure plan, that goal has not been achieved and estimated driving time tends to be longer than expectations.

- The proposed travel times are not reliable, and they vary widely. Whereas it is rare for the railway to deviate from an estimated transport time of 42 hours, in the case of road vehicles there is a lack of consistency and a high risk that the transport time will be longer than estimated, therewith endangering the fluidity of the total logistic chain.

- It is difficult to ensure safety during transport for drivers, cargoes or equipments. It is unfortunate that the safety level of both vehicles and road infrastructure is low, and there is a high possibility of accidents or breakdowns. Furthermore, there exists no system for compensation of damages using road transport further increasing the risks related to sending cargo by road. In contrast, rail transport is far superior in terms of safety and liability insurance.

Since infrastructure problems are already mentioned, other factors that hinder qualified road transportation service from the standpoint of operators are investigated in the next paragraphs.

<Driving conditions>

In northern India, there are three major seasons per year, see Table 8.8. There is only one of the three seasons appropriate for transportation by road. Drivers cannot drive during the daytime in the summer, nor can they drive during the rainy season when roads are submerged. Because the period for road transport operations lasts for approximately half of the year, it is difficult for trucking operators to provide stable and guaranteed services throughout the year. Driving at nighttime is indispensable for high-speed truck transport but due to the lack of streetlights, etc., it is far from safe and many accidents occur.

Table 8.8 Truck Transport Environment

Season	Months	Transport Conditions
Tropical Season	March-August	Driving during daytime is impossible because temperatures reach over 40 degrees Celsius. (Indian trucks usually have no air-conditioning, and it is hard for drivers to drive 'hot' daytime.)
Rainy Season	September-October	There are floods that frequently cut the road network. It is too risky for trucks to run at night.
Monsoon	November-February	Driving conditions are relatively good during this season. It is easier to stay on schedule than during the tropical and rainy seasons.

Source: "Report on Condition of Distribution in India" (in Japanese), Japan Federation of Freight Industries, 2000.

<Crossing Provincial Borders>

The Regional Transport Office (RTO) conducts systematic checks for transport of goods crossing provincial borders. This check at the border minimum includes vehicle registration, vehicle specification weight, and vehicle tax payment, etc.. There is variance in the time required for the control and its concrete impact of transport fluidity and guaranteed transport time is difficult to estimate. In order to avoid troublesome control procedures and operations for passing provincial borders, drivers adjust their schedules to pass though checkpoints at nighttime while they are closed.

To deal with the differences in the tax systems of different provinces, the documents to be processed before departure also requires a large amount of time and during the journey, there is a strong possibility that the police or other controlling organizations will stop the vehicle for checks and document examination.

The "transparency" of procedures for passing through checkpoints is not ensured and it appears that, in many cases, a speedy transit is secured in an amicable way via bribes.

<Quality of Vehicles>

Because of the very low quality of trucks and other vehicles used to transport goods, there is a large risk for serious breakdowns or accidents (overturn) while driving. The number of vehicles has been increasing constantly in recent years but this phenomenon has not been followed by an increase in vehicle quality because most small-scale operators cannot procure new (foreign-made) vehicles which are subject to high import taxes. Domestic manufacturers such as TATA make most of the vehicles operated by the small scale truck operators, and the quality of these vehicles is notably lower and modern equipment such as air suspension is not installed on the standard versions.

Because many vehicles are decrepit and lack horsepower, they are unable to maintain a steady travel speed over long distances and have serious problems driving regions with many hills or hard up-and-down tilting roads. Breakdowns of the Indian-made and worn-down trucks are extremely frequent because their basic design and engine construction allows drivers to do the repairs themselves if they can procure the parts. For that reason, many vehicles can be observed along the roadside which are being repaired by their drivers and the need of these frequent and artificial repairs guaranteeing the time of arrival becomes increasingly difficult the longer the distance of the trip.

The demand for highly qualified van-like vehicles remains low because there is limited demand for such high-performance vehicles. It is common use that versatile flatbed vehicles are contracted for general cargo transportation and flatbed trucks (not the tractor-chassis type) are used for ocean container transport.

Flatbed trailer used for containers

General-use trailer

Picture 8.3 Quality of Vehicles

8.5.3 Port Operations

(1) Mumbai Port

1) Port Operations

The main port operations issues (problems) are:

- Not sufficient draft due to the sedimentation and,
- The size of the vessel calling is reached by the narrow lock gate at Indian Dock
- The depth at Victoria and Princes Dock is 2 to 3 m at the present time since the port has not carried out maintenance dredging for low draft vessels, such as tug boats and barges.
- The container yard is occupied only at 40% of capacity at the present time, but it was almost 100% in 1997– 98. The container traffic has at present dropped to 150,000TEU per year, as compare with 660,000TEU per year in 1997/98.

The feasibility study in the development of the container terminal was carried out by JICA in 1997. In 2005, a local consulting farm (Consulting Engineering Service PVT LTD) carried out a revision of the JICA feasibility study. The Project consists of 1) construction of a jetty 800m long from the existing wharf, 2) construction of 3 berths and 3) reclamation and pavement at Victoria and Princes Dock as container yard. The Port Trust is predicted to increase 1.2 million TEU by after development of the new container berth. If this project is not implemented, container traffic will not be able to continue growing in the future.

2) Railway Operations

The railway between Vadala Road and Kurla lacks the necessary capacity and it is difficult to change to introduce the double stack system in a distant future since existing rail tracks from the port are electrified.

(2) Jawaharlal Nehru Port

1) Port Operations

The annual maintenance dredging volume at the turning basin and inner channel to maintain the 10.8 – 11.0m depth and 325m width is about 8 million m^3 at an annual cost of some Rs. 100 million. Maintenance dredging at the outer channel is further being carried out every 4 years and accounts for more than 90% of all maintenance cost for JNPT.

2) Railway Operation

Container transport via railways could in theory reach 35 to 40% of all transportation to and from the port, road transportation but is at present limited to 27%. The cause of this lower share is a consequence of mixing container cargo for JNPCT and NSICT and of a lack of wagons owned by CONCOR.

(3) Kolkata Dock System

1) Port operations

Previously, some 12,000TEU per year are bound for Delhi from APL vessels calling at kolkata Dock System. However, since APL vessels shifted to using J.N.P.T, there is no container cargo for Delhi left.

2) Railway operations

Of all containers from/to Kolkata Dock System, about 70% is handled by road and 30% transported via the railway system. It is expected that in the future, the share between both modes will switch as a consequence of increasing traffic congestion in and around the Kolkata Dock System. Tractor-trailer traffic is further prohibited in the city between 8:00 and 20:00, forcing these trucks to dwell during a long line in and around the Kolkata Dock System waiting to be processed.

A part of the area between the dock and the marshaling yard for freight trains was submerged after a heavy rainfall which still hinders the efficient use of the rail system at maximum capacity.

(4) Haldia Dock Complex

1) Port Operation

With APL container cargo shifting to J.N. Port in the year 2000, port for Delhi lost 12,000 to 15,000TEU per year it handled between 1997 and 1999. Water in the dock complex is also highly polluted from bulk cargoes such as iron ore and coal which spill from the apron into the dock after each heavy rainfall because these bulk cargoes are directly loaded/unloaded on the aprons at Berths No.6 to 9 without any protection or consideration of the effects of rain on the cargo.

Berths No.6 and 7 are called “Finger Piers” because vessels berth on both sides of the pier. It is impossible to handle dry bulk simultaneously on both berth sides of the pier due to the narrow width of the pier (only 15m). One solution to enable cargo handling on both berth sides simultaneously would be to handle dry bulk on one side and liquid bulk on the other side.

Unloading processes at Berths No.3 and No.4 have substantially deteriorated given the facilities were installed over 30 years ago.

2) Railway Operations

Wooden railway sleepers are used in the HDC area but the quality is low and it was observed that some railway rails wound from side to side.

(5) Gujarat Pipavav Port (Railway Operation)

According to the information from Western Railway, it is necessary to construct a modern office building to replace the present facility to improve container-related operations.

(6) Kandla Port

Engine escapes lines through crossover are not available in port area. A cargo stacking facility near the track in the port area is also not available and is urgently required to improve operations.

(7) Mundla Port

Bagged cargo loading lines and 2 coal loading lines are not connected with main line for engine escape and cannot be used for the placement of empty rakes in pulling mode.

8.6 COMPARATIVE CASE STUDY (RAIL VERSUS ROAD)

To consider the present efficiency of rail transport services, it is important to consider its level of competitiveness compared to its main competitor, truck transport. From a users' perspective, competitiveness and the level of services is in particular defined by the total lead time and total cost for transport via one of the two transport modes. Therefore, a tentative investigation is conducted to compare both lead times and transportation costs for traffic via road and rail between Nhava-Sheva port and Delhi.

8.6.1 Travel Time

At present, CONCOR's offered transit time for rail transport on the investigated corridor is 42 hours while the estimated time for trucks is three days. But the present case study will investigate the **total** transport time required from the moment freight arrives at Nhava-Sheva port.

In the past, rail transport was considered competitive with truck transport, leading the study of the Japan Federation of Freight Industries to conclude in the year 2000 that (Table 8.9)

- In the case of truck transport, there is a large element of uncertainty particularly for long-distance transport. There are problems in calculating the lead time, but given a daily average driving distance of 100 km to 200 km, the time required may therefore be estimated at about 8 to 10 days.

- For rail transportation, the estimated time is four to six days making railway transport in theory superior in terms of transport lead-time. However, if actual door-to-door delivery is considered, then it is necessary to add the days required from Delhi Station to the final destination which makes lead times for both transport modes similar.

Table 8.9 Comparison of Trucks and Rail (Nhava-Sheva -Delhi route)

Transport Mode	Required Days	Comparison of Both
Truck	8 – 10 days	- Rail is superior in terms of cost and time. - With rail, sometimes some freight cannot be loaded due to lack of space. - Superior points of trucks are delivery to the door and reliability of the departure time.
Rail	4 – 6 days	

Source: "Report on Condition of Distribution in India" (in Japanese), Japan Federation of Freight Industries, 2000.

Five years ago, rail transport was thus considered superior to truck transport. However, a survey conducted in the context of underlying Study reveals that railway's superiority is no longer maintained and direct delivery from the port by truck has become more competitive although there is discussion about whether or not road is quicker than rail or not.

Depending on forwarder and shipping line's calculation of lead time, actual transportation time by rail is 42 hours (2 days) an is this faster than by truck where it takes 3 days from the port area to Delhi. But again, considering total lead time, it is highly likely that rail transport is slower than trucks because the time for final delivery of the goods needs to be added to the transportation time of railway transport. A particular problem is the time required for loading the train because there is generally more than a week backlog of containers at the port, the "waiting time" for container transport via rail substantially increases the total transportation time required. In contrast, truck transport can depart faster than rail and is not hindered by backlog.

The particulars concerning the total time until door delivery are summarized in the following Table 8.10.

Table 8.10 Comparison of Total Time Required

	Truck	
Operation	Minimum	Maximum
Arrival in port and transfer to of-dock CY	2	3
Customs clearance	2	3
Truck departure – travel – arrival	2	4
Total	6	10

	Railway	
Operation	Minimum	Maximum
Arrival in port and loading on train	7	12
Train travel	2	3
Arrival at ICD and customs clearance	2	3
Pick up at ICD and shipment	1	1
Total	12	19

Source: study by this research group

Analysis of each element follows in the following paragraphs.

8.6.2 Rail Transport Case

a) Arrival in port and transfer to off-dock CY

The backlog of containers at Nhava-Sheva is long, with a backlog of 10 to 12 days worth of containers at the time of underlying study. Currently shipping lines are informing their customers that a period of one week or longer is required for loading trains after the ship's arrival. This long loading time makes up the majority of the total transportation time for rail transport. In addition, it is not known beforehand how many days will be required before freight is loaded onto the train because there are no fixed rail schedules. This is a major reason why freight owners avoid rail transport and prefer sending their cargo via the road.

As a result, the time required for this part is minimum 7 days. At maximum, it is estimated at 10 days and even 12 days at time of this study.

b) Train Travel

After containers are loaded on a train, it arrives in Delhi after 42 hours. Once freight is loaded on the train railways can almost guarantee to arrive at the ICD on time. The mode is thus highly reliable in terms of transport time during the physical movement. However, arrival at the ICD does not guarantee final delivery because it is necessary for the ICD to receive the bonded transport permit from Nhava-Sheva Customs Office to start the import declaration at the ICD.

After the shipping line submits the Cargo Manifest to the Nhava-Sheva Customs Office and after the customs manually inspect the cargo, one additional day is required for the ICD to receive the departure permit for transportation bound for ICD because the permit is sent to the ICD by courier.

The electronic data interchange (EDI) system between Nhava-Sheva Customs Office and inland customs offices is not completed and documents cannot yet be sent electronically. For that reason, shipping lines take into account the time required for customs procedures and inform customers that the time required is 60 hours which is longer than the physical transport time.

As a result, the time required for this part is two days at minimum. At maximum, it is estimated at three days (taking into account the time required to pass through customs).

c) Arrival at ICD and Customs clearance

In the case of Dadori ICD, one day is required from unloading from the rail car and placing freight in the storage yard. Thus freight handling at the ICD does not require a long time.

After freight is placed in the customs area, customs clearance can begin after receiving the import permits which requires two to three days f there is no problem with the documents.

As a result, the time required for this part is minimum two days and maximum three days.

d) Pick Up at ICD and Shipment

After the freight receives a customs clearance permit, it is possible to pick the cargo up. Delivery from the ICD to the final destination takes on average 1 day.

The time required for this part may be estimated at one day.

As a result of the above observations, the total time required to transport cargo via rail from origin to destination is minimum 12 days and maximum 19 days.

8.6.3 Case of Truck Transport

a) Arrival in port and transfer to off-dock CY

After being unloaded at the port, containers are moved to the off-dock CY within three days. The import declaration begins after the container is brought into the off-dock CY.

As a result, the time required for this part is two days at minimum and at maximum three days.

b) Customs clearance

If there is no problem with the documents and after declaration of the goods, custom clearance may be completed in about two to three days which is needed to screen the documents and payment of customs tax.

No difference was observed in the time required to clear customs at the ICD and at Nhava-Sheva Port.

As a result, the time required for this part is two days at minimum. At maximum, it is estimated at three days.

c) Truck Departure, Travel, and Arrival

Truck transport from Nhava-Sheva to the Delhi ICD is estimated at three days or two days with two drivers. However, as frequently stated above, it is difficult to guarantee the required time, which varies because

- There is a high risk of accidents (causing vehicle /cargo damage and delays),
- Time delays are suffered in crossing provincial borders due to administrative controls by Regional Transport Offices (RTOs),
- The road driving conditions change depending the season.

This is the negative and uncertainty aspect of truck transport, in contrast to rail transport which is basically always on schedule and independent of weather conditions. Moreover and as stated before, rail transport is more generous with damage compensation in case of accidents, and also the safety record of rail transport is far superior to the one of road transport.

As a result, the time required for this part is two days at minimum. At maximum, the time needed is estimated at four days.

For road transport, the total time required to transport cargo from the port to Delhi is minimum 6 days and maximum 10 days.

Concluding, truck transport is faster than rail transport by a minimum of six days or a maximum of nine days, and so rail transport is inferior in terms of time required. However, while truck transport is fast, rail transport is superior in terms of “punctual transport” and “cargo safety.”

8.6.4 Comparative Cost

In terms of total transport time, rail transport scores unfavorably as compared to truck transport, a phenomenon that can be observed in many countries where rail transport compares unfavorable with truck transport on a door-to-door basis.

On the other hand, it is usually regarded that rail transport costs are cheaper than the costs of road transport which is the main reason that transport by rail remains competitive to road transport and this in spite of the inferiority of transit times. But in the case of Indian cargo transport, there is high possibility that the cost of rail transport is not necessarily lower than road transportation costs.

In short, railway fees are made up of three components:

(a) Charges by Indian Railway to CONCOR (including profit)

(b) Charges by CONCOR to the shipping line (including profit)

(c) Charges by the shipping line to the customer (including profit)

Because profits are taken at each level, the total amount of charges to the final customer (component (c) above) is proportionally high. Of the costs, the amount (b) is disclosed on CONCOR’s website as tariff. Charges for tracking from Nhava-Sheva to TKD (which are the same as Dadori) are as follows

- 20-foot container: 20,100 rupees
- 40-foot container: 40,100 rupees

Assuming general cargo, which weights 20 tons in a 20-foot container and 27 tons in a 40-foot container

The amount of (c) is the sum of CONCOR charge (b) and the shipping line’s cost including container-positioning costs, administrative costs and others. According to interviews, there is variation depending on the shipping line, but a 40-foot container can be estimated at 50,000 to 70,000 rupees.

Meanwhile in the case of truck transport, there is no tariff system as with rail transport, and the charges depend on the market (demand and supply mechanism). Moreover, in a market environment whit many small operators and without any large operators who influence the market, prices tend to decrease. For this reason, charges vary widely depending on market conditions and various terms (content of freight, existence of return freight, season, etc.). Moreover, because truck charges are set with an awareness of the cost of rail transport quiet "cheap" rates offered by truckers-owners can be found in the market.

As a trial, inquiries were made for container delivery charges between Nhava-Sheva -Delhi under the condition that transit time is designated within three days (80 hours to 90 hours). Reponses were received from two companies and are represented in following Table 8.11.

Table 8.11 Estimates of Trucking Charges

	Container Type	Fee (rupees)	Fixed Lead Time
Transport Company A	20-foot	25,500.	72 to 80 hours
	40-foot	43,500	80 to 90 hours
Transport Company B	20-foot	30,000.	80 hours
	40-foot	55,000.	85 to 95 hours

Source: study by this research group

These charges are higher than CONCOR's charges, but they are competitive compared to the shipping lines' rates. *Thus, no advantage can be discerned cost-wise for rail transport.*

To corroborate the conclusion of the small test case that trucking charges are extremely competitive, the results were compared with the previously mentioned World Bank Study that analyzed the transportation costs of tractor-trailers type 3 that is commonly used for ocean container delivery. According to this report, the cost price is estimated at about 22 rupees per kilometer for a 27-ton tractor-trailer (Table 8.12).

Table 8.12 Analysis of Tractor-Trailer Annual Costs

(Based on data from 27 tractor-trailer companies; unit: rupees)

	Item	Large Companies	Small Companies
Direct Expenses	Fuel	746,667	711,100
	Lubricants	42,000	40,000
	Tires	191,520	182,400
	Parts	42,000	40,000
	Drivers' Salaries	177,000	168,600
	Repairs	42,000	40,000
	Road Tolls, etc.	84,000	80,000
Indirect Expenses	Administrative Personnel Expenses	120,000	0
	Taxes	54,910	54,910
	Interest	0	63,000
	Depreciation	315,000	225,000
	Other	79,500	112,400
	Profit		64,200
	Total Costs	1,894,597	1,781,610
	Km traveled	84,000	80,000
	Km unit cost	22.55	22.27

Source: "India Road Transport Service Efficiency Study,"WB South Asia Regional Office, Energy & Infrastructure Division, November 1, 2005.

Applying the World Bank assumptions, a fairly inexpensive rate of 30,000 rupees emerges calculated as 22 rupees times 1400 km. *According to the World Bank study, rail transport again does not have a cost advantage.* However, there remains the concern that cheap rates may not be accompanied by quality of service. The difference of costs with the test case is probably a consequence of the additional condition of "time required", making the proposed prices in the test case higher than those of the World Bank where no conditions were set and the cheapest cost selected.

If there is no advantage in cost, rail transport must offer advantages in punctuality and in travel speed. However, all respondents in the interviews of the test case, including local staff of transport companies and the auto industry (Suzuki, Honda, Toyota, Hyundai, etc.) indicated that they abandoned using rail transport on the given route and were shifting to truck transport. No clear reasons were given for the shift.

Needless to say, the auto industry poses tough conditions on transportation because it applies modern supply chain management techniques including "just-in-time delivery" and "kanban system", no inventory, guaranteed speed and punctual delivery. The fact that this industry terminated the use of rail transport indicates that rail transport services do not meet the conditions in terms of time required and transportation costs. There is concern that if rail transport does not improve in quality, this trend may spread from the auto industry to other manufacturing industries, consequence of the historically observed trend that policies adopted by the auto industry become a 'standard' for the manufacturing industry.

8.7 CONCLUSIONS ON CARGO TRANSPORT

Railway transport is rapidly loosing ground against road transport predominantly because railway transport is not competitive in the areas put forward as essential transport efficiency conditions, see Table 8.13

Table 8.13 Comparative analysis of competitiveness for rail and road

Competitive Factor	Railway transport	Road transport
Transportation time	2-3 days but only for rail tracking with necessary additional time for pre- and post activities, bringing **total transport time to 12 to 19 days**	Total time is between **6 and 10 days**
Transportation costs	Average transportation costs of a container is around **50,000 to 70,000 rupees** for a 40 feet container	Total cost for a 40 feet container is between **43,000 and 55,000 rupees**
On time delivery guarantee	Travel time is guaranteed but there is no certainty regarding the time when cargo is loaded on the train for transport	Travel time is guaranteed but the reliability of road traffic and of equipments is low, making the guarantee unreliable
Customer satisfaction	In spite the higher service quality in terms of accidents and damages (including compensations), the Indian industry is increasingly abandoning railway transport in favor of road transport	In spite of the low quality, the share of road transport is constantly growing at rapid pace. The reason is that in spite of its many deficiencies, flexibility and low cost, combined with the higher travel speed make road transport more attractive

As was argued in the introduction of this Chapter 8, the competitiveness of railway transport is not only defined by its assumed lower cost, more secure travel times and overall reliability of operations. On the contrary, the industry increasingly defines the usefulness of a transport mode on the basis of an integrated vision on logistics, where a wide range of decision factors influence the modal selection process.

Considering successful railway operations in other parts of the world, it can be observed that most benchmark / textbook examples are on dedicated corridors for dedicated cargoes, and this traffic is organized according to *intermodal transport corridor principles* whereby the total transport process is considered from origin to destination and each mode is used in the chain to maximize its competitive advantages. In general, this implies that road transport is used for pre- and end-haul while railway transport is selected for the long haul.

Consequently, the DFC project should not be considered as an end in itself, but should be considered as a first (indispensable) step in the development of an intermodal East and West Corridor. The intermodal corridor vision for the DFC project will be discussed in detail in Chapter 9.

CHAPTER 9 INTERMODAL TRANSPORT DEVELOPMENT STRATEGY

9.1 INTRODUCTION

India is one of the fast growing economies in the world, with a growth in GDP of 7.5% in the year 2004 and 8.1% in the year 2005[1] and is expected to remain very strong[2]. India is leading the economic growth in the East Asian region and accounts for approximately 70% of the region's output[3]. India's Tenth Five-Year Plan, covering the years 2002/3 to 2006/7, set forward some ambitious economic goals concentrated around a projected annual economic growth of around 8% over that period[4].

According to World Bank experts, ensuring and sustaining such ambitious economic growth will require substantial investments in 3 principal domains which are infrastructure, human development and rural livelihoods and on the participation of the private sector in the development of the necessary infrastructures (World Bank Strategy Paper, p 13). The Bank therewith reiterated its opinion expressed in the year 2002 transport sector report that poor transport has become a major drag on economic growth. India's transport system, especially surface transport has serious deficiencies and services are highly inefficient by international standards, generating losses estimated to be as high as 120-300 billion rupees (equivalent to US$2.6-6.5 billion) a year[5].

Major investments will be necessary if the transport sector will become a stimulator of growth rather than a hindrance. In particular the Indian Railways, a key component in social and economic development in the past, will have to undergo a major rehabilitation and transformation process at each structural level. "*If IR is to survive as an ongoing transportation organisation it has to modernize and expand its capacity to serve the emerging needs of a growing economy. This will require substantial investment on a regular basis for the foreseeable future*"[6].

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1 Asian Development Bank: "Basic Statistics – 2006", ADB, Economic and Research Department, 2006. The World Bank sets year 2004 GDP at 8.5% with an expected average growth of 6.9% till the year 2008.

2 World Bank ""Global Economic Prospects – 2006", IBRD / The World Bank Group, Development Prospects Group, 2006, p 2

3 World Bank *World Development Indicators – 2005*, IBRD / The World Bank Group, Development Data Group of the World Bank's Development Economics Vice Presidency, 2005, Chapter 5: Economy

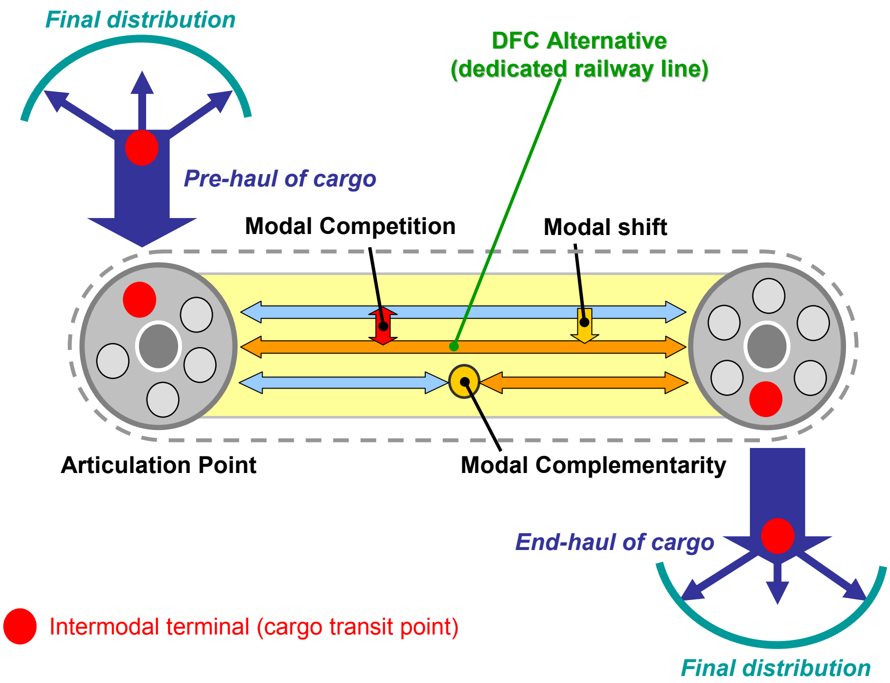
4 World Bank *Country Strategy Paper for India*, IBRD / IFC / The World Bank Group, India Country Management Unit, South Asia Region, September 2004, p 8

5 World Bank *India's Transport Sector: The Challenges Ahead*; the World Bank Group, 2002 Volumes 1, p13

6 Rakesh Moham Committee: *The India Infrastructure Report – Policy Imperatives for Growth & Welfare*, Rakesh Mohan Expert Group on Commercialisation of Infrastructure Project, 1996; Executive Summary Hihglights

The DFC initiative is undoubtedly a leap forward in the right direction and could open the way for a major transformation process for IR's freight transportation business where innovation, integration and private sector participation are key development components. The DFC project intends to develop its railway cargo service according to the corridor approach where freight is moved from origin to destination and the interference on the movement of goods and the flexibility of alternative routing is minimized. The corridor approach therewith aims at maximizing cargo throughput speed and minimizing transportation costs.

However, construction of railway infrastructure is only a part of the comprehensive effort that will be necessary to create an efficient and intermodal railway corridor, as clearly demonstrated in Figure 9.1.



Source: Study Team, based upon Rodrigue (2003)

Figure 9.1 The structure of an intermodal railway corridor

The DFC Alternative, consisting of the construction of a railway line dedicated to the transport of cargo is the central point of the intermodal corridor, although the efficiency of its operations is defined by the relationship with the other transport modes, in particular at the pre- and end- haulage stage of cargo transport.

In general terms, 4 critical efficiency components exist that will ensure efficient cargo flows from origin to destination:

1. *Intermodal equipments* consisting of adapted load and traction units;
2. *Intermodal terminals* where the cargo is transshipped from the road / sea to the railway car;
3. *Information management* that ensures the efficient flow of cargo along the corridor; and

4. *Expertise and know-how* of personnel that will ensure the best use of the state-of-the art equipment and technologies.

Each of these aspects will be briefly discussed in the following paragraphs after which, in a final paragraph, the observations will be related to the Project of constructing a dedicated Multimodal High-axle Load Freight Corridors with Computerised train control system.

9.2 INTERMODAL EQUIPMENTS

(1) Load units and traction systems

The efficiency of the intermodal transport chain is largely determined by the functioning of its individual components of which the intermodal terminal is the key to a competitive transport service, meeting customer requirements in respect of time, reliability and quality. But also modern intermodal equipment is a key success-factor and includes packaging systems (load units) transporting of cargo (transport or traction units), and the handling equipments which all are essential parts in intermodal efficiency, see following Figure 9.2.

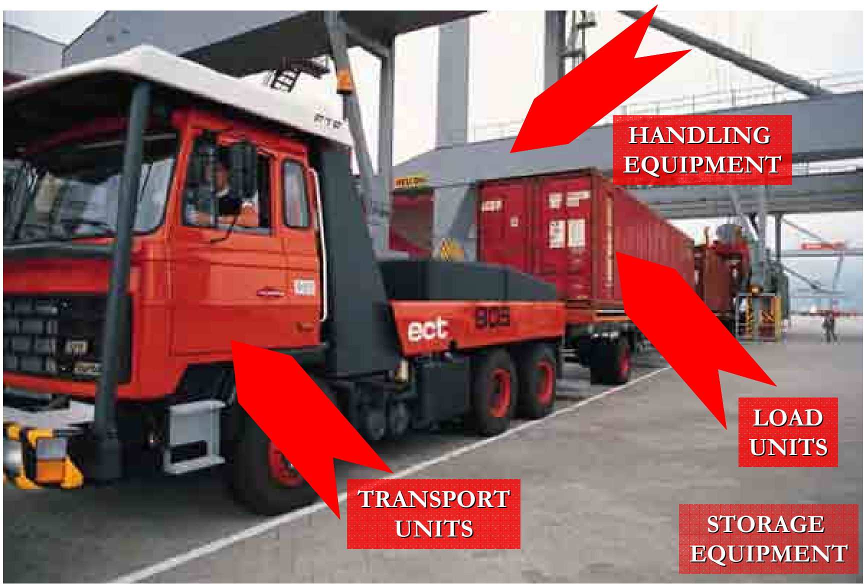


Figure 9.2 Components of efficient intermodal transport

Intermodal transport could not have grown into what it is today if not of the impact of the standardized load units. Nowadays, the load units used in intermodal transport are referred to as Intermodal Load Units or ILUs. Three groups of ILUs have emerged and each contribute to the continuing growth of intermodal and combined transport, notably

1. Container
2. Swap body
3. Semi-trailer

Complementary to the three ILUs, accompanied transport is also recognized as a type of intermodal transport because the driver of a road vehicle goes with his entire vehicle (load unit and tractor) onto a dedicated and specially equipped railcar or ferry.

Other standardized load units exist and have their merit, such as the pallet of which the standard pallet (1.02 m by 1.22 m) and the Europallet (0.8 m by 1.2 m) are the most common used in the US and maritime for the standard pallet and in European transport for the Europallet.

Containers

A container is the generic term for a box to carry freight, strong enough for repeated use, usually stackable and fitted with devices for transfer between modes. Container technology was first used in 1956, when a converted tanker carrying carried 58 trailer vans from Newark (New Jersey) to Houston (Texas) on a specially adapted deck. This public demonstration proved the feasibility of container transport and set off what was to become known as the "container revolution". It should be observed that it was not called the "intermodal revolution", a still ongoing (r)evolution triggered by the container as common denominator.

The 20 years that followed since the emergence of the container, the market and the applications expanded and until the late eighties, containerized transport was clearly divided between two components, the sea-leg and the land-leg of the journey with their operations and functioning almost completely separated. But the efforts by ISO and other organizations to standardize containers was a first step towards intermodal transport.

Nowadays, a wide variety of container types are operational among which the ISO-defined container (varying between 10 ft and 40 ft length), refrigerated or reefer containers for transportation of refrigerated goods, either integrated (with cooling unit) or insulated (without cooling unit but for low-temperature transport), tank containers either reefer type or classical for the transport of liquid products, ventilated containers for the transport of condensation sensible commodities, bulk cargo and dry cargo containers, and specialized containers.

The standardized identification of containers proved to be extremely important for the automation of processes and is done by means of a series of letters and numbers on all of the four sides of the container. The identification number includes the owner's letter code, a 6 digit serial number and a 7th control digit, and finally the code for the country of origin. The owner's letter code is based upon 4 letters of which the first 3 letters refer to the owner (e.g., TRL for Transamerica Leasing Co) and a 4th letter, which is U (for container, Z (for trailer) or C (for Chassis). A final 4 digit code identifies the type of container with the first digit indicating the length of the container (1 – 9 equals 10 to 45 feet container type); the second digit specifies the height and width of the container and the last 2 digits define the container type.

Containers are transported by one of three means of transport. The first is the container vessel (either maritime or river vessels), the second is the railcar and the third is via the road on a specialized truck.

The design of the railcar for the transport of containers remains relatively constant over the years and is predominantly divided between the US and European types, see Figure 9.3. The US types are for double stacking maritime containers while the EU railcar types are unable to transport double stacked containers but on the contrary are multi-purpose, able to transport various sizes of containers as well as swap-bodies and trailers on the same railcar.

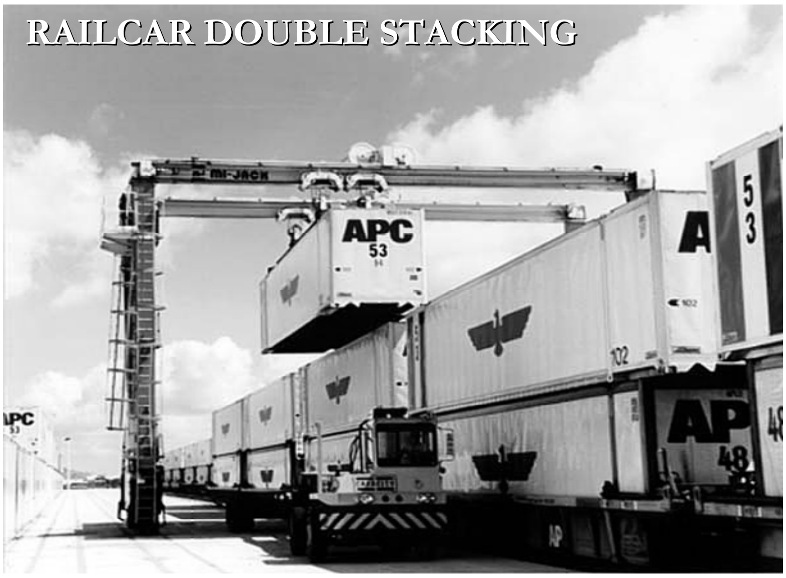


Figure 9.3 Modern US-type container railcar

Contrary to the railcars, the container vessel underwent substantial changes over the last 40 years. The first generation container vessels emerged before 1960 and were converted Dry Cargo Vessels with a capacity of less than 1000 TEU (Twenty Feet Equivalent Unit), generally around 700 TEU. The second generation of containerships were converted Oil Tankers that operated between 1960 and 1970 and had a capacity of approximately 1000 TEU. The third generation was the first vessel constructed specially for the transport of containers. This first Cellular Containership was of the Panamax Class and operated between the seventies and eighties and had a capacity of 2000 TEU. Since the end of the eighties, the evolution in container vessel design exploded with the introduction of Post Panamax Cellular Ships of the fourth and fifth generation with a capacity of respectively 4 to 5000 TEU and 5 to 6000 TEU and recently the first orders that are placed for the sixth generation exceeding 8000 TEU.

Also the road transport sector has adapted its equipments and now makes use of specialized chassis, allowing the container to be fixed to the chassis, after which the chassis is attached to a tractor for transport.

Swap-body

The swap-body originally was a special type of container. A freight carrying unit optimized to road vehicle dimensions and fitted with handling devices for transfer between modes, usually road/rail. Container-like swap-bodies come in many sizes and types and have as common denominator that they are, contrary to the ISO containers, designed for bottom-lift only and have a limited stacking capacity (maximum 3 high in some cases).

Swap-bodies can be divided into two main categories, the “tilt swap-bodies” which is essentially the body of the road haulage (very similar to the trailer and can have curtain walls) without the wheels and which is not stackable, and the all-steel construction which resembles the ISO container. Originally, the all-steel units were not capable of being stacked when full or top-lifted but many units now can be. The main feature distinguishing them from containers is that they are optimized to vehicle dimensions. Some swap-bodies are equipped with folding legs on which the unit stands when not on the vehicle. Many swap-bodies can be separated from their chassis and are fitted with extendable parking legs to allow the tractor driver to leave the ILU behind at the shipper's premises. But not all swap-bodies have legs and the final design of the swap-body largely depends upon their use and the nature of the traffic.

The most common swap-body is the 7.15 m (23.6 ft) long unit, but increasingly the 13.67 m (44.7 ft) unit (usually 2.9 m or 9.6 ft high) is used in Europe as this corresponds to the maximum allowed size of the European semi-trailer. As for the semi-trailer, the major markets for swap-bodies are Germany, Scandinavia and France. But with combined transport developing (partly also thanks to the Channel Tunnel) other markets are expected to emerge in Italy, Spain and the UK.

The swap-body represents in Europe the fastest growing market segments since the single market, the Channel Tunnel and the limitations for cargo to transit Switzerland by road stimulated combined transport (rail / road). Putting the swap-body on the railcar can be done either by using ro/ro (roll on / roll off) equipment or by means of lifting and stacking equipment that transfers the swap-body on the railcar, see Figure 9.4. Lifting equipment exclusively is used to put the swap-body on the chassis for transport by road.

Figure 9.4   Swap-body on road chassis

Semi-trailer

The third large group of intermodal load units is the semi-trailer. A semi-trailer is "a non-powered vehicle for the carriage of goods, intended to be coupled to a motor vehicle in such a way that a substantial part of its weight and of its load is borne by the motor vehicle"

Although European road transport is dominated by semi-trailers, accounting for 60% to 85% of total road volume, not even 5% of the semi-trailers are suited for combined or intermodal transport because semi-trailers must be specially adapted for use in combined transport a transformation process making the capital cost per unit much higher as containers or swap-bodies, generating higher unit handling cost and with the evolution towards large size (100 m2) and high volume (28 tons) semi-trailer systems, difficult the integrate in standard combined transport systems.

Semi-trailers thus come in many different forms and shapes, depending upon their use and functionality, see Figure 9.5.

Figure 9.5 Selection of semi-trailers

The semi-trailer can be “closed” or “open”. The *open* semi-trailers come with high-strength covering with or without gliding awning (Savojard) and / or curtainsider (gliding awning or covering systems). The *closed* semi-trailer can be without isolated walls (e.g. Plywood or sheet metal structures, etc.) or with isolated walls (temperature regulated semi-trailers) and can be volume-optimized or weight-optimized. There are also specialized semi-trailers for the transport of chemical and petroleum products as well as food commodities.

Although considered as a part of the intermodal family of load units, the semi-trailer is in reality still a road-based load unit, although gradually evolving towards a combined and intermodal transport application. The load unit ‘semi-trailer’ thus still stands only for a minor part of the total intermodal transport. The percentage of semi-trailers transported by rail (combined transport) has decreased below 10% of total Intermodal transport volume while the share of swap-bodies and even rolling roads constantly increased. The semi-trailer’s intermodal and combined transport qualities remain until now limited. Intermodal semi-trailer transport, this is combined and intermodal transport combinations together, is still developing and presently constitutes not even 5% of this huge market.

Transferring semi-trailers on the railcar is thus a complex process that comes in many different forms. Growth in intermodal semi-trailer transport by rail is slow because:

- Semi-trailers are compared to other load units very expensive. Such an investment requires a certain reliability to plan the future.

- Both weight and volume is limited in today’s craneable semi-trailers. These craneable semi-trailers have a higher dead-weight because of their required technical standards. Swap-bodies can carry 28 tonnes, Intermodal semi-trailers only in the range of 26 ½ tonnes. This difference is essential for the profit margins of the forwarder.

- There is an evident trend to longer and lighter semi-trailers to increase as much as possible the possible payload. In consequence this means that these semi-trailers are less craneable, most of them are not craneable at all.

- A swap-body has a life of app. 8-10 while a semi-trailer only has 7-8 years while maintenance costs for swap-bodies are far lower.

- Technical constraints:

- Non-standardised height of the coupling height

- Difficulties in operating the pneumatic suspension.

- The lifting equipment of the reach-stackers or the cranes sometimes damages the curtain-siders.

The semi-trailer should be clearly distinguished from the trailer, which is “a non-powered vehicle for the carriage of goods, intended to be coupled to a motor vehicle, excluding semi-trailers”. The trailer remains a road-based load unit and is therefore not included in the group of intermodal ILUs. The difference between the trailer and the semi-trailer is solely on the distribution of weight over the trailer and the market segment is gradually overtaken by the semi-trailer which is better adapted for combined transport applications.

But this does not mean that trailers are not incorporated in combined (rail / road) transport, commonly knows as Trailers On Flat Cars (TOFC), see Figure 9.6.

Figure 9.6 Trailers On Flat Cars

However, positioning the trailer on the flat railcar frequently poses a serious technical problem, making the option less attractive from a commercial point of view. One example by which the market tries to improve the quality and efficiency of TOFC and reduce its operational and equipment cost is by eliminating the railcar. The Road-Railer concept could be promising as it has several advantages of semi-trailer and container combined transport as it does not require the complex and expensive terminal equipment and is also less damaging to the payload as the slack action of the railcar is almost inexistent because the technology does not have traditional freight car couplings.

Given the wide variety of load units, not only the traction systems need constant modernization, but also the cargo handling equipment knows a constant evolution.

(2) Cargo handling equipment

Transshipment from a vessel to a truck or railcar is a segmented process referred to as "conveying", a process which can be continued (immediate transfer between modes) or discontinued (transfer with temporary positioning). Some conveying activities are increasingly automated while others are mechanical or remain fully manual. This depends upon the complexity of the loading units (trailers, semi-trailers, different types of containers etc…), the traction system and the handling equipment available. Sophisticated equipment is increasingly automated and is part of a computer processed and controlled handling and storage of the load units.

There are several steps in the throughput of an ILU in a typical terminal. Taking the example of a port terminal, once the ILU is on the quay, the ILU can be static (quay side storage), bound to hall (covered storage) or prepared for transfer (shipping via rail, road or river). In a next step, the ILU is either put in storage in the hall or directly put on the Intermodal Transport Unit, a railcar or truck (ITU) for shipment outside the terminal. Finally, the ILU that is stored in the hall will be put on an ITU and shipped outside the terminal. Automation is possible at most processing stages and in all phases of terminal operations. Although still far from a general phenomenon, the development of fully automated terminals is growing rapidly. In fully automated terminals, the combined use of optical recognition systems and computer-controlled operations allows a full terminal to be operated by very few persons, mainly to control the processes and not to operate equipment or take decisions.

It is important to remember that handling equipment has a wide range of variations due to their modular set-up and can be equipped with various kinds of different (additional) aggregates, according to the ULIs to be handled on the terminal. That demand is defined by the growing use of dedicated and specialized containers, swap-bodies and (semi-)trailers by the shipper, stimulated by the continuous search for lower cost and higher efficiency of transport.

Container handling equipment is the best known although also intermodal handling equipment exists for break bulk sea freight. Intermodal container handling equipment comes in various models and types and each have their particular function, depending upon the location where it is used, see Figure 9.7. The best known equipments are:

- **Container cranes (quay side transshipment)**: in the beginning, containers were handled using the ship's cranes but since 1959, shore-based cranes started to emerge in the terminals. The best known and most used are the rail-based gantry cranes. The growth in vessel size forced the continued growth in cranes starting from

    a. first generation in the 1960s with reach between 70 and 115 feet

    b. second generation in the 1970s with reach between 106 and 130 feet, known as the Panamax crane

    c. third generation since 1986 with a reach between 145 and 156 feet, known as Post Panamax crane

    d. fourth generation since 2000 with a reach of 170 feet, referred to as Post Panamax Plux

- **Spreaders and Frames (quay side transshipment)** : spreaders and frames are used with cranes to appropriate and hold the containers and come in 3 models, self leveling spreaders, fixed spreaders and expandable

- **Straddle carriers (transfer between quay side and intermediate or longer term storage area)**: are used to lift and then transport containers over short distances, e.g., between the loading area and trucks, railcars or storage areas. The carrier was first used in 1957 and underwent since then many changes, with an increasing computerization. Some of the most modern straddle carriers can stack containers 4 high.

- **Stacking cranes (container handling at storage area)**: these cranes are also known as rubber tired gantry (RTG) crane and fall between the gantry crane and the straddle carrier. This specialized equipment is used in the terminal to stack containers. It usually can stack containers higher and wider than straddle carriers.

Figure 9.7 Examples of modern handling equipments

9.3 INTERMODAL TERMINALS

Modern intermodal terminals are operated as multi-purpose-centres capable of handling every current intermodal load unit.

In the past terminals were regarded as "Black boxes" and designed as stand-alone projects without any attachment to logistics processes. An optimisation of the transhipment process as well as the costs was given little thought as the building and operations of the terminals were subsidised.

One of the main considerations in the development of new terminals is the cost and time factor of terminal operations in total transportation chain as compared to the absence of the terminal when transporting the cargo via the road. To be competitive in the intermodal freight transport market, terminals of the future must fulfill the following conditions:

- Simple, fast transshipment.
- High flexibility concerning capacity, storage capacity, terminal functions.
- Economical transshipment performance.
- Integrated IT.
- Optimal land usage.

The existing competition in modern terminal technology is between what is known as “Conventional terminals” and the new generation of terminals, known as “Compact terminals”.

The last generation of conventional terminals which cost approximately 30 - 50 million Euro, built after a prototype, with two Gantry cranes, which bridge 6 rail tracks, as well as 6 lanes, two for roads traffic and 4 for stacking of loading units. This initial terminal handles approximately 150,000 load units per year. An increase to 300,000 load units per year requires a track extension to 700 m as well as a third crane. The stacking of overseas (ISO -) containers is to be expected in a general-purpose Terminal. The 6 train tracks under the crane are 500 m long, i.e. a complete train cannot be serviced under the cranes. Rather, it is expected that the main line trains are composed in the marshalling yard for departure.

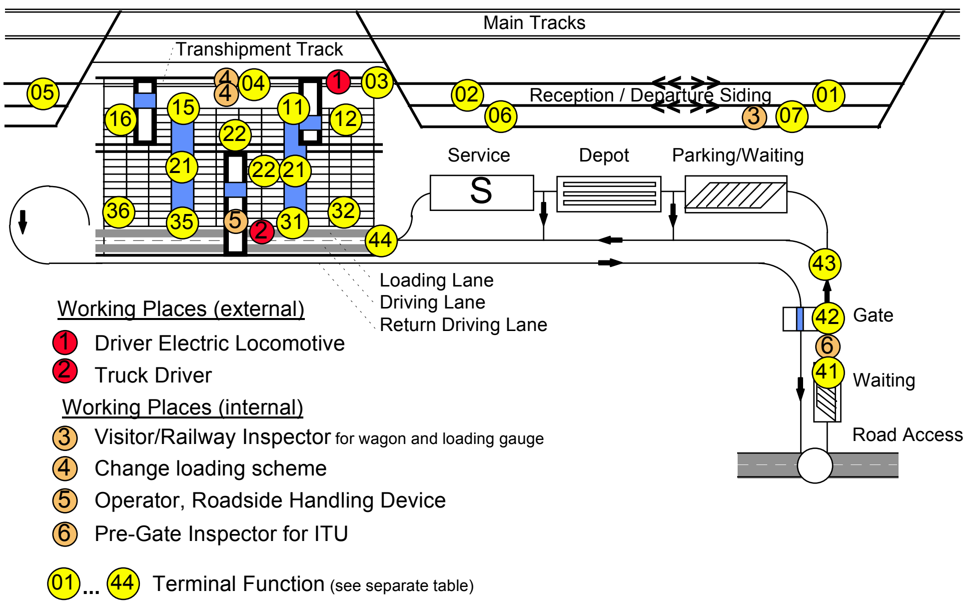
The compact terminal is the modern generation terminals, concentrating on maximizing efficiency and minimizing operational cost and transit time. Road-rail and rail-rail transfer become part of an optimised, competitive intermodal service to transport users. The compact terminal achieves the objectives of competitive intermodal service with:

- Modular construction
- Cost reduction in transhipment operations
- Minimal container handling during process
- High level of automation
- Optimal use of space

- Direct rail-rail/rail-road
- Integrated rail wagon/load unit identification system
- Damage elimination with vertical transfer in place of rail shunting
- High availability by use of proved and tested components
- Weatherproof operation at all hours with reduced noise levels

The objective in compact terminal development as well as in similar types on terminal technologies can be described as "lean logistics". Simple processes, minimal container handling with short transfer moves, no modifications required to rail wagons or load units, using wherever possible existing or proved individual components and low operating costs were the most important conditions imposed on the terminal design. An additional advantage of the compact terminal and other designs is that the modular design allows constructing these terminals in different sizes without loosing operational efficiency.

There no general standard for an intermodal terminal layout but following example for a road/rail terminal offers a guideline for an efficient terminal lay-out, making up the train operation siding are the reception and departure sidings, the erection, removal and transport tracks (loop lines and engine storage tracks) and, depending on the type of organisation involved, the transfer tracks. The transhipment plant comprises the rail transfer area, the materials handling equipment, the intermediate buffer area and the loading and travel lanes. The remaining area includes the approach road and the land made available for any congestion, the reception and departure gate(s), the traffic area (parking spaces and waiting areas, turning area and reversing lane), buildings and technical installations and service areas and depots where applicable.



Source: SAIL - project (EU project, reference 5FW n° 10277)

Figure 9.8 Basic terminal layout rail/road

The main terminal functions are listed in following Table 9.1.

Table 9.1 Main terminal functions

N°	Area/Function	N°	Area/Function (continued)
0	Railway Operation	2	Internal Transport/Buffer/Storage
01	Entering into Reception Siding	21	Internal Transport
02	Transfer from Reception Siding to Transhipment Track	22	Storage
03	Identification of Train, Wagon and / or ITU	3	Transhipment, roadside
04	Change to new loading scheme (spigots, semitrailer)	31	From Road to Buffer/Internal Transport
05	Exit Transhipment Track	32	From Road to Storage
06	Wagon Inspection/Visitor, Loading gauge (Dispatch) Breaking test	33	From Road to Rail
07	Exit departure Siding	34	(not applicable)
1	Transhipment, sail-side	35	From Road to Buffer/Internal Transport
11	Unloading Rail to Buffer/Internal Transport	36	From Road to Storage
12	Unloading Rail to Storage	37	From Road to Rail
13	Unloading Rail to Road	4	Road Traffic
14	From Rail to Rail (direct)	41	Pre-Gate Inspection of transport ability of ITU
15	Loading Buffer/Internal Transport to Rail	42	Gate Procedure
16	Loading Storage to Rail	43	Movement on driving paths and parking
17	Loading Road to Rail	44	Driving and Loading Lane

Source: SAIL - project (EU project, reference 5FW n° 10277)

Efficient terminals are a key aspect for the competitiveness of the integrated transport chain, see Figure 9.9. The type of railway access is an important element related to operation forms on network that influences terminal design. In particular the interfacing with advanced Intermodal-handling leads to automatic configuration of loading schemes and to fix ITU for save transport.

Source: SAIL - project (EU project, reference 5FW n° 10277)

Figure 9.9 Example of a modern terminal: DB-terminal in Hamburg-Billwerder

The share of the long-distance market already being considerable by the railways, the medium and short-distance markets are now coming into view. This is a market with large freight volume and the Shuttle-train seems to be a highly adapted and very economic method of transport. It is defined as a fixed composition of wagon, which is running twice a night between two terminals replacing one complete set of wagon. Shuttle-trains are therefore less expensive than pure road transport. Besides the origin-destination volume between terminals, such trains benefit from an enlarged catchment area and transfer from other destinations (hub system).

But advanced handling technology optimally supports such logistics, which is fully automated and able to serve these trains in the night nearly without employees leading to the increased importance of information technology and automation, briefly discussed hereafter.

9.4 INFORMATION AND AUTOMATION

The evolutions in integrated information management and automation have been discussed previously and several examples provided of detailed applications aiming at collecting and distribution information on cargoes and transport units. The examples made clear that IT plays an increasingly important role in transport operations and demonstrates its usefulness at various operational levels such as vehicle and cargo identification and tracking, terminal gate control etc…

The introduction of information technology and automation, in spite of its initial capital costs, will rapidly generate important savings because a relatively high level of errors and are eliminated with automation. Such inefficiencies include intensive checking processes, wasted manpower, performance failures and higher transport cost are all logical consequences of transshipment inadequacies and human-error.

For intermodal traffic, the principal aim is to obtain automatic and error-free information on the load units and (unaccompanied) transport equipment via the increased use of tracking and tracing (T&T) applications. These applications, although still predominantly implemented in road transport and terminal management, start spreading to railway networks. Although technical solutions are also available of the railways and a UIC Standard (DT 239) for automatic identification of rolling stock exists, there has been little progress in implementing such innovations in railway freight transport. Trying to eliminate human errors and increase transit speed requires in particular an efficient system of cargo and vehicle identification.

Several modern applications are briefly discussed hereafter.

A first IT application is *Automatic Vehicle Identification* (AVI) and is applied to systems which can automatically capture data for the identification of rolling stock. The functionality of such systems requires that rolling stock (ITUs – Intermodal Transport Units) is equipped with transponders (TAGs), on which specific data is installed: vehicle number, number of axles, tare weight, owner, etc. At neuralgic locations, such as transshipment terminals or rail stations, high frequency radio devices (interrogators) are installed which can read the data programmed on the tag, automatically. The data is passed to a defined interface and to a basic operating system. From here it goes over existing links to any desired system or location, to be processed and evaluated.

The UIC has established a standard for a unified European Automatic Vehicle Identification system in compliance with the prevailing UIC norm (ORE DT 231). The system has an open communication protocol, responding to the needs of network interoperability and free choice of sourcing. The performances comply with an even exceed the UIC specifications as the system has been successfully tested above 400 km/h.

A second application is the *Automatic Equipment Identification* (AEI) for the tracking and tracing of containers, swap bodies or trailers. ILUs are equipped with transponders (TAGs), on which specific data is installed. At neuralgic locations, especially at the terminal entrance and exit gates, high frequency radio devices are installed which can read the data programmed on the TAGs automatically, as the ILU passes. The data is then transmitted to a defined interface and further to a basic operating system, in terminals to the warehousing software that manages the positioning and control of the ULIs while remaining on the terminal. In Europe all this systems operates on the principle of modulated backscatter of radio-frequency (RF) signals, in the 2.45 GHz frequency band. The main elements of this system are TAGs (transponders), Antenna and reading equipment.

For the AEI, two standards regarding communication protocols exist:

- ISO 10374 (Freight Containers – Automatic Identification)
- CEN 13044 (Swap Bodies – Coding, Identification and Marking)

AEI applications also make frequent use of optimal identification systems. Cameras are strategically placed at the terminal/port gates to capture the identifying marks of ILUs passing through the portal. All containers, swap bodies, (semi-)trailers to be processed by automatic optical identification must pass single file through the image acquisition portal while maintaining a constant speed of between 3 and 24 km/h avoiding sudden changes in acceleration or stopping. To control this event, normally a traffic light (red, green) and a barrier gate will be placed at the terminal/port gate entrance to signal to the next driver for clearance through the portal.

Optical character recognition (OCR) is a third process that identifies alphanumeric characters from a black and white image and is used for inspection. The OCR process is normally activated on the left side, right side and back of the UTI and produces a high-resolution digital image of the top and nose, sides, and rear of all equipment that passes through the OCR night or day. This collection of images is stored locally for playback review on demand by a workstation user to perform a damage inspection, validate equipment identification marks and hazardous material placards. The greatest advantage of optical identification systems is their operational autonomy. Load units can be picked up optically without any additional fittings, using their visible identification number.

Contrary to the United States, this technology knows only a gradual implementation in Europe because of its relatively high system costs and the lack of comprehensive (100%) system performance.

A final large group of applications is the satellite based applications. Satellite based applications can be found in various field of public and private transport such as fleet control, automated ticketing, intelligent transport systems and management, safety and security applications (emergency services, tunnel control etc…).

In (intermodal) freight transport, satellite systems make it possible at any time a specific enquiry into location of rolling stock or load units. Satellite-based applications are nowadays widely used for ITU tracking and tracing and to follow cargo through the transport network. Most of these systems also incorporate sensors and other dedicated applications which allow the monitoring of the state of the cargo (temperature control) or its condition (anti-theft protection). The data communication from the on-board system could be made by satellite, by GSM SMS or both (Hybrid technology).

But satellite systems are, in contrast to AVI systems active systems. This means that they transmit and receive signals actively, and for this a source of power is required. Satellite based systems include the following components, which may be physically contained in a black box:

1. GPS component

2. GSM or satellite communication element

3. Battery or accumulator

4. Supplementary generator supporting batteries(solar, generic or any generator)

Therefore, most applications are applied on trailers and trucks where an energy source is available and are less successful when applied on ILUs or railcars. If applied on ILUs or railcars, supplementary generators are in most cases essential, since the operational life of internal power source is too limited. The operational cost of installing these systems on non-powered ILUs or railcars is costly in terms of maintenance, damage and replacement costs, etc…

The important role of information and automation becomes clear when looking at the world's transport integrators, the best known examples are the courier services such as DHL, UPS, FedEx, etc… These logistics specialists organize, control and manage global transport networks not only for courier services but also for cargo transport applications. Their services are based upon the collection in and long-haul transport between strategically located regional and final delivery, including high-tech information and automation services such as document and payment management and tracking and tracing. The dominant fields for automation and information management are schematized in Figure 9.10.

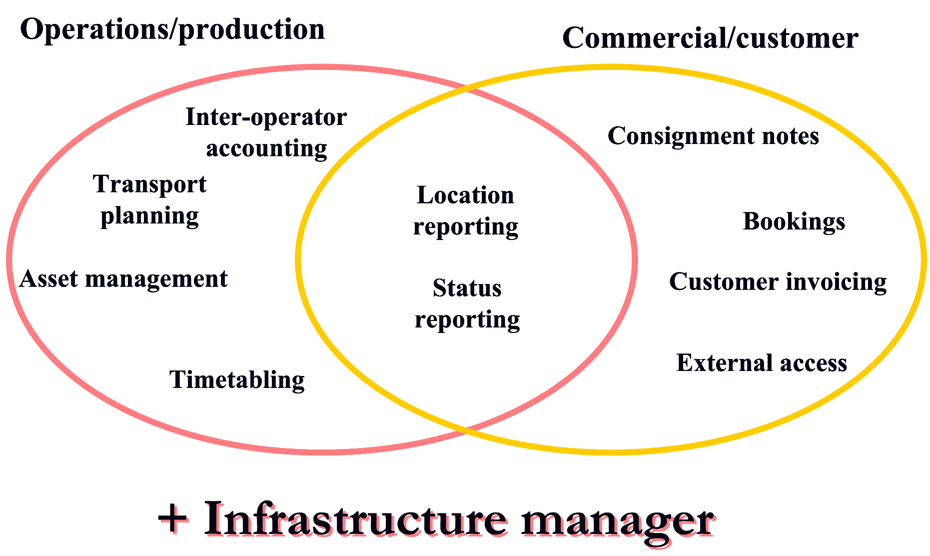


Figure 9.10 Main fields for automation and information

9.5 INTERMODAL TRANSPORT AND THE DEDICATED FREIGHT CORRIDOR IN INDIA

Outside the development of the dedicated railway cargo corridor, there is still much to be done if railways will become truly competitive, in particular in the domain of container transport, the construction of the dedicated railway corridor is only a part of the solution: “Rail linked container depots and integrated logistic parks will have to be created to make the new container policy successful and increase railways’ share in non-bulk freight business. Railways have enough land in its goods sheds, which could be made use of for this purpose. In this regard, we would encourage creation of such facilities …in a short time. With the help of this policy, we would be able to mobilize sizeable investments in container depots and container wagons.” [7]

But success will also come from investments needed outside the railway sector. Looking at intermodal transport from a corridor and a “hub and poke” vision, Woxenius (2001,2002) comes to the conclusion that the future corridor for trains (in Europe) will focus on *swap-bodies* and *containers* while semi-trailers will be gradually phased-out. Woxenius further focuses information as a critical factor because railways are country / region specific networks, requiring efficient multimodal gateways for connecting into a cross-border network. In his opinion, to achieve efficient operations in such complex environment, for long distance transport ISO-containers are primarily used in Intermodal services because they guarantee rapid and (cost) efficient transfer and are adapted to both railways and terminals.

Taking the wide spectrum of needs into account, following table 9.2 summarizes the results of comparing the railway sector in India with the requirements of modern intermodal logistics as discussed above.

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7 Speech of Shri Lalu Prasad Introducing the Railway Budget 2006-07 on 24th February 2006, Section on Record Braking Output in Freight Business, paragraph 21

Table 9.2 Comparing Indian transport with modern applications

Item	***India***	***Intermodal logistics***
Railway	Passenger and freight trains share the same track. There is no fixed schedule service for freight	Modern track system will be developed along the East and West Corridor Modern and standardized New tracks will be developed at high speed and automated signalling High speed (140 km/hr) and automated to allow maximized capacity utilization
Information management	Only limited application via CONCOR but no integration or cross mode linking	Fully integrated cross-mode systems allowing information processing prior to cargo arrival
Railway rolling stocks	It is expected that modern equipment will be used along the new corridor that allows double stacking of containers	Double stacking or multi purpose railcars
Other rolling stocks (road transport)	Trucks are outdated, badly maintained and not equipped for modern logistics or integrated services. Fragmentation and lack of know-how also reduce the efficiency of road transport and make the mode inadequate to be integrated in intermodal transport applications	Very modern standardized trucks adapted for intermodal and combined transport applications, possessing modern on-line information and communication technologies to ensure the optimization of integrated services (on time delivery)
Terminals (internal)	An increasing number of efficiently operating inland container depots are developed. Their internal functioning is modern and efficient with adapted technologies available. However, information management is lacking creating delays in pick-up, positioning and delivery of containers. Although documentation is frequently processed in a single area, all processing remains manual with substantial delays	Modern terminals are multi-functional, highly automated and use state-of-the-art information systems to handle the containers from the moment they enter the terminal to the moment of leaving the facility. Automation is increasingly used to reduce human error and increase transit times
Terminals (external)	Access to many container terminals is poor and the organization of waiting areas is chaotic, generating serious delays in container transit. In particular access to terminals in many Indian ports is problematic and is cause of long dwell times of containers. Customs services are not automated and systematic control of containers still applied, causing further delays in transit of containers through Indian ports. Customs services at origin or destination of cargoes is not a common practice	Although modern terminals have a waiting area, modern logistics processes, stimulated by the use of on-line information & communication systems allows timing arrival and departure to avoid waiting time at terminal gates. The location of terminals is also a studied decision where accessibility via available and well maintained infrastructure is a priority condition. Customs and security services are integrated in the logistics process and cargo is checked randomly without causing any serious delays. Customs services are available at origins and / or destinations of high volume cargo flows, e.g., at ICD or at the warehouses of major industrial shippers
Handling equipments	ICD in India have modern equipments to handle containers although the capacity of the equipment is sometimes not adapted to actual demand	Utilization of modern cargo handling equipment is a priority condition in modern terminals and these equipments become increasingly sophisticated to meet the ever complex requirements of the latest generation of load units. Equipment to handle containers is also increasingly automated and connected with the terminal's information system.
Automation	Not or only scarcely available in logistics processes	Widespread and the applications are constantly growing

Source: Study Team

Many of the flaws in the Indian transport have been discussed in more detail in the Chapter 8 of this Report. Although many things remain to be done to upgrade the Indian transport system to international standards, three issues are critical for the successful realization of the DFC Project, namely

1. The improvement of vehicles used for pre- and end-haul in the corridor, and

2. The improvement of infrastructure to access the terminal and to better organize the waiting times of trucks.

3. Capacity improvement at terminal such as port and ICD and efficiency improvement in document transaction including custom clearance, etc.

Of course, these three components are only the first steps in a complete overhaul of the sector where improvements are made in all aspects of the intermodal transport chain and which have been briefly discussed in this Chapter.

The reason why immediate attention should be paid to the quality of trucks and terminal access is because these have an immediate impact on the efficiency of operations along the new railway infrastructure and consequently on benefits that can be generated. The following pictures (Figure 9.11) clearly demonstrate the validity of the argument.

Indian application	vs	Modern intermodal logistics
	vs	
 	vs	

Figure 9.11 Comparing systems

The first row of pictures compares container operations and equipment in terminals, and shows clearly that at that level, Indian terminals are at equal level. But the transport of containers in the terminal demonstrated in the second row already shows that investments are required to purchase dedicated traction systems to transport containers inside the terminal. The discrepancy between the Indian system and modern logistics applications becomes even more obvious in the third row of pictures, where the terminal parking area and trucks are compared. In India, old vehicles are randomly scattered over an area that is artificially organized as waiting space, although no real accommodations are available or any organization and structure implemented, contrary with modern terminals where organization is a key component to ensure efficient throughput.

Finally, container technology and road transport of containers is visualized in the final two rows of pictures and clearly accentuates that much still needs to be done to make the road transport sector efficient and adapted to the requirements of modern logistics. Furthermore to achieve efficient and safe road transport, it is imperative that truck traffic is also organized along the roads and in particular highways where the sides are constantly used as parking space.

CHAPTER 10 DEMAND FORECAST

10.1 INTRODUCTION

The objective of this chapter is to provide numerical clue for planning the freight transport services, rail systems and associated infrastructure of the DFC project. The study also required to provide essential inputs in selecting preferred alternatives and for preliminary economic and financial analysis for the DFC project.

In order to achieve the above-mentioned study objectives, this chapter initially explores recent methodological discussions on the freight demand forecast followed by a review work on RITES report. This chapter goes on to identify an appropriate methodology for freight demand forecast of this DFC project. Finally and foremost, this chapter explores a preliminary work on the freight demand forecast along the DFC.

Traffic demand forecast models, which can deal with both of the freight and passenger demand, shall be developed for this DFC project, as indicated in Chapter 2 of this report. The forecasting models are developed by two stages, namely, preliminary model for assessing three candidate alternatives at conceptual level of detail, and more detailed transport model which can discuss the selected alternative with the information of detailed engineering study in the latter phase. In this chapter, the former model is studied and developed based on the available statistical data and a supplemental field survey newly conducted by JICA Study Team.

10.2 METHODOLOGICAL DISCUSSION

10.2.1 Literature Review on Demand Modeling

In general, freight demand forecast models have been built on either of two approaches: 'vehicle (trip)-based' or 'commodity-based' modeling. As the names suggest, these approaches model vehicle trips (the number of trips) and commodity type typically by size and weight respectively. Common to both approaches are trip generation, trip distribution and traffic assignment. This section starts to review these two approaches studied by Holguín-Veras (2001)[1].

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[1] Holguín-Veras J. (2001) AN ASSESSMENT OF METHODOLOGICAL ALTERNATIVES FOR A REGIONAL FREIGHT MODEL IN THE NYMTC REGION, City College of the City University of New York

(1) Vehicle (Trip)-based Model

Trip-based models focus on modeling vehicle-trips. Since the focus is on vehicle-trips, which presupposes that the mode selection and the vehicle selections are given, trip-based models do not need mode split or vehicle loading models. Trip-based models have some advantages. First, traffic data is relatively easy to get. Second, since the focus is on the vehicle-trip, considering empty trips does not present any major problem. The model generally consists of the following steps:

1. Obtaining data on economic activity for traffic analysis zones;

2. Applying trip generation rates to estimate the number of vehicle trips for each traffic analysis zone;

3. Estimation of vehicle volumes at external stations;

4. Estimation of the number of commercial vehicle trips between pairs of traffic analysis zones or external stations;

5. Estimation of the mode share for each trip;

6. Loading the O-D trip to the network; and,

7. Calibration of estimated vehicle-km with control vehicle-km.

(2) Commodity-based Model

Commodity-based models focus on modeling the amount of freight, generally measured in tons. It is accepted that the focus on the cargoes enables commodity based models to capture more accurately the fundamental economic mechanisms driving freight movements, which are largely determined by the cargoes' attributes (e.g., shape, unit weight).

Commodity based modeling is comprised of the following process: Commodity generation models are used to estimate the total number of tons produced and attracted by each zone in the study area. Next, in the distribution phase, the tonnage moving between each origin-destination pair is estimated using gravity models and other forms of spatial interaction models. The mode split component, intended to estimate the number of tons moved by the various modes, is done by applying discrete choice models and/or panel data from focus groups of business representatives or freighters. Finally, in the traffic assignment phase of commodity-based models, a combination of vehicle loading models and complementary models that capture empty trips, applied to origin-destination matrices by mode, are used to assign vehicle trips to the network.

10.2.2 Review of RITES Report

A review work on RITES report[2] (PETS1) is available in the Progress Report 1[3] of JICA Study and is summarized as below.

[2] RITES (2006) Preliminary Engineering-cum-Traffic Survey for Dedicated Multimodal High Axle Load Freight Corridor

[3] JICA (2006) The Feasibility Study on The Development of Dedicated Multimodal High Axle Load Freight Corridor with Computerised Control for Delhi-Mumbai and Delhi-Howrah in India

(1) Bulk Cargo

Regarding bulk cargos, traffic and transport projection in the RITES report was made through interviewing the Zonal Railways, obtaining their perspectives on traffic growth and existing and future development plans, and setting up industrial/consumption growth scenarios. The detailed projection study, especially that on coal and iron & steel, was made by interviewing major industrial entities and trade organizations along the corridors to obtain an independent perspective on future development.

1) Target Year

Target year of DFC project is set Year 2021/22 and projections have been made for freight traffic for 17 years from Year 2004/05.

2) Forecasting Method

The freight forecast in the RITES report is based on commodity-wise O/D matrices by rail. Growth rates or the future transport volumes themselves were directly applied to each OD pair per commodity.

3) Baseline Data

The commodity wise O/D matrices were elaborated from CRIS data of March 2005, which is the busiest month in terms of freight transport volume throughout the year.

4) Projection

RITES report made a projection of the future freight volume through two approaches: 1) estimating future traffic volumes based on business/development plans and 2) setting growth rates per commodity. Coal for thermal power plants and iron & steel along the east corridor were projected by the former approach by obtaining detailed sector development projects. Growth factor method was applied to the other commodities through obtaining the trend of traffic volumes and local perspectives on traffic growth. The growth rates applied to each commodity in RITES report are summarized as follows.

Table 10.1 Growth Rates Applied in RITES Report

	Eastern Corridor	**Western Corridor**
Coal for Thermal Power Plants	- Around 10% estimated from coal demand for thermal power plants	3% growth rate
Coal for other purposes	- No increase in coal for fertiliser plants - 2% was adopted for public coal	7% was adopted for imported coal
Ore		5%
Iron & Steel	- Around 14.5% up to 2011 and 8.3% afterward estimated from production plans of steel plants	5%
Cement	5%	5%
Food-grain	2%	2%
Fertilizer	2%	2%
Others	Not mentioned	3%

Source: prepared by JICA Study Team based on RITES-F/S

5) Modal Share

Modal share was not explicitly mentioned.

(2) Container Cargo

1) Target Year

The same target year with a bulk cargo projection, Year 2021/22, is set and projections have been made for freight traffic for the next 17 years from Year 2004/05.

2) Total Container Traffic

Container traffic forecasting of the western corridor by RITES were based on the previous port studies[4]. Total container traffic volume was estimated by two sets of growth rates: 12.6% and 13.65%.

3) Container Traffic at Western Ports

Container traffic at the western ports, e.g., JNPT, Mumbai, and Kandra, accounts for 67.6% in 2003-04 of all container throughputs in India. A share of the container traffic at the west is assumed to slightly decrease to 61.0% in 2021-22.

4) Modal Share

At JNport, 27 % of container traffic is transported by rail in 2003-04. For the projection, RITES report favours railway transport and assumes that the share of railway increases to reach 30 – 45 %. This result was led by the local perspectives on the rail traffic growth, including that of CONCOR and Ministry of Shipping.

10.2.3 Methodological Implications to DFC Project

(1) Mixed Use of Vehicle- and Commodity-based Model

The availability of the data suggests that mixed use of vehicle-based and commodity-based model is useful to discuss the demand forecast of DFC project, especially on the bulk cargo. The CRIS database[5] includes train OD information by type of commodity as well as volume information. Accordingly both of the train OD and rail based commodity OD can be developed.

Since no information is available regarding commodities transported by other land transportation in the CRIS database, modal split issues cannot be discussed in terms of competition between rail and truck. However, when we look at historical data of the major bulk cargos transported by rail and trucks, there has been no significant changes in the modal share in terms of the tonnage carried by rail and trucks in recent years (see Box 10.1). This implies that the modal split issues of the bulk cargo is not significant for the demand forecast of DFC project.

[4] RITES (2005) Rail Transport Logistics Study for the Planned Development of JNPort
[5] Centre for Railway Information Systems

Box 10.1 Modal share in road and rail transport

Regarding information on cargo traffic in India, there are two fundamental sources: Total Transport System Study (1987) studied by Planning Commission and Study on Decline in Railway's Share in Total Land Traffic in India (1997) studied by Ministry of Railways. Commodity-wise OD survey was carried out to grasp the cargo movement by major modes of inland transport. Looking at the trend of the modal share from 1986 to 1995, there has been no significant changes in carrying nine major commodities, of which the transport largely depend on railway. It should be noted that Total Transport System Study is currently being carried out by Planning Commission and will provide an essential input for the demand forecast of this Study.

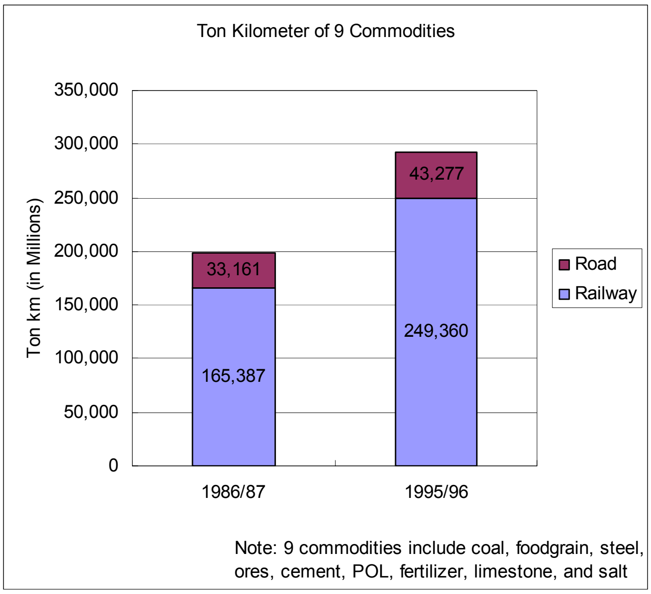

Figure 10.1 Share of Rail and Road Transport

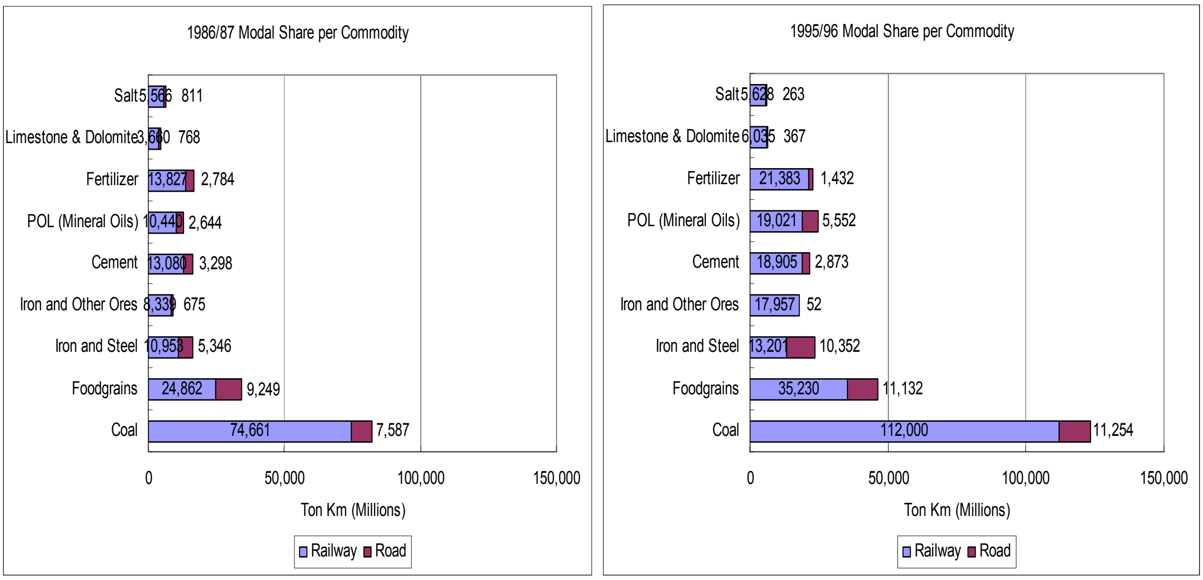

Figure 10.2 Share of Rail and Road Transport per Commodity

Source: Planning Commission (1987) Total Transport System Study and Ministry of Railways (1997) Study on Decline in Railway's Share in Total Land Traffic in India

On the other hand, the commodity-based model is applied to the container demand forecast of DFC project. It is because the commodity-based model focuses on modeling the amount of freight measured by any comparable unit, such as TEU, and capturing more accurately the fundamental economic mechanisms driving freight movements. Also, the commodity-based approach can incorporate the modal choice model, which is largely determined by the cargos' attributes (e.g., shape, specific weight, volume).

(2) Further Implications for Demand Forecast of DFC Project

The review work on RITES report provides further implications to demand forecast, and some are listed below:

- Projection period should be 20-30 years, considering a scale of the investment in DFC project and the service periods of DFC project. Assuming DFC project terminates its construction work by 2011, it is reasonable to set Year 2031/32 as the target year for DFC project.

- RITES report may overestimate the traffic volume, of which the annual figures are estimated based on traffic data of the busiest month. Thus, the baseline data should be revised, based on annual traffic data to avoid peculiar information.

- Regarding the bulk cargos, excluding coal and iron & steel, the growth rates applied to the freight projection in RITES report, are considered a little vague. Thus, the growth rate of each commodity should be justified based on historical traffic trends and economic activity.

- At last, to incorporate a cross section method and modal choice model into container demand forecast is vital. It is because the tendency in container traffic is by and large determined by the global economic activities and tends to follow development trend of the advanced countries. Also road transport becomes more competitive even in the long-distance freight transport due to the recent development of highway network. Thus, alternative approaches for container cargo projection should be well considered.

10.3 METHODOLOGY FOR FREIGHT DEMAND FORECAST

10.3.1 Factors Affecting Freight Demand

This section identifies and describes a number of factors that affect the freight demand. The factors may either directly influence the demand for goods and services; or they may impact on the costs and/or levels of service of freight transport modes, which influence whether or not the freight demands will be met.

The discussions pertaining to the factors affecting freight demand are mostly adopted from the Quick Response Freight Manual[6]. The essential factors that need to be incorporated in the model include:

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[6] Federal Highway Administration (1996) Quick Response Freight Manual prepared by CAMBRIDGE SYSTEMATICS INC. COMSIS CORPORATION and UNIVERSITY OF WISCONSIN -MILWAUKEE

1. Economy and Population, 2. Industrial Location Patterns, 3. Globalization of Business, 4. International Trade Agreements, 5. International Transportation Agreements, 6. Just-in-Time Inventory Practices, 7. Carrier-Shipper Alliances, 8. Centralized Warehousing, 9. Packaging Materials, 10. Recycling, 11. Economic Regulation and Deregulation, 12. Intermodal Operating Agreements, 13. Fuel Prices, 14. Publicly Provided Infrastructure, 15. User Charges and Other Taxes, 16. Government Subsidization of Carriers, 17. Environmental Policies and Restrictions, 18. Safety Policies and Restrictions, 19. Effects of Changes in Truck Size and Weight Limits, 20. Congestion, 21. Technological Advances.

Freight demand forecasting model studied by JICA incorporates the following two factors: Economy and Industrial Location Patterns.

1. Economy and Population

As a derived demand, freight demand is primarily influenced by the volume of goods produced and consumed. Expansion in the national economy, or the economy of any region, results in increases in overall demand (in terms of volume) for goods and services. Overall economic condition is also indicative of the buying/purchasing power of the population. The types and values of commodities produced and consumed usually reflect this economic condition.

2. Industrial Location Patterns

Industrial location patterns are critical to determining transport demand as measured in ton-km, line-haul km or other units which reflect length of haul. The influence of spatial distribution can best be measured through its actual effect on demand - as average length of haul by commodity or total ton-km transported.

10.3.2 Forecasting Method

As discussed above, two different approaches are applied to the freight demand forecast of DFC project: mixed use of the vehicle and commodity-based approach for bulk cargos and the commodity-based approach for container cargos. The following figure shows the basis of the forecasting procedure as consisting of the following steps:

Step 1: Obtain data on economic activity for each traffic analysis zone (including population and gross (state) national products),

Step 2: Apply freight traffic generation to estimate the tonnage of commodity generated from each traffic analysis zone,

Step 3: Estimate the tonnage of commodity between OD pairs of traffic analysis zones,

Step 4: In forecasting bulk cargoes, estimate the number of trains by using the maximum capacity that can be loaded per train. For container cargos, develop a preliminary estimate of trains and commercial vehicles by using a table of zone-to-zone distances and time,

Step 5: In forecasting container cargos, compare the results of Step 4 and the control total from the actual survey data, and, if necessary, develop adjustment factors to trip generation or trip distribution factors.

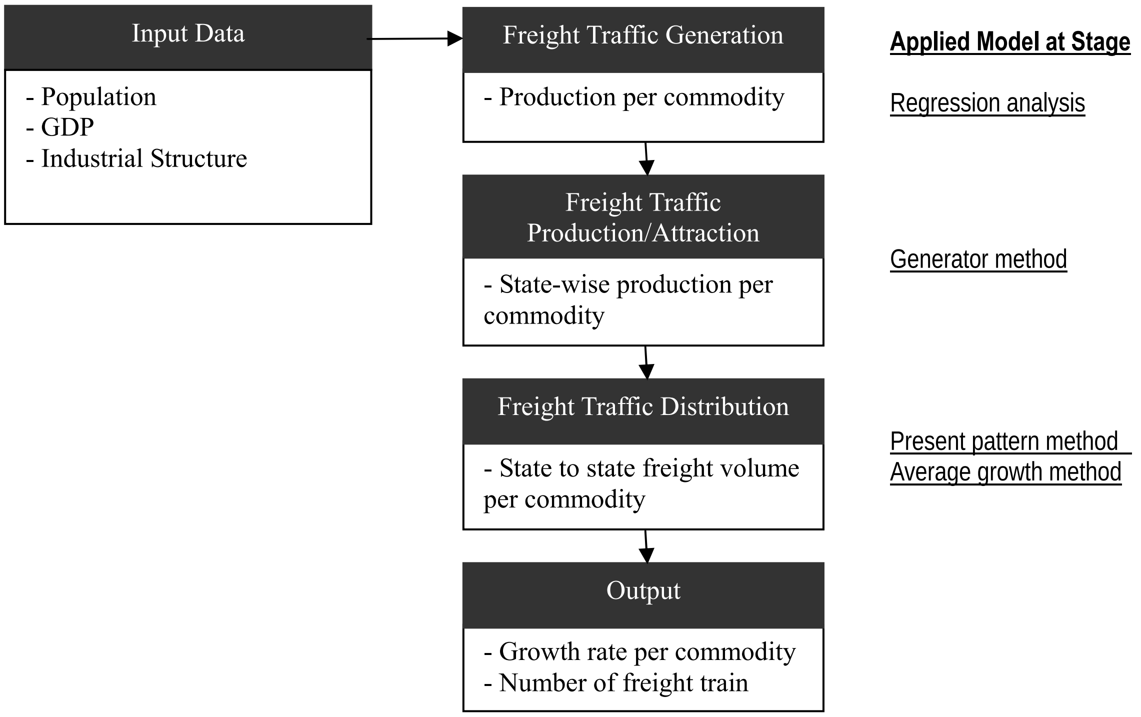


Figure 10.3 Forecasting Procedure of Bulk Cargos

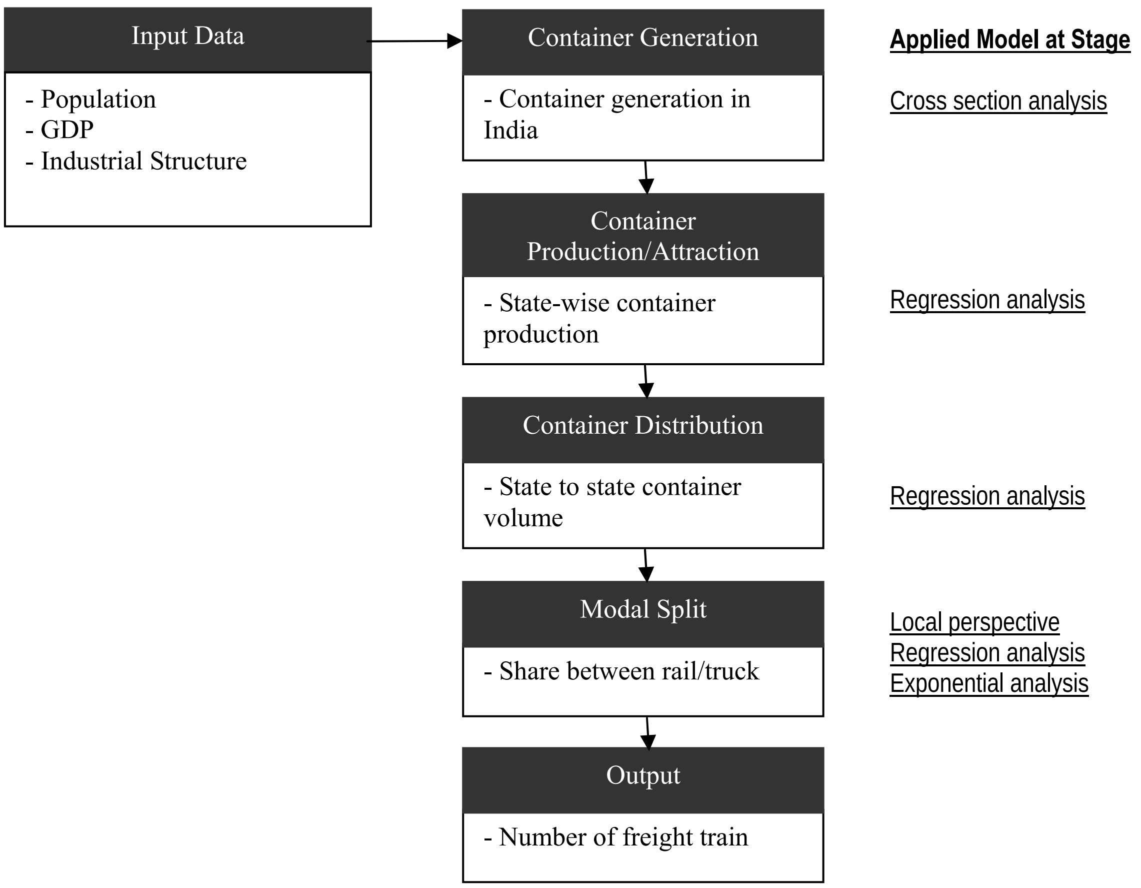


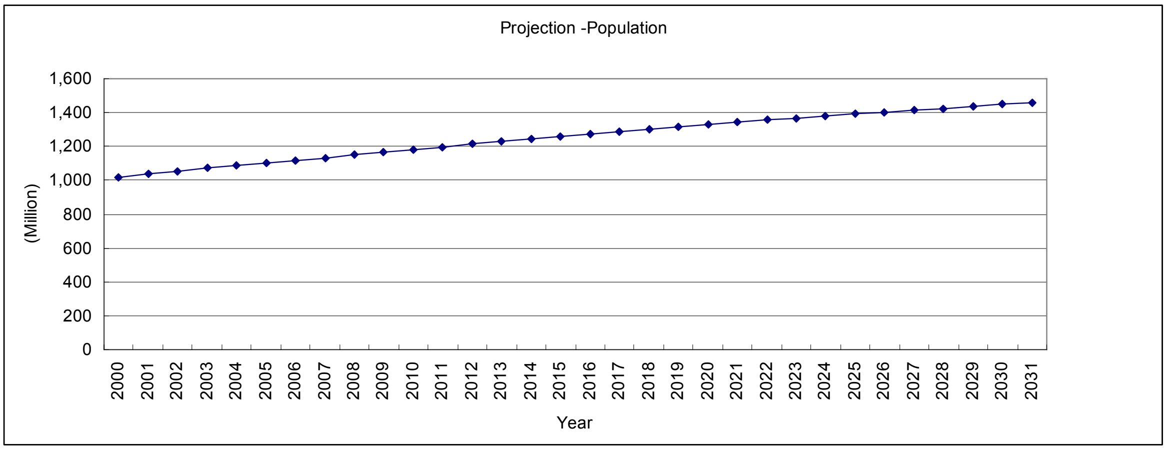
Figure 10.4 Forecasting Procedure of Container Cargos

10.4 DEMAND FORECAST

10.4.1 Socio-economic Framework

(1) Population

Indian population accounts for 17% of the world population. In the last five years, population in India increased by 1.7% p.a. and reached 1,073 million in 2003/04. The future population in this Study is estimated by two sources: population projection by the population census up to 2026 and that by the United Nations afterward. Based on these two projections, the average population growth is estimated by 1.1% p.a. up to 2031 and 2031 population reaches 1,458 million.



Source: GOI (2001) CENSUS OF INDIA 2001 POPULATION PROJECTIONS FOR INDIA AND STATES 2001-2026 (up to 2026) and World Population Prospects (afterward)

Figure 10.5 Population Projection

(2) GDP

All historical economic data of Indian shows sings of a rapid and sustained growth. The average growth rate of real GDP records 4.6% p.a. in 1980s, 5.8% p.a. in 1990s and 5.9% p.a. after 2000. The projection work of future economic growth by several planning and financing institutions also shows a persistent growth, which ranges from around 6-9% p.a.. GDP growth rate of 7% p.a., the same rate to RITES study, is employed in this Study.

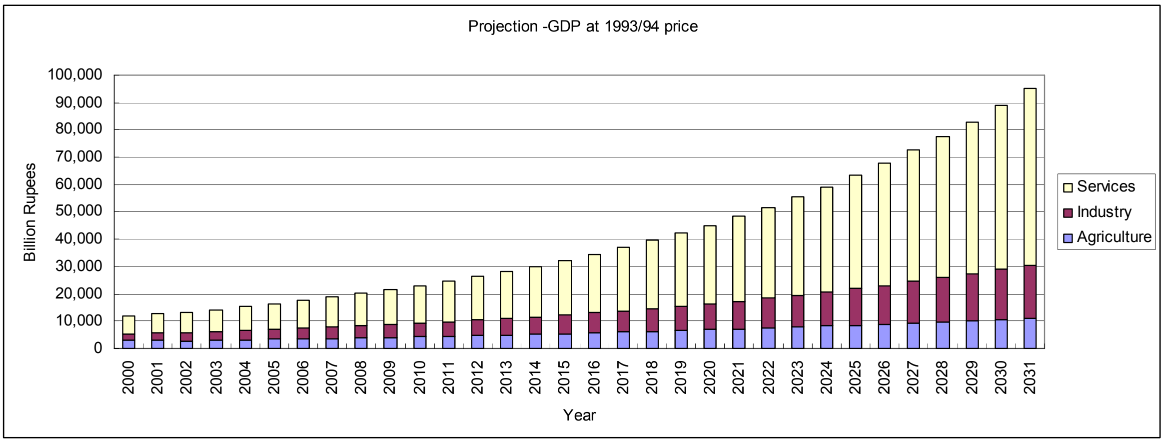
Table 10.2 GDP Growth Projection

Source \ Year	2006	2007	2008-2012	2013-	Source
IMF	7.3	7.0			
ADB	7.6	7.8	8.0-8.5		Asian Development Outlook (2006)
Planning Commission	7.93	7.93	9.4		10th Five Year Plan (2002)
Planning Commission			8.0-9.0		Draft 11th Five Year Plan (2006)
Intl. Energy Agency	5.6	5.6	5.6	5.6	World Energy Outlook (2004)
RITES Report	7.0	7.0	7.0	7.0	DFC Pre-F/S Study (2006)

Source: listed in the table

(3) Industrial Structure

Like many other developing countries, sector-wise economy in India shows a rapid growth of the tertiary industry (service sector). GDP share of the tertiary industry accounts for 57.9% in 2004/05 and grows by 10 points in the last 10 years. Considering the development trends of other developed and developing countries, the economic growth favors the tertiary industry, and GDP of primary, secondary, and tertiary sector will account for 5%, 20%, and 75%, respectively. (20.5, 21.9, 57.9% in 2004)



Source: Reserve Bank of India

Figure 10.6 Projection in GDP and Industrial Structure

10.4.2 Freight Demand Forecast

(1) Precondition and Data Sources

As discussed above, two different approaches are applied to the freight demand forecast of DFC project: the vehicle and commodity-based model for bulk cargos and the commodity-based approach for container cargos. Common to both approaches are trip generation, trip distribution and modal split model. Preconditions for freight demand forecast of DFC project are listed below.

- Target year is set for Year 2031/32, considering a project life and the phases of Five-Year Plan.
- Analysis zones are divided into 35 states.
- Commodities analyzed for freight demand forecasting are eight bulk cargos (coal, cement, POL, fertilizer, food-grain, iron and steel, ore, others) and container cargo.
- Mode of transport incorporated into the model includes rails for bulk cargos and rails and trucks for container demand forecasting.

Historical socio-economic and traffic data are collected and analyzed for freight demand forecasting. Some essential data sources include Total Transport System Study (1987), Study on Total Land Traffic (1997), CRIS's Freight Train Operation Data (2003-05), Roadside Interview Survey and Company Interview Survey, both of which are conducted by JICA Study Team.

(2) Freight Traffic Generation

In the initial process of freight demand forecast, the tonnage transported per commodity and container throughputs (in TEUs) handled in overall India are calculated.

Following figures show the historic time-series data per commodity, i.e., population, production in India, GDP of selected industrial sector and traffic volume over 30 years (1970-2004). These figures imply that the traffic volume per commodity is determined by population and economic activities and can be explained by the linear regression equation. Eight bulk commodities are, accordingly, estimated by regression analysis, which encompasses independent variables (e.g., GDP and population). Applying the annual GDP growth of 7%, traffic volumes are estimated to grow by 2.3-3.8%, excluding that of coal and POL.

Energy production, such as coal for the thermal plants, is closely related to the national policy. In RITES report, the detailed projection study on coal (along the east corridor) was made by interviewing major industrial entities and trade organizations along the corridors to obtain an independent perspective on future development. The result of RITES report is applied to this Study.

Table 10.3 Estimated Annual Growth Rate per Commodity by JICA Study Team

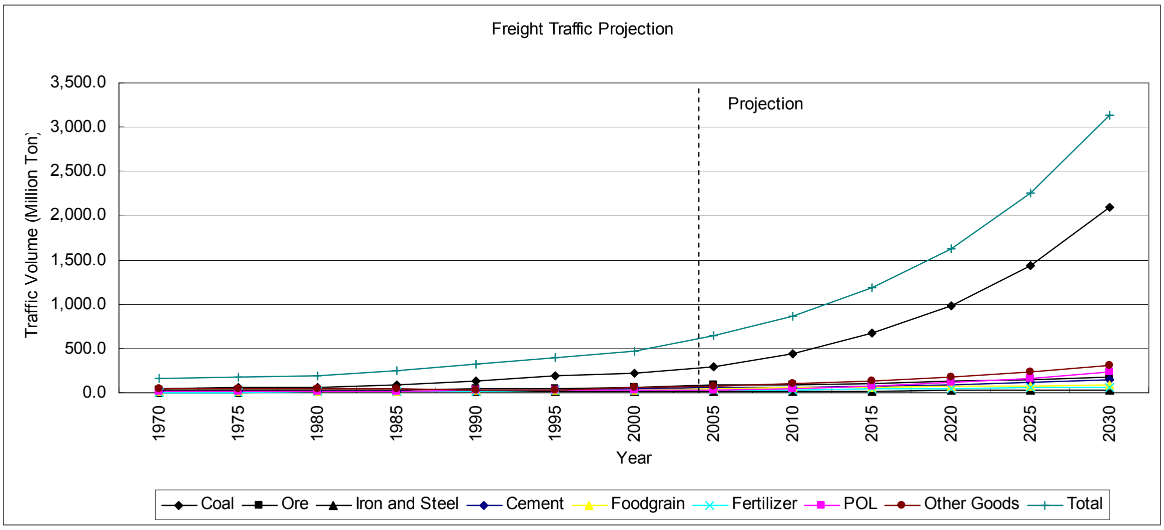
Commodity	Coal	Ore	Iron and Steel	Cement	Food-grains	Ferti-lizers	POL	Other goods	Total
Growth Rate per Annum	(8.1%)	3.1%	3.1%	3.8%	2.3%	2.7%	(7.9%)	5.8%	(6.6%)
Independent Variables	GDP	GDP (Secondary)	GDP (Secondary)	GDP (Secondary)	Population	Population	GDP	GDP	GDP

Source: JICA Study Team

Table 10.4 Estimated Annual Growth Rate per Commodity by RITES report

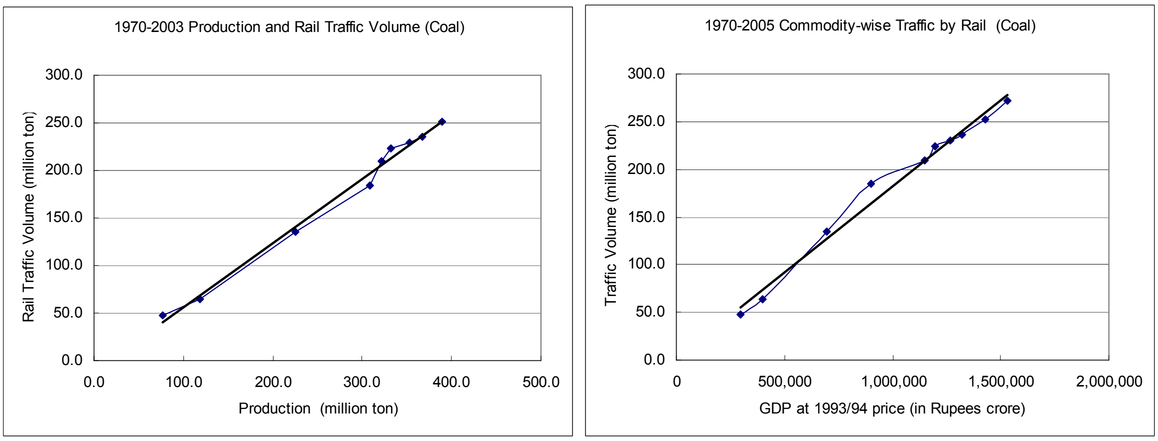
Commodity	Coal	Ore	Iron and Steel	Cement	Food-grains	Ferti-lizers	POL	Other goods	Total
West Corridor	3.0% (7.0%*)	5.0%	5.0%	5.0%	2.0%	2.0%	2.0%	3.0%	
East Corridor	0.0-10.0%	-	14.5% (8.3%**)	5.0%	2.0%	2.0%	-	-	

Source: prepared by JICA Study Team based on RITES F/S
Note: *: Imported Coal, **: After 2012



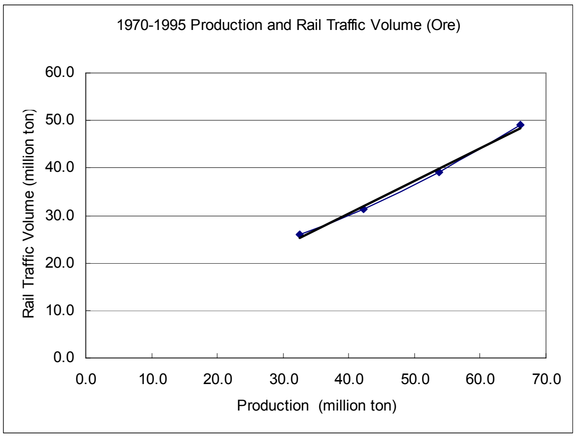
Source: Ministry of Railways (2004/05) Annual Statistical Statements (present figures) and JICA Study Team (projection)

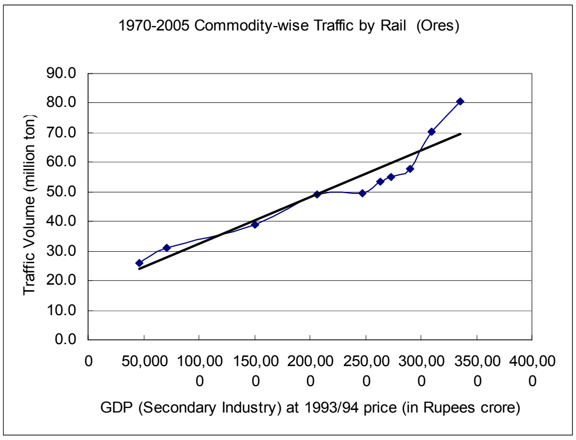
Figure 10.7 Projection in Bulk Cargos by Rail



Source: Ministry of Railways (2004/05) Annual Statistical Statements (traffic volume) and Department of Coal (production)
Note: Dots shows the actual figures and liner line shows that by the regression analysis.

Figure 10.8 Trend in Production, GDP and Traffic Volume by Rail (Coal)

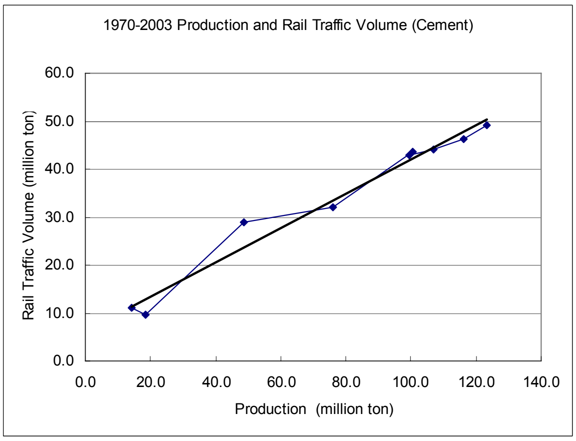


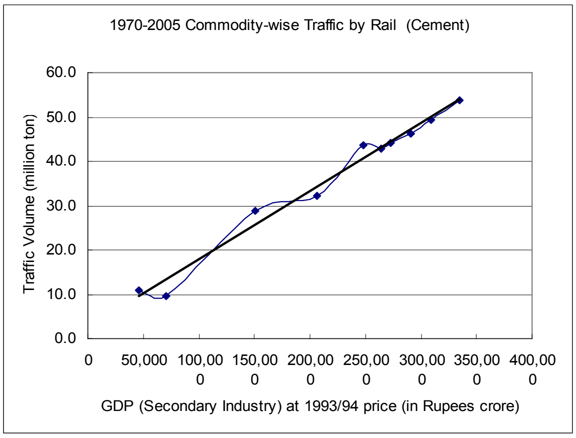


Source: Ministry of Railways (2004/05) Annual Statistical Statements (traffic volume) and Development Commissioner for Cement (production)

Note: Dots shows the actual figures and liner line shows that by the regression analysis.

Figure 10.9 Trend in Production, GDP and Traffic Volume by Rail (Ores)

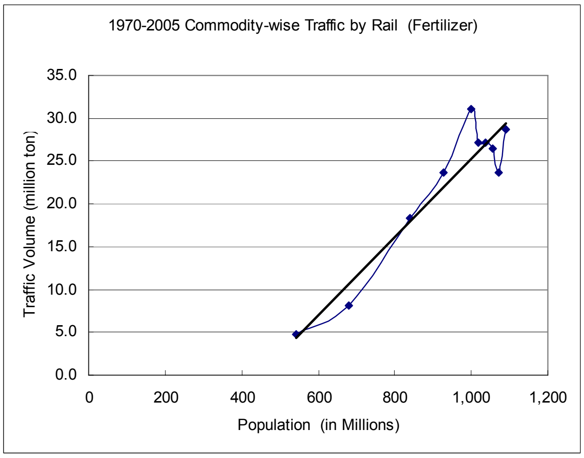




Source: Ministry of Railways (2004/05) Annual Statistical Statements (traffic volume) and Department of Coal (production)

Note: Dots shows the actual figures and liner line shows that by the regression analysis.

Figure 10.10 Trend in Production, GDP and Traffic Volume by Rail (Cement)



Source: Ministry of Railways (2004/05) Annual Statistical Statements (traffic volume) and Ministry of Chemicals & Fertilizers (production)

Note: Dots shows the actual figures and liner line shows that by the regression analysis.

Figure 10.11 Trend in Population and Traffic Volume by Rail (Fertilizer)

The tendency in container traffic is by and large determined by the global economic activities and tends to follow development trend of the advanced countries. Thus, container throughput in India is estimated by cross section analysis, which incorporates GDP and population (see the following equation). Applying the annual GDP growth of 7%, the container traffic is estimated to increase by 9.0% p.a. in average and reach 43 million TEUs in 2031/32.

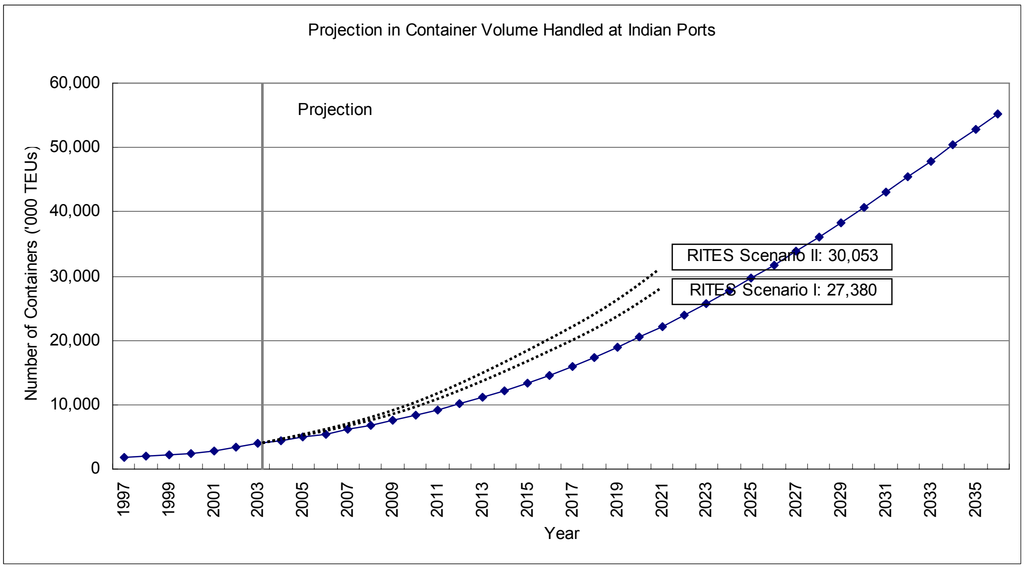
$$CONT = 0.66 + 2.41^{-6} \times GDP + 0.0212 \times Pop \; (\mathrm{r2} = 0.96)$$

where, *CONT*: Annual container throughputs (million TEU/Annum), *GDP*: Nominal Gross Domestic Products (million USD), *Pop*: Population (million)

Table 10.5 Container Traffic and Socio-economic Indicators in Selected Countries

Country	2002 Container Throughput (million TEU)	Nominal 2002 GDP (million USD)	2002 Population (million)
Bangladesh	0.57	47,195	132.9
Pakistan	0.94	73,701	144.9
Viet Nam	2.28	35,063	79.7
Indonesia	5.75	200,111	211.4
Philippine	3.77	75,250	79.5
China	31.89	1,303,588	1,284.5
Egypt	1.86	84,200	66.6
Thailand	4.17	126,769	63.5
South Africa	2.76	110,518	45.5
Brazil	3.41	460,811	174.6
Turkey	1.88	184,165	70
Mexico	1.56	648,627	103.0
Italy	7.95	1,186,335	57.2
Australia	3.82	399,358	19.6
Canada	3.30	735,965	31.4
Germany	9.48	2,022,210	82.5
France	3.28	1,457,369	59.5
U.K.	7.59	1,574,028	59.3
Japan	14.04	3,915,450	127.5
U.S.	30.81	10,469,600	288.4

Source: Economic and Research Institute, Cabinet Office, Government of Japan



Source: Indian Ports Association http://www.ipa.nic.in (present figures) and JICA Study Team (projection)

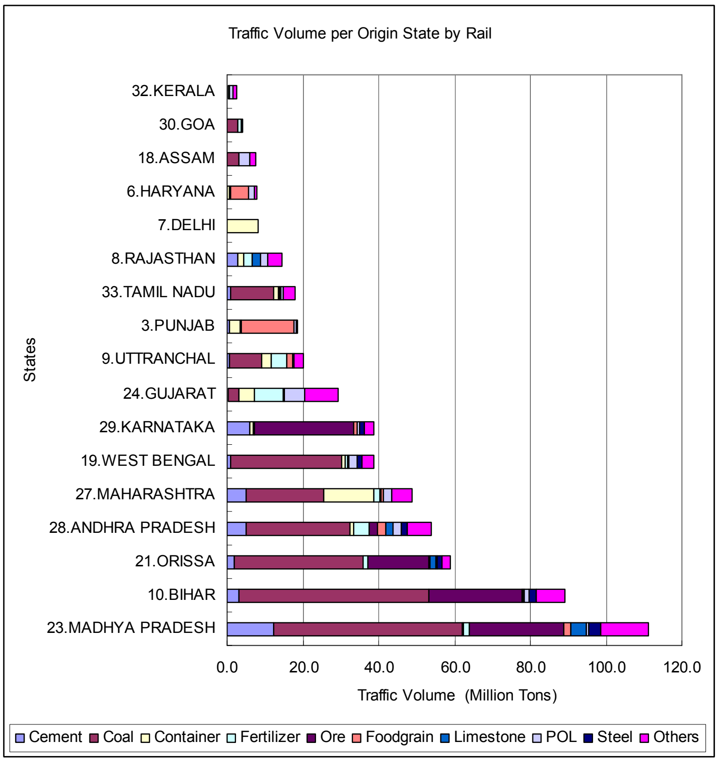
Figure 10.12 Projection in Container Throughput in India

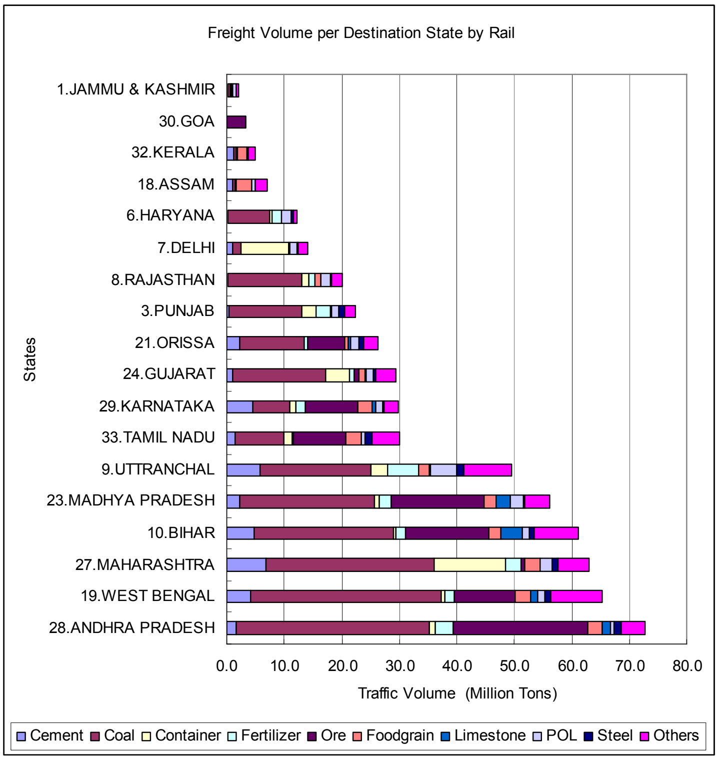
(3) Freight Traffic Production/Attraction

The second step of freight demand forecast calculates state-wise tonnage transported per commodity or container traffic (in TEUs) produced and attracted.

As shown in the following figures, the traffic produced and attracted flows between specific states, e.g., coal to the thermal plans, and ores to steel refineries. This implies that economic activities per state can represent traffic production and attraction of each state. Thus, traffic production/attraction per commodity is estimated by the generator method, adopting GSDP (Gross State Domestic Products) as generator unit.

Table 10.8 and 10.9 show the tonnage per commodity of both traffic production and attraction respectively.





Source: prepared by JICA Study Team based on CRIS (Centre for Railway Information Systems)

Figure 10.13 Freight Traffic Volume by Rail at Top 17 States (Above: Origin State, Down: Destination State)

When calculating container traffic production and attraction at each state, there are two approaches generally practiced; the supply-side approach and demand-side approach. The supply-side approach assumes that the handling capacity of the ports can be the key determinant of the container traffic. On the other hand, the demand-side approach assumes that container traffic generation and attraction is determined by the economic activities of the hinterlands without incorporating capacity constraints into the model. This Study applies the demand side approach for the forecasting work since provision of the DFC may become a key determinant of the port selection for forwarders and investors and may determine the port development strategy.

Container traffic generation is, accordingly, estimated by regression analysis which encompasses the secondary industry's GDP as its independent variables (see the following equation). As a result, 15.3 million TEUs at Maharashtra and 13.4 million TEUs at Gujarat is expected to generate in 2031/32.

$$CONTs = -230.6 + 0.000287 \times GSDP \text{ (r2} = 0.93)$$

Where, *CONTs*: Annual container throughputs in the state (thousand TEU/annum), *GSDP*: Gross State Domestic Products (10 million Rs.)

Table 10.6 2031/32 Container Throughput at States

State	Hinterlands	2031/32 Secondary Industry GSDP (Rs.lacs)	Estimated Container Traffic Volume ('000 TEUs)	Share of Traffic Volume (%)
West Bengal		11,171,288	2,929	6.8%
Orissa		1,783,039	277	0.6%
Andhra Pradesh		11,085,823	2,905	6.7%
Tamilnadu	Karnataka	25,865,277	7,081	16.4%
Kerala		4,645,069	1,086	2.5%
Goa		1,068,721	75	0.2%
Maharashtra	Delhi, Uttar Pradesh, Punjab, Haryana	54,971,090	15,304	35.5%
Gujarat	Delhi, Uttar Pradesh, Punjab, Haryana	48,215,618	13,395	31.1%
Total		158,805,926	43,052	100.0%

Source: Reserve Bank of India

(4) Freight Traffic Distribution

Trip distribution is the process by which trips between traffic analysis zones are connected. The output of trip distribution is a tonnage table in which the origins and destinations of tonnage per commodity are identified. Traffic distribution for bulk cargos is estimated by present pattern method and adjusted by average growth method.

For container cargos, the present distribution pattern between Maharashtra and other states is applied to estimate container traffic distribution. Also, the rail share is assumed to be 35% of container cargos in Maharashtra and 45% in Gujarat. *(the rail share will be revised by the result of modal split model)*

Table 10.7 2031/32 Container Traffic by Rail (in TEUs)

To/From State	From Gujarat	To Gujarat	From Maharashtra	To Maharashtra
Punjab	312,171	273,552	277,394	243,077
Haryana	0	0	0	0
Delhi	1,442,422	1,219,718	1,281,732	1,083,838
Rajasthan	100,410	182,153	89,224	161,861
Uttra Pradesh	79,169	186,015	70,349	165,292
Bihar	0	0	0	0
Assam	0	0	0	0
West Bengal	30,895	9,655	27,453	8,579
Orissa	0	0	0	0
Madhya Pradesh	60,503	47,630	53,763	42,324
Gujarat	617,905	617,905	255,660	301,416
Maharashtra	287,712	339,204	549,068	549,068
Andhra Pradesh	97,191	101,697	86,364	90,368
Karnataka	644	1,287	572	1,144
Kerala	0	1,287	0	1,144
Tamil Nadu	11,586	7,080	10,295	6,291
Total	3,040,607	2,987,184	2,701,874	2,654,403

Source: JICA Study Team

Table 10.8 2031/32 Freight Traffic Generation (in Tons)

O	State	Cement	Coal	Fertilizer	Ore	Foodgrain	Limestone	POL	Steel	Others
1	JAMMU AND KASHMIR	0	0	0	0	0	0	0	0	250,569
2	HIMACHAL PRADESH	0	0	0	0	0	0	0	0	0
3	PUNJAB	1,384,314	0	1,272,957	0	24,067,313	0	3,659,102	0	2,517,988
4	CHANDIGARH	0	0	0	0	83,666	0	0	0	576,550
5	UTRANCHAL	0	0	0	0	0	0	0	0	0
6	HARYANA	0	74,417	742,824	0	11,396,763	0	11,411,224	87,161	3,068,211
7	DELHI	0	0	787	0	226,522	0	3,237	0	444,115
8	RAJASTHAN	7,678,547	288,175	5,553,346	168,034	568,931	13,385,582	16,728,766	0	13,657,243
9	UTTAR PRADESH	2,622,081	77,495,911	10,694,735	13,153	3,637,619	3,122	983,467	14,472	12,708,563
10	BIHAR	6,889,332	412,930,715	721,362	68,773,276	49,490	340,934	5,161,416	6,816,440	40,983,971
11	SIKKIM	0	0	0	0	0	0	0	0	0
12	ARUNACHAL PRADESH	0	0	0	0	0	0	0	0	0
13	NAGALAND	0	0	0	0	0	0	0	0	76,275
14	MANIPUR	0	0	0	0	0	0	0	0	0
15	MIZORAM	0	0	0	0	0	0	0	0	0
16	TRIPURA	0	0	0	0	0	0	0	0	334,928
17	MEGHALAYA	0	0	0	0	0	0	0	0	0
18	ASSAM	5,605	18,246,966	252,758	0	10,082	88,008	13,786,594	0	7,150,344
19	WEST BENGAL	1,592,901	175,554,139	970,441	79,997	100,291	0	15,708,704	2,593,551	18,202,859
20	JHARKHAND	0	0	0	0	0	0	0	0	0
21	ORISSA	3,613,399	261,972,036	2,477,287	20,152,876	192,152	5,082,981	855,587	1,655,797	15,802,005
22	CHATTISH GARH	0	0	0	0	0	0	0	0	0
23	MADHYA PRADESH	40,844,547	369,966,697	3,572,444	69,085,780	2,140,674	16,290,199	2,255,696	7,411,225	23,336,577
24	GUJARAT	221,123	12,857,254	12,492,893	0	97,711	447,875	33,455,079	169,207	49,181,402
25										
26										
27	MAHARASHTRA	10,034,647	185,912,202	4,221,967	660,873	519,678	0	19,764,372	89,236	29,963,486
28	ANDHRA PRADESH	11,322,259	210,053,106	5,646,136	513,389	4,308,357	7,348,663	19,202,092	1,977,327	26,823,761
29	KARNATAKA	17,554,270	306,970	364,465	52,229,737	708,224	0	604,728	2,236,713	9,961,959
30	GOA DAMAN AND DIU	0	13,223,692	1,809,569	9,091	3,933	830,215	3,366,712	0	700,226
31										
32	KERALA	247,709	1,013,354	407,866	6,312	14,281	0	20,177,490	5,192	734,150
33	TAMIL NADU	1,410,076	89,718,880	703,739	0	86,717	160,837	3,208,162	229,563	7,669,488
34	PONDICHERRY	0	0	0	0	0	0	0	0	4,171
35										
Total		105,420,808	1,829,614,512	51,905,578	211,692,517	48,212,405	43,978,415	170,332,429	23,285,884	264,148,843

Source: JICA Study Team

Table 10.9 2031/32 Freight Traffic Attraction (in Tons)

D	State	Cement	Coal	Fertilizer	Ore	Foodgrain	Limestone	POL	Steel	Others
1	JAMMU AND KASHMIR	774,607	1,435,698	348,667	18,935	552,996	0	3,856,262	57,164	725,806
2	HIMACHAL PRADESH	0	0	0	0	0	0	0	0	0
3	PUNJAB	771,310	97,383,123	6,062,559	80,712	100,664	17,427	7,494,834	1,281,969	5,298,275
4	CHANDIGARH	226,305	815,600	220,797	6,312	24,350	0	0	487,449	361,365
5	UTRANCHAL	0	0	0	0	0	0	0	0	0
6	HARYANA	220,869	47,291,550	4,089,739	0	60,752	0	6,573,062	610,113	1,536,288
7	DELHI	3,049,644	10,870,038	21,710	157,262	274,978	13,603	5,609,414	680,419	9,609,572
8	RAJASTHAN	536,444	88,933,553	1,990,586	6,312	2,221,702	0	12,206,625	291,693	8,210,052
9	UTTAR PRADESH	20,084,925	165,744,158	13,000,887	94,606	2,516,331	53,922	32,847,668	2,328,487	29,427,551
10	BIHAR	14,304,916	167,859,715	3,709,416	33,318,346	2,347,337	20,193,498	9,459,797	2,608,339	25,612,884
11	SIKKIM	0	0	0	0	0	0	0	0	0
12	ARUNACHAL PRADESH	0	0	0	0	0	0	0	0	0
13	NAGALAND	374,553	0	0	0	356,628	0	57,870	0	220,409
14	MANIPUR	0	0	0	0	0	0	0	0	0
15	MIZORAM	0	0	0	0	0	0	0	0	0
16	TRIPURA	0	0	0	0	0	0	0	0	0
17	MEGHALAYA	0	0	0	0	0	0	0	0	0
18	ASSAM	2,304,595	672,823	396,343	22,091	3,028,221	84,964	1,066,115	130,160	12,053,106
19	WEST BENGAL	15,063,138	213,546,775	3,663,613	28,376,345	3,414,870	6,088,259	5,769,027	4,563,732	48,955,992
20	JHARKHAND	0	0	0	0	0	0	0	0	0
21	ORISSA	5,443,517	85,163,836	1,072,846	11,759,937	1,522,004	1,918,899	9,888,309	1,338,622	14,917,361
22	CHATTISH GARH	0	0	0	0	0	0	0	0	0
23	MADHYA PRADESH	3,893,641	159,522,344	4,686,219	34,965,749	3,473,920	6,631,527	15,700,356	284,535	28,809,335
24	GUJARAT	906,482	132,408,694	1,337,763	25,651	6,493,268	456,479	8,842,683	762,183	19,091,936
25										
26										
27	MAHARASHTRA	18,262,578	272,278,410	4,624,632	1,038,787	3,985,999	17,427	14,630,024	1,560,039	14,173,723
28	ANDHRA PRADESH	3,365,713	269,088,787	3,994,982	53,972,103	6,233,044	6,421,760	8,268,435	2,432,432	22,341,743
29	KARNATAKA	9,127,628	46,680,167	1,850,873	14,545,460	4,518,381	1,919,813	13,963,249	709,634	10,547,745
30	GOA DAMAN AND DIU	22,420	54,147	9,836	8,820,091	27,938	0	0	197,355	60,326
31										
32	KERALA	2,015,403	1,668,016	62,963	27,778	2,080,541	0	6,337,194	64,999	1,582,719
33	TAMIL NADU	4,672,120	68,197,078	761,148	24,456,041	4,978,482	160,837	7,761,503	2,896,561	10,612,656
34	PONDICHERRY	0	0	0	0	0	0	0	0	0
35										
Total		105,420,808	1,829,614,512	51,905,578	211,692,517	48,212,405	43,978,415	170,332,429	23,285,884	264,148,843

Source: JICA Study Team

Table 10.10 2031/32 Freight Traffic Distribution (in Tons, Cement)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	340,644	0	0	0	0	23,197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	388,784	0	0	0	0	0	0	0	0	0	0	0	0	752,625
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	226,582	0	0	0	0	408,842	0	0	0	0	0	0	0	0	0	0	0	0	21,369	0	92,781	0	0	0	16,645	0	0	0	0	0	0	0	0	766,220
4	0	0	13,370	0	0	0	0	56,418	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166,008	0	0	0	0	0	0	0	0	0	0	0	0	235,795
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	18,542	0	0	0	0	80,412	2,499	0	0	0	0	0	0	0	0	0	0	0	0	0	137,980	0	0	0	1,273	0	0	0	0	0	0	0	0	240,706
7	0	0	136,886	0	0	0	0	1,488,566	29,390	0	0	0	0	0	0	0	0	0	0	0	0	0	1,430,775	0	0	0	4,692	5,625	0	0	0	0	0	0	0	3,095,934
8	0	0	0	0	0	0	0	553,739	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,771	0	0	0	0	0	0	0	0	0	0	0	0	561,509
9	0	0	679,516	0	0	0	0	3,812,061	2,463,190	7,453	0	0	0	0	0	0	0	0	0	0	28,247	0	13,148,058	0	0	0	5,612	83,801	0	0	0	0	0	0	0	20,227,937
10	0	0	0	0	0	0	0	10,912	90,582	3,566,336	0	0	0	0	0	0	0	0	85,794	0	1,105,742	0	9,057,721	0	0	0	5,279	0	0	0	0	0	0	0	0	13,922,364
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	61,420	0	0	0	0	0	0	0	0	2,634	0	12,297	0	284,414	0	0	0	12,517	0	0	0	0	0	0	0	0	373,282
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	4,766	0	323,864	0	0	0	0	0	0	0	5,851	84,179	0	70,881	0	1,649,374	0	0	0	135,676	8,360	0	0	0	0	7,327	0	0	2,290,279
19	0	0	0	0	0	0	0	0	20,272	3,118,683	0	0	0	0	0	0	0	0	1,582,091	0	960,191	0	8,127,632	0	0	0	436,853	150,405	0	0	0	0	0	0	0	14,396,126
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	235,113	0	0	0	0	0	0	0	0	0	0	1,534,872	0	2,914,163	0	0	0	119,819	525,361	0	0	0	0	0	0	0	5,329,328
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	95,827	2,313	0	0	0	0	0	0	0	0	0	0	0	56,058	0	3,292,358	0	0	0	471,147	87,794	0	0	0	0	0	0	0	4,005,497
24	0	0	0	0	0	0	0	367,508	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41,360	136,371	0	0	285,564	115,707	18,454	0	0	0	0	0	0	964,964
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	568,133	0	1,829	0	0	0	0	0	0	0	0	0	0	4,011	0	217,272	63,379	0	0	7,454,488	2,438,524	7,756,303	0	0	0	0	0	0	18,503,938
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44,307	3,186	0	0	845,182	1,438,775	1,107,726	0	0	0	4,769	0	0	3,443,945
29	0	0	0	0	0	0	0	25,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21,127	0	0	0	42,214	2,722,011	6,787,608	0	0	1,685	66,005	0	0	9,665,740
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,870	905,058	226,652	0	0	240,487	623,357	0	0	1,998,425
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26,084	0	0	0	195,829	2,668,136	974,514	0	0	5,050	765,058	0	0	4,634,671
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	239	0	0	0	46	27	0	0	312
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	1,415,541	0	0	0	0	7,495,469	2,608,245	7,314,697	0	0	0	0	0	0	0	5,851	1,754,698	0	3,793,667	0	41,047,969	202,935	0	0	10,035,661	11,149,795	16,871,258	0	0	247,269	1,466,543	0	0	105,409,598

Source: JICA Study Team

Table 10.11 2031/32 Freight Traffic Distribution (in Tons, Coal)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	0	0	0	18,312	0	111,128	0	143,266	0	0	0	0	0	0	0	528,662	606,550	0	0	0	0	11,910	0	0	13,699	0	0	0	0	0	0	0	0	1,433,527
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	60,161	55,474,254	0	0	0	0	0	0	0	8,366,464	5,303,246	0	24,799	0	18,858,030	753,424	0	0	9,258,853	0	0	0	0	0	0	0	0	98,099,230
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	554,250	153,193	0	0	0	0	73,464	0	0	0	0	0	0	0	0	0	0	0	780,907
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	7,826,012	32,665,879	0	0	0	0	0	0	0	441,637	0	0	0	0	982,113	447,948	0	0	6,232,509	0	0	0	0	0	0	0	0	48,596,097
7	0	0	0	0	0	0	0	0	9,583,912	0	0	0	0	0	0	0	0	0	0	0	0	0	1,564,845	14,023	0	0	0	0	0	0	0	0	0	0	0	11,162,780
8	0	0	0	0	0	0	0	16,595	10,719,419	79,827	0	0	0	0	0	0	0	0	0	0	72,906	0	73,746,946	2,940,226	0	0	819,032	0	0	0	0	0	16,004	0	0	88,410,955
9	0	0	0	0	0	0	0	54,367	47,550,672	100,958,395	0	0	0	0	0	0	0	4,965,605	7,593,615	0	44,362	0	5,097,653	641,576	0	0	2,020,268	25,112	0	0	0	0	0	0	0	168,951,625
10	0	0	0	0	0	34,327	0	61,947	0	95,756,443	0	0	0	0	0	0	0	873,778	36,956,727	0	33,312,198	0	2,228,087	24,130	0	0	195,677	933,257	0	0	0	0	0	0	0	170,376,571
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	744	0	0	0	0	0	0	0	582	0	0	0	0	0	0	0	0	1,326
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	18,496	0	36,588	0	0	0	0	0	0	0	0	0	385,880	168,662	0	0	0	0	0	0	0	81,371	0	0	0	0	0	0	0	0	690,996
19	0	0	0	0	0	0	0	0	0	70,466,943	0	0	0	0	0	0	0	903,930	115,152,369	0	26,608,846	0	1,344,507	0	0	0	16,391	237,403	0	0	0	0	184,128	0	0	214,914,517
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	548,301	0	0	0	0	0	0	0	415,640	305,331	0	82,141,831	0	966,550	0	0	0	90,808	718,940	0	0	0	0	134,337	0	0	85,321,737
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	54,665	15,065,482	0	0	0	0	0	0	0	307,675	2,701,004	0	5,687,245	0	91,920,074	142,582	0	0	12,500,073	30,760,978	0	0	0	0	0	0	0	159,139,777
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,183	0	115,471,348	6,816,202	0	0	7,631,374	210,490	0	0	0	0	0	0	0	130,141,599
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	30,527,506	0	0	0	0	0	0	0	0	4,410,726	0	30,183,885	0	58,652,190	1,449,943	0	0	123,124,902	21,750,327	0	65,032	0	0	30,785	0	0	270,195,296
28	0	0	0	0	0	0	0	0	0	4,491,331	0	0	0	0	0	0	0	0	0	0	82,996,589	0	2,220,282	15,986	0	0	23,380,856	135,663,182	136,393	0	0	0	18,398,894	0	0	267,303,513
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	522,880	1,374,222	0	0	0	168,733	0	0	0	2,141,303	19,786,037	81,844	14,419,456	0	0	5,795,685	0	0	44,290,159
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47,752	0	0	0	0	0	47,752
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	664,747	0	0	0	0	0	0	352,497	0	0	0	585,434	49,407	0	0	1,652,085
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,879	0	16,116	8,990	0	0	0	2,056,573	102,811	0	0	439,032	65,463,662	0	0	68,104,064
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	0	0	0	71,135	0	280,626	75,794,841	406,177,627	0	0	0	0	0	0	0	18,266,399	174,726,387	0	261,766,470	0	373,237,472	13,340,405	0	0	187,507,698	212,494,796	321,049	14,532,239	0	1,024,466	90,072,902	0	0	1,829,614,512

Source: JICA Study Team

Table 10.12 2031/32 Freight Traffic Distribution (in Tons, Fertilizer)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	129,305	0	0	0	0	24,615	100,508	0	0	0	0	0	0	0	0	0	0	0	23,483	0	0	72,972	0	0	0	0	0	0	0	0	0	0	0	350,884
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1,010,622	0	0	180,157	0	1,367,275	1,141,854	214,248	0	0	0	0	0	0	0	0	0	0	44,605	0	56,598	1,847,480	0	0	131,509	45,298	3,568	0	0	5,800	0	0	0	6,049,012
4	0	0	0	0	0	0	0	0	89,447	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95,036	0	0	30,920	0	0	0	0	0	0	0	0	215,402
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	62,863	0	0	387,874	0	1,137,603	740,392	176,944	0	0	0	0	0	0	0	0	0	0	32,809	0	67,603	1,335,087	0	0	107,632	19,321	0	0	0	0	0	0	0	4,068,128
7	0	0	11,760	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,383	0	0	0	0	0	0	0	0	22,144
8	0	0	41,302	0	0	21,771	0	787,149	50,402	0	0	0	0	0	0	0	0	0	0	0	0	0	72,588	970,729	0	0	0	12,712	0	0	0	0	0	0	0	1,956,653
9	0	0	6,956	0	0	107,427	0	1,506,534	4,521,714	71,146	0	0	0	0	0	0	0	0	77,214	0	714,011	0	1,218,647	3,483,086	0	0	659,438	492,676	0	0	0	0	0	0	0	12,858,850
10	0	0	0	0	0	0	0	7,291	1,709,949	232,872	0	0	0	0	0	0	0	78,256	467,251	0	230,041	0	660,324	58,074	0	0	100,445	230,894	0	0	0	0	0	0	0	3,775,397
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	17,640	129,008	0	0	0	0	0	0	0	0	108,033	27,137	0	19,106	0	18,663	8,797	0	0	4,586	70,860	0	0	0	0	0	0	0	403,831
19	0	0	0	0	0	0	0	22,846	1,602,733	0	0	0	0	0	0	0	0	58,541	366,066	0	381,165	0	21,439	241,393	0	0	146,588	799,012	0	0	0	0	0	0	0	3,639,784
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	20,001	355,556	0	0	0	0	0	0	0	0	0	16,719	0	81,500	0	52,306	28,539	0	0	0	496,138	0	0	0	0	10,086	0	0	1,060,844
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	559,874	272,908	0	0	0	0	0	0	0	0	0	0	0	402,416	0	981,479	1,677,707	0	0	161,991	536,909	0	0	0	0	0	0	0	4,593,284
24	0	0	0	0	0	0	0	96,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,907	1,008,794	0	0	153,600	33,405	0	0	0	0	0	0	0	1,302,306
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	37,714	0	0	0	0	0	0	0	0	0	0	6,892	0	176,440	0	276,159	1,134,832	0	0	1,845,774	274,157	97,815	848,492	0	58,877	4,212	0	0	4,761,364
28	0	0	0	0	0	0	0	6,325	0	0	0	0	0	0	0	0	0	0	0	0	258,713	0	111,565	353,561	0	0	366,534	2,475,561	88,897	82,681	0	36,875	202,290	0	0	3,983,003
29	0	0	0	0	0	39,474	0	12,843	7,115	0	0	0	0	0	0	0	0	0	0	0	66,602	0	19,242	276,114	0	0	281,008	128,880	108,330	738,923	0	102,531	220,246	0	0	2,001,308
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,205	1,055	6,949	0	2,092	0	0	0	11,302
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,607	12,479	0	0	0	0	14,781	0	0	42,720	545	0	0	72,133
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61,646	0	12,876	111,450	0	0	120,934	74,311	31,703	0	0	130,559	236,078	0	0	779,557
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	1,262,807	0	0	736,703	0	5,604,309	10,721,587	695,210	0	0	0	0	0	0	0	244,830	961,279	0	2,492,537	0	3,581,004	12,716,128	0	0	4,121,342	5,691,340	346,149	1,677,046	0	379,455	673,458	0	0	51,905,185

Source: JICA Study Team

Table 10.13 2031/32 Freight Traffic Distribution (in Tons, Ore)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17,662	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17,662
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	21,555	0	0	0	0	0	0	0	0	0	0	43,737	0	7,276	0	0	0	0	0	4,999	0	0	0	0	0	0	77,567
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,872	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,872
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79,080	0	0	0	77,585	0	0	0	0	0	0	0	0	156,665
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	1,101	0	79,698	0	0	0	0	0	0	0	0	0	0	20,518	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101,316
10	0	0	0	0	0	0	0	0	0	30,944,022	0	0	0	0	0	0	0	0	0	0	3,044,224	0	5,386	0	0	0	167,040	0	0	0	0	0	0	0	0	34,160,673
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	5,583	0	0	0	0	0	0	0	0	0	0	2,926	0	2,830	0	0	0	6,640	803	3,420	0	0	0	0	0	0	22,203
19	0	0	0	0	0	0	0	0	0	24,167,227	0	0	0	0	0	0	0	0	93,407	0	4,010,907	0	119,553	0	0	0	230,406	864	23,601	0	0	0	0	0	0	28,645,964
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	6,213,803	0	0	0	0	0	0	0	0	1,262	0	5,090,391	0	225,096	0	0	0	0	0	14,087	0	0	0	0	0	0	11,544,639
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	4,019,888	0	0	0	0	0	0	0	0	0	0	6,331,939	0	25,017,704	0	0	0	48,835	70,064	3,915	0	0	0	0	0	0	35,492,344
24	0	0	0	0	0	0	0	0	0	36,721	0	0	0	0	0	0	0	0	0	0	6,978	0	7,583	0	0	0	432	37	16,134	0	0	0	0	0	0	67,884
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	438,687	0	0	0	0	0	0	0	0	0	0	149,868	0	40,657	0	0	0	32,792	6,173	358,417	2,248	0	0	0	0	0	1,028,844
28	0	0	0	0	0	0	0	165,522	0	1,526,593	0	0	0	0	0	0	0	0	0	0	1,804,967	0	42,052,556	143	0	0	90,080	416,859	8,691,405	3,870	0	0	0	0	0	54,751,994
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,050	0	0	0	0	4,716	14,014,569	1,209	0	0	0	0	0	14,025,545
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,386,005	2,427	0	0	0	0	0	8,388,432
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27,702	0	0	0	0	0	0	27,702
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	272	0	0	0	149,778	23,014,252	0	0	0	0	0	0	23,164,301
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	0	0	0	0	0	166,644	0	67,453,777	0	0	0	0	0	0	0	0	94,669	0	20,529,988	0	67,562,772	414	0	0	653,809	649,293	54,558,506	9,754	0	0	0	0	0	211,679,629

Source: JICA Study Team

Table 10.14 2031/32 Freight Traffic Distribution (in Tons, Foodgrain)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	112,885	0	0	13,218	2,387	0	516,463	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,344	0	0	0	0	0	0	646,299
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	22,104	0	0	0	0	0	16,704	3,971	0	0	0	0	0	0	0	0	0	0	0	0	0	4,096	0	0	5,231	18,694	23,224	0	0	0	0	0	0	94,024
4	0	0	0	0	0	0	0	0	20,448	658	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,620	2,596	0	0	0	0	0	0	26,321
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	23,860	0	0	14,461	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,021	23,003	0	0	0	0	0	0	0	62,346
7	0	0	88,892	0	0	60,471	0	0	0	1,478	0	0	0	0	0	0	0	0	0	0	0	0	1,953	8,545	0	0	73,442	30,506	3,268	0	0	0	0	0	0	268,555
8	0	0	695,415	0	0	1,432,705	0	104,505	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,444	4,288	0	0	0	0	0	0	0	2,238,356
9	0	0	1,135,374	0	0	485,932	0	22,924	1,070,814	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,374	0	5,574	0	0	0	0	0	0	2,721,992
10	0	0	1,426,932	0	0	360,063	0	7,382	293,476	20,396	0	0	0	0	0	0	0	0	7,259	0	11,763	0	222,752	0	0	0	4,639	10,755	17,893	0	0	0	0	0	0	2,383,309
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	262,349	0	0	28,278	0	0	25,114	0	0	0	0	0	0	0	0	4,809	0	0	0	0	9,138	0	0	0	3,030	20,900	1,868	0	0	0	0	0	0	355,487
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	2,013,819	19,845	0	316,856	207,249	6,764	453,778	0	0	0	0	0	0	0	0	5,275	1,674	0	0	0	34,288	0	0	0	7,015	51,800	33,645	0	0	0	0	0	0	3,152,007
19	0	0	2,077,247	0	0	661,059	0	15,422	326,156	2,967	0	0	0	0	0	0	0	0	88,754	0	2,252	0	129,941	0	0	0	74,117	17,417	65,877	0	0	0	0	0	0	3,461,208
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	485,673	0	0	281,467	0	0	103,240	0	0	0	0	0	0	0	0	0	0	0	174,527	0	328,632	0	0	0	58,757	0	14,577	0	0	0	0	0	0	1,446,873
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	2,006,094	0	0	1,321,650	0	18,184	6,860	0	0	0	0	0	0	0	0	0	0	0	9,877	0	106,845	0	0	0	6,947	3,598	2,637	0	0	0	0	0	0	3,482,691
24	0	0	3,512,416	0	0	2,045,424	0	0	96,899	16,354	0	0	0	0	0	0	0	0	0	0	0	0	66,592	64,258	0	0	52,584	149,464	283,801	0	0	0	0	0	0	6,287,792
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	2,396,874	3,233	0	1,357,454	0	7,953	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71,595	0	0	0	152,846	18,212	6,400	0	0	0	0	0	0	4,014,566
28	0	0	2,266,764	11,635	0	1,196,659	0	0	9,647	0	0	0	0	0	0	0	0	0	0	0	21,059	0	350,721	0	0	0	40,248	2,079,431	96,252	0	0	0	0	0	0	6,072,416
29	0	0	3,211,437	27,746	0	805,900	0	9,148	219,451	8,863	0	0	0	0	0	0	0	0	0	0	0	0	48,722	6,767	0	0	2,023	11,215	153,864	0	0	0	0	0	0	4,505,135
30	0	0	17,644	0	0	7,202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,874	0	0	0	0	0	0	0	0	28,720
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	443,304	4,657	0	420,874	0	24,479	33,557	0	0	0	0	0	0	0	0	0	0	0	0	0	124,012	5,294	0	0	8,883	951,563	4,041	0	0	17,995	17,396	0	0	2,056,055
33	0	0	1,840,054	15,580	0	616,278	0	341,780	133,935	0	0	0	0	0	0	0	0	0	0	0	0	0	728,993	17,818	0	0	36,620	1,034,886	69,500	0	0	0	70,747	0	0	4,906,191
34	0	0	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	0	0	95
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	24,039,194	82,695	0	11,425,950	209,636	558,540	3,326,544	54,689	0	0	0	0	0	0	0	10,083	97,687	0	219,479	0	2,224,183	106,777	0	0	534,094	4,428,351	786,362	0	0	17,995	88,180	0	0	48,210,438

Source: JICA Study Team

Table 10.15 2031/32 Freight Traffic Distribution (in Tons, POL)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	2,383,685	0	0	422,676	0	138,755	86,217	77,109	0	0	0	0	0	0	0	82,154	37,536	0	7,572	0	60,470	605,261	0	0	21,948	0	0	0	0	0	0	0	0	3,923,383
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1,179,864	0	0	518,536	0	2,680,950	192,948	85,233	0	0	0	0	0	0	0	739,383	143,755	0	5,270	0	124,280	1,886,428	0	0	69,830	9,601	0	0	0	0	0	0	0	7,636,076
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	1,180,357	0	991,527	52,035	11,247	0	0	0	0	0	0	0	448,096	101,228	0	0	0	65,648	3,030,432	0	0	675,637	174,630	0	0	0	0	0	0	0	6,730,838
7	0	0	0	0	0	1,526,997	0	1,021,825	8,524	43,931	0	0	0	0	0	0	0	596,047	177,705	0	0	0	188,004	1,435,999	0	0	702,574	0	0	0	0	0	0	0	0	5,701,607
8	0	0	0	0	0	2,118,005	0	2,288,333	0	100,699	0	0	0	0	0	0	0	1,691,539	85,688	0	7,111	0	291,017	2,667,093	0	0	2,935,874	86,473	0	0	0	0	4,813	0	0	12,276,645
9	0	0	0	0	0	5,301,093	0	7,143,051	677,090	2,905,140	0	0	0	0	0	0	0	3,714,648	4,053,028	0	229,867	0	641,719	6,641,911	0	0	964,640	39,658	0	0	0	0	16,453	0	0	32,328,298
10	0	0	0	0	0	240,431	0	0	0	1,154,453	0	0	0	0	0	0	0	1,530,653	5,700,595	0	0	0	0	326,102	0	0	0	233,646	0	0	0	0	0	0	0	9,185,881
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55,287	0	0	0	0	6,219	0	0	0	0	0	0	0	0	0	0	0	0	61,506
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	7,584	0	0	0	0	0	0	0	0	0	762,410	196,900	0	3,690	0	28,845	100,238	0	0	7,058	7,712	0	0	0	0	0	0	0	1,114,437
19	0	0	0	0	0	60,909	0	81,701	0	319,170	0	0	0	0	0	0	0	2,561,300	2,067,565	0	3,463	0	66,335	76,371	0	0	67,005	431,894	0	0	0	0	10,763	0	0	5,746,476
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	9,318	0	0	0	0	0	0	0	458,465	2,717,222	0	650,118	0	66,287	13,359	0	0	0	5,843,257	0	0	0	0	0	0	0	9,758,025
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	1,189,382	0	435,584	0	0	0	0	0	0	0	908,154	679,259	0	0	0	724,071	3,086,255	0	0	2,075,928	6,561,757	0	0	0	0	0	0	0	15,660,390
24	0	0	0	0	0	0	0	985,300	0	215,999	0	0	0	0	0	0	0	89,163	43,746	0	0	0	0	7,160,229	0	0	381,753	0	0	0	0	0	0	0	0	8,876,189
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	23,287	4,859	0	0	0	0	0	0	0	0	0	0	0	0	0	46,887	4,476,371	0	0	9,601,230	485,234	32,936	0	0	0	9,084	0	0	14,679,889
28	0	0	0	0	0	0	0	42,630	0	0	0	0	0	0	0	0	0	97,248	0	0	0	0	11,056	423,447	0	0	251,096	5,566,913	0	0	0	0	1,406,381	0	0	7,798,771
29	0	0	0	0	0	0	0	0	0	118,076	0	0	0	0	0	0	0	0	0	0	0	0	0	1,237,028	0	0	2,099,482	0	1,125,802	0	0	6,429,661	1,488,107	0	0	12,498,156
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32,115	0	0	0	51,344	7,773	0	0	6,594,011	41,793	0	0	6,727,037
33	0	0	0	0	0	0	0	0	10,033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	212,047	0	0	6,407	33,532	8,517	0	0	6,899,061	774,257	0	0	7,943,852
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	3,563,549	0	0	11,369,003	0	16,594,325	1,031,704	5,475,959	0	0	0	0	0	0	0	13,734,546	16,004,227	0	907,091	0	2,320,838	33,410,685	0	0	19,860,463	19,525,651	1,175,028	0	0	19,922,733	3,751,652	0	0	168,647,455

Source: JICA Study Team

Table 10.16 2031/32 Freight Traffic Distribution (in Tons, Iron and Steel)

O	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	総計
1	0	0	0	0	0	0	0	0	0	24,762	0	0	0	0	0	0	0	0	6,620	0	0	0	26,798	0	0	0	0	0	0	0	0	0	0	0	0	58,180
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	79,318	0	0	0	252,303	0	0	0	0	0	0	0	0	172,594	0	95,051	0	577,002	0	0	0	8,698	85,174	52,576	240	0	3,749	0	0	0	1,326,705
4	0	0	0	0	0	0	0	0	0	221,671	0	0	0	0	0	0	0	0	12,159	0	49,870	0	170,790	0	0	0	0	40,538	0	0	0	0	0	0	0	495,028
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	434,425	0	0	0	0	0	0	0	0	19,273	0	0	0	98,274	23,273	0	0	0	43,253	36,254	0	0	0	0	0	0	654,752
7	0	0	0	0	0	0	0	0	0	203,655	0	0	0	0	0	0	0	0	122,352	0	3,441	0	195,012	0	0	0	0	135,562	0	1,186	0	0	0	0	0	661,208
8	0	0	0	0	0	0	0	0	0	91,392	0	0	0	0	0	0	0	0	24,723	0	0	0	145,462	0	0	0	0	40,231	0	0	0	0	0	0	0	301,809
9	0	0	0	0	0	0	0	0	0	712,374	0	0	0	0	0	0	0	0	259,334	0	95,779	0	1,175,722	41,611	0	0	1,618	92,122	26,455	61	0	0	0	0	0	2,405,076
10	0	0	0	0	0	0	0	0	0	1,440,751	0	0	0	0	0	0	0	0	295,196	0	108,772	0	643,963	0	0	0	0	48,889	59,178	0	0	0	46,621	0	0	2,643,370
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	66,433	0	0	0	0	0	0	0	0	29,709	0	6,839	0	22,480	0	0	0	6,939	0	0	0	0	0	0	0	0	132,400
19	0	0	0	0	0	0	0	0	0	1,688,906	0	0	0	0	0	0	0	0	1,472,699	0	492,446	0	379,063	0	0	0	0	329,326	0	0	0	0	25,378	0	0	4,387,818
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	144,328	0	0	0	0	0	0	0	0	14,494	0	622,438	0	413,356	35,691	0	0	0	44,779	10,236	0	0	0	11,507	0	0	1,296,830
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	34,814	0	0	0	0	0	0	0	0	23,632	0	3,201	0	192,580	6,309	0	0	14,905	14,902	11,898	0	0	0	0	0	0	302,241
24	0	0	0	0	0	0	0	0	0	150,765	0	0	0	0	0	0	0	0	31,217	0	2,414	0	408,051	0	0	0	3,806	133,247	45,981	0	0	0	0	0	0	775,481
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	198,252	0	0	0	0	0	0	0	0	53,238	0	3,418	0	725,811	12,579	0	0	37,976	152,251	430,277	0	0	0	0	0	0	1,613,803
28	0	0	0	0	0	0	0	0	0	277,493	0	0	0	0	0	0	0	0	41,794	0	256,873	0	1,112,152	2,554	0	0	9,860	395,543	299,423	0	0	0	30,565	0	0	2,426,258
29	0	0	0	0	0	0	0	0	0	80,583	0	0	0	0	0	0	0	0	62,465	0	5,000	0	221,861	2,519	0	0	0	124,489	116,921	0	0	0	97,252	0	0	711,091
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57,557	0	0	0	1,780	0	0	0	59,337
33	0	0	0	0	0	0	0	0	0	701,131	0	0	0	0	0	0	0	0	65,315	0	0	0	695,114	36,561	0	0	0	299,521	1,114,219	0	0	0	16,725	0	0	2,928,585
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
総計	0	0	0	0	0	79,318	0	0	0	6,724,038	0	0	0	0	0	0	0	0	2,706,816	0	1,745,542	0	7,203,490	161,097	0	0	83,803	2,037,385	2,203,418	1,486	0	5,529	228,048	0	0	23,179,971

Source: JICA Study Team

(5) Modal Split

The share of transport modes is estimated through constructing state-wise OD matrices per commodity per mode of transport, using the results of 2006 road interview survey and freight and forwarder company interview survey (the obtained data in these two surveys is tabulated in Appendix), both of which are carried out by JICA Study Team.

The following table shows current daily container traffic volume between the selected states and indicated that 41% of the containers between Maharashtra and Delhi and neighboring states are transported by rail. Allowing that the container traffic between Maharashtra and Delhi and neighboring states can represent all containers to/from Maharashtra[7]. and assuming that 30% of containers handled at the port in Maharashtra are delivered to the hinterlands (Maharashtra and its surrounding area), 29% (70%*41%) of all containers at Maharashtra ports are transported by rail.

Table 10.17 Current Daily Container Traffic (in TEUs)

Origin	Destination	TEU/day/direction			Rail Share
		Truck	Rail	Total	
MAHARASHTRA	DELHI	378	418	796	52.5%
	HARYANA	277	27	304	9.0%
	PUNJAB	64	108	172	62.7%
	RAJASTHAN	135	35	170	20.6%
	Sub-total	854	588	1,442	**40.8%**
GUJARAT	DELHI	140	138	278	49.6%
	HARYANA	228	7	234	2.8%
	Sub-total	368	144	512	**28.2%**

Source: Container traffic volume by truck is obtained from the result of the road interview survey, conducted by JICA Study Team in July and August 2006, and container volume by rail is estimated using CRIS database.

The following discussion will reveal the modal split of the container traffic handled at Maharashtra and Gujarat ports.

1) RITES Report

The discussion on the modal split explored in RITES report is a little vague, though it provides reasonable estimates in the modal split as discussed later. The rail share of container traffic is a mere 24% in 2003-04 for all containers in the western region. The RITES report estimates the modal split which gradually increases to 35% in Maharashtra and 45% in Gujarat, considering the following factors.

- Studies undertaken by different agencies, including the Ministry of Shipping, have revealed that 50% of total container traffic handled at Indian ports is long distance (above 300km) traffic suitable for rail transportation.

- CONCOR is currently the sole agency managing rail transportation of EXIM containers, but the market will soon be open to other private operators, which will help enhance the rail share.

[7] The container traffic between Maharashtra and the selected four states (Delhi, Haryana, Punjab, Rajasthan) accounts for 55% of all containers to/from Maharashtra. The container traffic between Gujarat and two states (Delhi and Haryana) accounts for 36%.

- CONCOR has estimated the extend of rail borne container traffic as 45% of the total containers handled at ports.

2) Modal Split Model

Regression Analysis

As shown in the following table, the level of service per mode of transport between the selected OD pairs is estimated, using various traffic information, including the result of the roadside OD interview survey and freight and forwarder company interview survey. The modal split mode (see the following equation), which encompasses time and cost ratio as dependent variables, is constructed by adopting regression analysis.

$$RailShare(\%) = 0.850 - 0.487 \times \frac{Trail}{Troad} - 0.101 \times \frac{Crail}{Croad} \ (\text{r2} = 0.71)$$

where, *T*: Haulage and dwell time, *C*: Haulage cost (Rs/FEU)

Table 10.18 Level of Service

Origin	Destination	Road		Rail		
		Haulage Time*1 (Hours)	Haulage Cost *2 (Rs./FEU)	Dwell Time at Port/ICD *3 (Hours)	Haulage Time*4 (Hours)	Haulage Cost *5 (Rs./FEU)
MAHARASHTRA	DELHI	135	31,750	3	51	49,258
	HARYANA	146	31,750	44	60	46,000
	PUNJAB	185	39,688	11	66	54,400
	RAJASTHAN	108	24,448	35	71	41,869
GUJARAT	DELHI	132	32,000	9	64	43,840
	HARYANA	151	27,520	165	59	43,840

Source: *1 Roadside Interview Survey by JICA Study Team, *2 Freight and Forwarder Company Interview Survey by JICA Study Team, *3 and 4 CRIS, *5 Freight and Forwarder Company Interview Survey by JICA Study Team

Exponential Analysis

Modal split can also be explained by the modal split curve and modeled by adopting the exponential function (see the following equation). The modal split model is constructed

$$RailShare(\%) = \frac{e^{f(x)}}{1 + e^{f(x)}}$$

$$f(x) = 3.43 - 2.19 \times \frac{Trail}{Troad} - 1.55 \times \frac{Crail}{Croad} \ (\text{r2} = 0.98)$$

where, *T*: Haulage and dwell time, *C*: Haulage cost (Rs/FEU)

3) Justification of Modal Split by RITES

Provision of DFC may extraordinarily increase the level of service by rail transport. Assuming the container traffic volume and road network and its level of service remain constant and the level of service by rail transport improves (i.e., the number of rail operated increases by 50% and the haulage time decreases by 50% by doubling the rail speed), the following tables show the changes in the modal split and estimate the container traffic between the selected OD pairs.

Assuming that 30% of containers handled at the port in Maharashtra are delivered to the hinterlands (Maharashtra and its surrounding area), the modal split models by both regression analysis and exponential analysis estimate 37% (70%*53%) of all containers at Maharashtra ports are transported by rail. On the other hand, the rail share at Gujarat ports is estimated at 43-48%, allowing that the container traffic between Gujarat and Delhi and Haryana represent all containers to/from Gujarat. Accordingly, it is concluded that RITES report provides reasonable estimates in the rail share of the container traffic (35% in Maharashtra and 45% in Gujarat).

Table 10.19 Estimated Container Traffic by Regression Analysis (in TEUs/day)

Origin	Destination	TEU/day/direction			Rail Share
		Truck	Rail	Total	
MAHARASHTRA	DELHI	302	494	796	62.1%
	HARYANA	231	73	304	23.9%
	PUNJAB	47	124	172	72.4%
	RAJASTHAN	99	71	170	41.9%
	Sub-total	679	762	1,442	52.9%
GUJARAT	DELHI	104	174	278	62.6%
	HARYANA	163	71	234	30.2%
	Sub-total	267	244	512	47.7%

Source: JICA Study Team

Table 10.20 Estimated Container Traffic by Exponential Analysis (in TEUs/day)

Origin	Destination	TEU/day/direction			Rail Share
		Truck	Rail	Total	
MAHARASHTRA	DELHI	295	501	796	62.9%
	HARYANA	226	78	304	25.6%
	PUNJAB	47	125	172	72.6%
	RAJASTHAN	102	68	170	40.1%
	Sub-total	670	771	1,442	53.5%
GUJARAT	DELHI	101	177	278	63.6%
	HARYANA	189	45	234	19.2%
	Sub-total	290	222	512	43.3%

Source: JICA Study Team

(6) Projection in Number of Trains

Regarding the bulk cargos, growth rates per commodity at selected eight state borders (three borders on the east corridor and five on the west corridor) are calculated by identifying the OD pair along the west and east corridor and estimating the freight traffic growth between 2004/05 and 2031/32. The number of trains is estimated by multiplying the growth rate and the current number of trains per commodity. Empty trains are also estimated using the current ratio of the number of empty trains to trains for specific use (for instance, the number of empty trains divided by that of trains for coal).

The number of container trains is calculated assuming 90 TEUs loaded per train. Other assumptions for projection in the number of trains are summarized below.

- This Study follows projection in the number of trains for coal at the east corridor (the annual growth rate between 2021 and 2031 is adjusted by that between 2016 and 2021) and the trains for 'other' transport in this Study is also applied from RITES report.

- This Study also follows the modal share of container traffic between rail and road estimated by RITES: Containers transported by rail account for 35% of total containers in Maharashtra and 45% in Gujarat.

The result of projection work in this Study is illustrated in the following figures.

Table 10.21 Projection in Number of Trains in 2031/32
(East Corridor, Up Direction: from Howrah to Delhi)

Section	Coal	Iron & Steel	Others	Empties	Total
Sonnagar-Mughalsarai	85.0	8.7	10.2	16.0	119.8
Mughalsarai-Allahabad	68.8	8.7	10.2	22.1	109.7
Allhabad-Kanpur	56.1	7.6	10.2	18.4	92.3
Kanpur-Tundla	49.3	6.0	10.2	16.9	82.3
Tundra-Khurja	45.5	5.4	10.2	13.0	74.0

Source: JICA Study Team

Table 10.22 Projection in Number of Trains in 2031/32
(East Corridor, Down Direction: from Delhi to Howrah)

Section	Foodgains	Fertilizer	Cement	Others	Empties	Total
Mughalsarai-Sonenagar	7.2	4.6	3.8	26.9	71.8	114.3
Allahabad-Mughalsarai	7.2	2.8	13.7	26.9	60.4	111.0
Kanpur-Allahabad	7.2	1.8	0.0	20.8	51.8	81.6
Tundla-Kanpur	7.0	2.1	0.0	19.7	41.3	70.0
Ghariabad-Tundla	7.9	0.0	0.0	9.0	40.1	57.0

Source: JICA Study Team

Table 10.23 Projection in Number of Trains in 2031/32
(West Corridor, Up Direction: from JNPT to Delhi)

<table>
<tr><th>Section</th><th>Route</th><th>Container</th><th>Others</th><th>Subtotal</th></tr>
<tr><td>Virar-Dahanu Road</td><td></td><td>99.1</td><td>7.6</td><td>106.7</td></tr>
<tr><td>Nagda-Kota</td><td>Southern Route</td><td rowspan="2">137.4</td><td rowspan="2">84.5</td><td rowspan="2">221.9</td></tr>
<tr><td>Palanpur-Marwar</td><td>North Route</td></tr>
<tr><td>Bayana-Mathura</td><td>Southern Route</td><td rowspan="2">133.6</td><td rowspan="2">67.8</td><td rowspan="2">201.3</td></tr>
<tr><td>Phulera-Rewari</td><td>North Route</td></tr>
</table>

Source: JICA Study Team

Table 10.24 Projection in Number of Trains in 2031/32
(West Corridor, Down Direction: from Delhi to JNPT)

Section	Route	Container	Others	Subtotal
Virar-Dahanu Road		95.7	9.7	105.5
Nagda-Kota	Southern Route	132.2	22.0	154.1
Palanpur-Marwar	North Route			
Bayana-Mathura	Southern Route	128.9	17.1	146.0
Phulera-Rewari	North Route			

Source: JICA Study Team

10.5 IMPLICATIONS TO TASK 2 STUDY

Freight demand forecasting work and its result, studied in this chapter, can provide the guidance for justification of DFC project. It also provides the essential inputs to practical selection of the project alternatives and preliminary economic and financial analysis for the DFC project. However, some of the limitation in this demand forecasting work should be noted: First and foremost, as the demand forecast model, studied in this chapter, is based on state-wise analysis, it cannot provide the detailed information on the commodity flow, e.g., Station-to-station OD, which cannot allow the operation planner to study the optimal operation plan of DFC project. Secondly, as the decent forecasting result requires reliable and up-to-date data, some of the freight information analyzed in this study are outdated, especially that on the freight surveys in 1987 and 1997. Thirdly and lastly, justification of port selection of the container cargos should be examined, since container traffic production/attraction was estimated under no-capacity-constraint assumption.

The modal split model in this Study also has some limitations: For instance, the model encompass the level of service of the line-hole transport but limits to include the service level of the access/egress (e.g., the travel time from ICD to consignee).

Accordingly, the implications for Task 2 Study, we suggest, are noted below:

- Freight demand forecasting analysis in the next phase should focus on more detailed OD, such as Division-to-Division OD or Station-to-Station which can allow engineers to practice the more detailed engineering study.

- In Task 2 Study, data updating will be required. One of the essential information can be obtained from the Total Transport Systems Study, of which the survey is now being carried out by the Planning Commission, GOI.

- The port and ICD development plans, including conceptual plans, in India should be carefully reviewed and the capacity, which determines the container throughput at each port/ICD, should be studied in view of both efficiency and physical capacity improvements (e.g., efficiency improvement in loading and unloading cargo and the expansion of container berth).

- The modal split model should be reviewed by obtaining sufficient amount of traffic information, including the level of service of line-hole transport and access/egress between an appropriate numbers of OD-pairs. To be specific, the supplemental freight survey, which interviews the port/ICD operators and transporters, should be taken into account in order to obtain the sufficient LOS data of the access/egress transport.

- Regarding bulk cargos, there seems no chance to transfer such cargo like coal and ore, from rail transport to road transport, because the origin (production) and destination (consumption) of those commodities is rigid usually connected by rail, while road transport can be more competitive when transporting food-grain. In that sence, the establishment of modal split model should be carefully examined in Task 2 Study.

CHAPTER 11 PRELIMINARY EVALUATION ON ALTERNATIVES

11.1 INTRODUCTION

The objective of this chapter is to provide a more detailed insight on the evaluation methodology and the role of the Goal Achievement Matrix (GAM) and Risk Analysis in the evaluation of the three alternatives that were prepared by the engineering study team. The comprehensive evaluation method will provide essential inputs for an argued selection of the preferred alternative on the basis of a detailed economic, financial, structural and risk analysis for the project. Through a series of the practices towards achieving the abovementioned objectives, this chapter tries to explain the methodological approach first and then identify appropriate methodologies for the evaluation of such large-scale projects as DFC.

The evaluation is performed in two stages during the study period. The first stage of which the results are provided in this Chapter 11 consists of a preliminary assessment of the three candidate alternatives at the conceptual level of detail. The second stage will include a more detailed evaluation of the selected alternative using the information of the detailed engineering study and will be realized in a later phase of the Study.

This Chapter 11 presents preliminary evaluation results and formulates an argued recommendation for the best alternative and the Project implementation approach. It should be noted that the underlying evaluation is based upon the information available. However, the applied approach and the in-depth evaluation of the three alternatives using equal evaluation conditions for all parameters that at present have to be assumed provides sustainable arguments for the recommendation of a particular alternative. Once the best alternative selected, much remains to be investigated in more detail to provide a final evaluation of the Project.

11.2 METHODOLOGICAL DISCUSSION

11.2.1 Financial evaluation

The construction of the dedicated freight corridor is one element of a multi-faceted approach to improve cargo traffic conditions in India. As such, the key criteria for their desirability are jointly determined by the cargo traffic, economic, structural and risk appraisals. On the basis of these, a prioritised implementation program can be recommended to ensure that the benefits from the construction of the new lines are maximised and that a prioritization considers the need to construct the planned rail freight network in a logical order. The financial appraisal is the first step in the evaluation, although the results of this section do not affect the overall desirability of the dedicated freight railway scheme themselves, or their relative priorities, it considers how the Project might be financed, and the resources that would be required.

In this preliminary stage of the evaluation, only limited information is available that does not enable discussing how the project might be financed or what could be the resources that might be mobilized. Only a strong and indicative perception is therefore possible about the financial performance of each of the alternatives, given similar assumptions and prepositions. The main purpose of the financial evaluation is thus to compare the attractiveness of the different alternatives for the proposed project in financial terms. The financial evaluation is not intended to quantify the relative or absolute desirability of a project to society in economic terms. Therefore, superior financial performance should not be interpreted as suggesting that a project should be accelerated, nor should poor financial performance be interpreted as evidence that a project should be abandoned or postponed.

A number of key measures can be identified, set out in Table 11.1.

Table 11.1 Main Indicators of Financial Viability

No	Measure	Units of Measure	Real or Nominal	Notes
Overall Performance Measures				
1	Project Capital Cost	RS Crore	Real	Total capital costs associated with provision of the freight railway line including land acquisition, construction and rolling stock costs
2	Project Rate of Return	Percent	Real	Excludes any financing costs
3	Pay Back Period	Years	Real	The numbers of years needed to pay back the capital cost
4	Annual Cash Flow	RS Crore	Real	Annual revenues and cumulated revenues generated by the Project
Investment Opportunity Test				
5	NPV	NPV	Real	NPV of revenues less NPV of operating costs
6	Benefit over costs	Ratio	Real	The benefits of the project as compared to the costs, given different NPV

The Overall Performance measures evaluate the project on their annual and total financial cash flow. The Project Capital Cost gives an indication of the scale of the Project and the resources which would need to be mobilised to progress the scheme. It is therefore of use when comparing the possible expenditure against the total resources likely to be available. This is expressed in real terms and excludes any costs of financing. It is also an important parameter to use when comparing other financial performance indicators. The Project Rate of Return is a measure of the overall financial viability of the project, before taking into account the way in which it is funded. This measure provides a simple indication of the extent to which it may be possible to involve the private sector in the project. A low overall rate of return would indicate that any financial participation by the private sector would have to be small. However, at this stage of the evaluation process, the issue of private sector participation in the development of the Project is not considered and the Rate of Return is only provided as a comparative financial indicator to compare the different alternatives. Finally, the Pay Back Period provides an indication about the financial strength of the revenues in relation to the invested capital while the Annual Cash Flow offers insights in the relationship between annual revenues and annual costs and whether the generated revenues are sufficient each year to cover the costs.

The Private Sector Opportunity Test relates to the project as a whole and indicates the extent to which the revenues from the project would be able to match the operating costs and possibly contribute towards the capital costs of the project.

Given the scarcity of information available in the present phase of the Project evaluation, the financial analysis will be approached from two different angles:

- The first angle is the strict financial evaluation from a *project perspective* where no costs are subsidized by government and revenues are only generated from the moment that the works are completed. As part of this evaluation and to assess the impact of the existing railway line on the Project's financial performance, costs and revenues emerging from operating the existing line during the construction phase of the new railway line are considered in addition to the strict financial performance; and

- The second angle is the financial evaluation from the *operator's perspective* (Indian Railways) where the capital investments are provided by the Government and the project considers revenues and costs of the existing line and the new line combined. This evaluation can provide valuable information to assess the potential for a participation of the private sector in operating the new service.

If the results in financial performance for each alternative are sufficiently divergent, a strong argument can be made to prefer one alternative over another, at least in terms of its financial performance.

11.2.2 Economic evaluation

The economic analysis will be conducted by means of a Cost Benefit Analysis (CBA) according to the EU Regulations for Structural Funds, for Cohesion Fund and for ISPA (pre-accession countries) projects with a budget higher than, respectively, 50, 10 and 5 Million Euro.

A Cost Benefit Analysis (CBA) is a means-end assessment defined by economic circumstances and where the investment is decided upon the conditioned evaluation cycle where input generates a result. As far as components are quantifiable, the CBA (can) incorporate(s) creative thinking by which less-tangible parameters are translated into "quantifiable" decision parameters. Whatever the level of creativity, the CBA upholds the principle that a final calculated recommendation can only be made on the basis of a numerical (formal) evaluation that uses mathematical algorithms without any distorting interventions.

The CBA is an effective evaluation technique for evaluating the different alternatives because it is widely recognized that the provision of a high-quality transport system plays a crucial role in long-term sustainable economic development and in that context it is important to identify the costs and benefits without possible distortions generated by weighting or quantifying efforts for non-quantifiable variables[1].

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[1] See for example, World Bank, *Sustainable Transport: Priorities for Policy Reform*" World Bank Policy Paper, Washington, D.C. (1996)

For each alternative, the Economic Internal Rate of Return (EIRR), the Net Present Value (NPV), and the Benefit/Cost (B/C) Raito will be computed.

In addition to the conventional evaluation methods, namely, financial and economic analysis, this study employed two new approaches for the purpose of alternative evaluation, namely Goal Achievement Matrix and Risk Analysis. A detailed discussion on these methods is already given in Chapter 2 of this report.

11.3 EVALUATION RESULTS

11.3.1 Basic assumptions for preliminary evaluation

- Start construction 2007, start operations 2012, evaluation time 20 years (year 2032). Financial calculations are expanded till the year 2050 to allow evaluating some long-term financial effects.

- Rolling stocks are not considered in this preliminary analysis. It is assumed that the cost of rolling stock for passenger transport will be higher as the costs for rolling stock for cargo transport.

- In the financial analysis, personnel costs are calculated as total personnel cost per km of railway track.

- In the financial analysis, non-traffic revenues are only considered at 14.36% of traffic revenues for the East and West Corridor combined and at 7.18% for each of the corridors individually. The share is based upon the share of non-traffic revenues as compared to total traffic revenues, published for the year 2004-2005 balance sheet of Indian Railways.

- In the financial analysis, operational costs are considered 70% of traffic revenues (basis year 2004-2005 financial results); additional costs and losses due to over-utilization of available capacity are not considered.

- In the financial analysis, taxes or interest costs on loans are not considered.

- Incremental traffic benefits only are considered for the Economic analysis.

The track alignment includes some variations and additions to the basic version. The West Corridor has two alignment options, a south route via Kota and a north route via Palanpur. The East Corridor has no alignment options but the Study also investigates the primary feeder line. The details are demonstrated in Table 11.2 hereafter.

Table 11.2 Detailed description of Project Options per Corridor

Project Corridor	Line length (km)
West Corridor (South Route via Kota)	1,415
West Corridor (North Route via Palanpur)	1,461
East Corridor	1,232
East Corridor (Primary Feeder Line)	
- Line 1	608.0
- Line 2	396.0
- Line 3	100.0

Forecasts for freight in TEU will be converted into tons using a ratio of 16 tons per TEU. This is based upon the Calcutta container statistics as shown in Table 11.3.

Table 11.3 TEU to ton conversion

IN TEU	2004-2005			2005-2006		
	KDS	HDC	Total	KDS	HDC	Total
Import	89,156	53,084	142,240	110,161	50,959	161,120
Export	70,086	75,429	145,515	93,320	59,360	152,680
Total	159,242	128,513	287,755	203,481	110,319	313,800
IN TON	2004-2005			2005-2006		
	KDS	HDC	Total	KDS	HDC	Total
Import	1,287,418	808,982	2,096,400	1,981,873	866,164	2,848,037
Export	1,070,052	1,220,462	2,290,514	1,251,819	1,044,238	2,296,057
Total	2,357,470	2,029,444	4,386,914	3,233,692	1,910,402	5,144,094
CONVERSION	15	16	15	16	17	16
Average tonnage	16	per container				

Source: Calcutta Port Statistics

For the purpose of the preliminary analysis of which the results are presented in underlying Report, the North Route via Palanpur is used as alternative for the West Corridor and the primary feeder line is not included for the East Corridor.

Personnel costs will be calculated on the basis of year 2005 personnel cost per track-kilometer. The value is calculated as IR's total year 2005 cost for personnel, thus including all provisions for pension and other costs, divided with the total km length of tracks in the year 2005. The values are annually increased with the current price adjustment factor.

Table 11.4 presents the evolution of the annual personnel cost for IR.

Table 11.4 Annual personnel costs (1950 – 2005)

Year	Group A&B	Group C	Group D	Total (persons)	Expenditure @ on staff
	in thousands				Rs. in crores
1950-51	2.3	223.5	687.8	913.6	113.8
1960-61	4.4	463.1	689.5	1,157.0	205.2
1970-71	8.1	583.2	782.9	1,374.2	459.9
1980-81	11.2	721.1	839.9	1,572.2	1,316.7
1990-91	14.3	891.4	746.1	1,651.8	5,166.3
2000-01	14.8	900.3	630.2	1,545.3	18,841.4
2001-02	14.3	890.0	606.5	1,510.8	19,214.1
2002-03	13.6	870.0	588.3	1,471.9	19,914.8
2003-04	14.3	860.1	567.1	1,441.5	20,928.4
2004-05	14.7	872.1	535.4	1,422.2	22,559.8

Source: IR year 2005 financial records
@ includes from 1980 on also number of Railway Protection Special Force (RPSF) personnel and expenditures

Total expenditure on personnel per Km track is calculated for each alternative as in Table 11.5 and translated into personnel costs for each of the two corridors and for the Project as a whole.

Table 11.5 Personnel cost per Alternative (year 2005)

Staff cost / year		**track length**			**personnel cost Rs crores**
Alternative	division	Existing (year 2005)	added	total	0.207
DFC alternative	corridor West	1,465	1,465	2,930	708.710
(new line cost increase)	corridor East	1,232	1,232	2,464	595.993
17%	total	2,697	2,697	5,394	1,522.039
DPC alternative	corridor West	1,465	1,465	2,930	794.643
(new line cost increase)	corridor East	1,232	1,232	2,464	668.260
31%	total	2,697	2,697	5,394	1,913.523
ML alternative	corridor West	1,465		1,465	312.606
(new line cost increase)	corridor East	1,232		1,232	262.888
3%	total	2,697		2,697	592.263
Do Nothing	corridor West	1,465		1,465	303.755
(base case)	corridor East	1,232		1,232	255.445
	total	2,697		2,697	559.200

Source: JICA Study Team based upon IR Yearbook 2004 – 2005, financial records and project data

For the preliminary analysis, the length of the new passenger line and the new cargo line are considered equal. To incorporate the impact of increased personnel for each of the alternatives, the personnel cost for the three alternatives are increased with the % increase for each alternative decided upon the type of personnel needed (type AB & C for DPC and type AB & D for DFC) multiplied with the weight of the investment.

The weight of the investment for each of the three alternatives is as in Table 11.6.

Table 11.6 Weight of the investment

	DFC	DPC	ML
Total investment (Rs. Crores)	26,635	30,552	4,659
weight (∂)	0.43	0.49	0.08

Throughout the financial model values at current prices are used. It is assumed that no extraordinary increases will occur during the project life cycle. In case an adjustment factor is used, this conversion factor is determined on the basis of the All-India Average Consumer Price Index Numbers for Industrial Workers (year 2001 = 100). The conversion of base 1982 values to base 2001 is equal to 4.58, see Table 11.7.

Table 11.7 Calculated CPI conversion value

base 1982 = 100												
Year	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Average**
1993	241	241	243	245	246	250	253	256	259	262	265	264	**252**
1994	263	265	267	269	272	277	281	284	288	289	291	289	**278**
1995	289	291	293	295	300	306	313	315	317	319	321	317	**306**
1996	315	316	319	324	328	333	339	343	344	346	349	350	**334**
1997	350	350	351	354	352	355	358	359	361	365	366	372	**358**
1998	384	382	380	383	389	399	411	413	420	433	438	429	**405**
1999	420	415	414	415	419	420	424	426	429	437	438	431	**424**
2000	431	430	434	438	440	442	445	443	444	449	450	446	**441**
2001	445	443	445	448	451	457	463	466	465	468	472	469	**458**
2002	467	466	468	469	472	476	481	484	485	487	489	484	**477**
2003	483	484	487	493	494	497	501	499	499	503	504	502	**496**
2004	504	504	504	504	508	512	517	522	523	526	525	521	**514**
2005	526	525	525	529	527	529	538	540	542	548	553	550	**536**
Year	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Average**
2001													**100**
2002	101.97	101.75	102.18	102.40	103.06	103.93	105.02	105.68	105.90	106.33	106.77	105.68	**104.15**
2003	105.46	105.68	106.33	107.64	107.86	108.52	109.39	108.95	108.95	109.83	110.04	109.61	**108.30**
2004	110.04	110.04	110.04	110.04	110.92	111.79	112.88	113.97	114.19	114.85	114.63	113.76	**112.23**
2005	114.85	114.63	114.63	115.50	115.07	115.50	117.47	117.90	118.34	119.65	120.74	120.09	**117.03**

Source: Labour Bureau Government of India

This price adjustment factor has been applied uniformly to convert constant price values to current prices. The average CPI value was calculated as in following Table 11.8.

Table 11.8 Growth rate for preliminary evaluation

Year	average growth
2001	
2002	3.98%
2003	3.83%
2004	3.50%
2005	4.10%
Applied average conversion rate	**3.86%**

11.3.2 Financial evaluation results

(1) East and West Corridor Combined

The next Table 11.9 provides a summary of the financial evaluation for the different alternatives, combining the East and West Corridors. These are the results of the evaluation for the Project in itself, considering the capital investment and revenues generated only after completion of construction works.

Table 11.9 Preliminary Results for the financial evaluation (project perspective)

Summary of results (YEARS 2007 - 2032)		**Results at various discount rate**				
All values RS Crore (Rs x 10^7) except where indicated otherwise		Current prices	NPV Value			
			at FIRR	6%	10%	12%
Alternative	Indicator					
DFC	Total Cash Outflow (cost)	389,176	-101,080	-161,368	-101,536	-83,279
	Total Cash Inflow (revenue)	469,741	101,080	177,154	101,649	78,957
	NET CASH FLOW (benefit/loss)	80,565				
	B/C Ratio (ratio)		1.00	1.10	1.00	0.95
	FIRR (%)	**10%**				
	Payback (No of years)	**19**				
DPC	Total Cash Outflow (cost)	393,212	-154,895	-167,464	-107,073	-88,457
	Total Cash Inflow (revenue)	439,778	154,895	169,788	98,615	76,983
	NET CASH FLOW (benefit/loss)	46,567				
	B/C Ratio (ratio)		1.00	1.01	0.92	0.87
	FIRR (%)	**7%**				
	Payback (No of years)	**23**				
ML	Total Cash Outflow (cost)	314,007	-5,236	-122,068	-71,747	-56,475
	Total Cash Inflow (revenue)	455,810	5,236	173,909	100,362	78,136
	NET CASH FLOW (benefit/loss)	141,803				
	B/C Ratio (ratio)		1.00	1.42	1.40	1.38
	FIRR (%)	**45%**				
	Payback (No of years)	**8**				

Source: JICA Study Team

From a project-oriented financial perspective, the Mixed Line Alternative is by far the preferred solution. Considering the project life till the year 2032, the ML Alternative generates the highest net cash flow (141,803 RS Crores), has a very strong rate of return

(45%) and can pay back its investment from revenues after eight years, equal to 3 years of operations.

Building a Dedicated Freight Rail Corridor (DFC Alternative) is the second best option for the East and West Corridor combined but the financial performance is less attractive with a net project cash flow of 80,565 RS Crores, a financial rate of return of 10% and a payback period of 19 years (14 years of operations). Building a Dedicated Passenger Rail Corridor (DPC Alternative) is the least attractive alternative, with only 7% FIRR for a total return of 46,567 RS Cores and a payback period equal to 23 years or 18 years of operators. However, the comparative financial evaluation is strongly distorted by the extreme difference in capital investment between the Mixed Line Alternative and the two other alternatives, as can be observed in following Table 11.10 and the relative similarity in revenues during the first 20 years of operations.

Table 11.10 Investment impact per alternative

Parameter	ML Alternative	DFC Alternative	DPC Alternative
Capital Investment Cost (CC)	4,659	26,635	30,356
Revenues till year 2032	455,810	469,741	439,778
Revenues till year 2050	982,855	1,190,793	929,186
CC versus revenues year 2032	1.02%	5.67%	6.90%
CC versus revenues year 2050	0.47%	2.24%	3.27%

The total capital investment for the ML Alternative is only 1/6th of the capital investment for the DFC Alternative and 1/7th of the capital investment for the DPC Alternative, but at the same time, the revenues for the three alternatives till the year 2032 hover around the 450,000 RS Crores (current prices). The difference in financial performance of the Project between the three alternatives can be observed when revenues till the year 2050 are compared, in which case the DFC Alternative outperforms both other alternatives. However, in terms or capital cost against revenues, the share of the ML alternative is 1.2% for the year 2032 (0.47% for year 2050 revenues), while this is 5.7% (2.2%) and 6.9% (3.2%) for the DFC and DPC Alternatives respectively.

Given that the project includes an existing line, the operations on this existing line could also be considered as part of the Project. But including revenues generated on the existing line during the construction period (2007 – 2012) does not engender a notable change on the relationship between the alternatives but only improves the financial results. For example, the financial rate of return for the DFC Alternative increases with 4% to 14% and the payback period reduces with 2 years while the rate of return for the DPC Alternative improves from 7% to 9% and the payback period reduces from 23 years to 21 years. The only important positive effect is that the B/C ratio for the DFC Alternative becomes positive for all three NPV values while it became slightly negative at 12% NPV in case revenues generated on the existing line are not considered during the construction period. For the DPC Alternative, which originally generated a negative B/C Ratio at 10% and 12% NPV, now only scores negative at 12% NPV.

The ML Alternative remains the alternative with the best financial performance when considering revenues on the existing line during the construction phase. But it should be noted that there has not been any provision for congestion costs generated by the works on the existing line during the period 2007-2012 which will have a direct impact on the revenue stream during that period for the ML Alternative but do not affect the revenue streams for the DFC and DPC Alternatives. However, even eliminating revenues assuming the line has been closed during rehabilitation works will not lead to the ML Alternative scoring below one of the two other alternatives.

A last issue that the above financial analysis does not consider is capacity limitations and the revenue losses therewith associated. In this context, the DFC Alternative is by far the best option given that the project is not confronted with any capacity constraints until the year 2050, contrary to the DPC and ML Alternatives that reach maximum capacity in the year 2029. The former reaches its maximum capacity for cargo and local passenger transport while long distance passenger transport continues to grow, the latter reaches total saturation of all types of passenger and cargo transport by 2029.

Looking at the investment from the operator's perspective (Table 11.11), it is assumed that the capital investment for infrastructure development is provided by the Government and the operator is not burdened to pay back this investment from generated revenues. The results of this approach provide a first indication about the (financial) role of the Indian Government, the profitability of the Project for the operator and gives also indications about the actual financial contribution of the government in case the private sector would be invited to participate in the realization of the project.

Table 11.11 Preliminary Results for the financial evaluation (operator's perspective)

Summary of results (YEARS 2007 - 2032)		**Results at various discount rate**				
All values RS Crore (Rs x 10^7) except where indicated otherwise		Current prices	NPV Value			
			FIRR	6%	10%	12%
Alternative	Indicator					
DFC	Total Cash Outflow (cost)	435,080	-30,470	-199,842	-136,047	-116,045
	Total Cash Inflow (revenue)	554,024	30,470	247,900	165,168	139,291
	NET CASH FLOW (benefit/loss)	118,944				
	B/C Ratio (ratio)		1.00	1.24	1.21	1.20
	FIRR (%)	**53%**				
	Payback (No of years)	**10**				
DPC	Total Cash Outflow (cost)	441,784	-43,373	-208,176	-143,593	-123,131
	Total Cash Inflow (revenue)	527,978	43,373	243,834	165,103	140,141
	NET CASH FLOW (benefit/loss)	86,194				
	B/C Ratio (ratio)		1.00	1.17	1.15	1.14
	FIRR (%)	**39%**				
	Payback (No of years)	**13**				
ML	Total Cash Outflow (cost)	353,575	#	-155,227	-101,488	-84,711
	Total Cash Inflow (revenue)	518,117	#	226,116	147,180	122,581
	NET CASH FLOW (benefit/loss)	164,543				
	B/C Ratio (ratio)		#	1.46	1.45	1.45
	FIRR (%)	**#**				
	Payback (No of years)	**3**				

The operator's perspective evaluates the different alternatives from the point of view of Indian Railways, CONCOR or any other private company and therefore assumes that the Project generates revenues from the beginning of the Project from the year 2007 via operations on the existing line on and that the capital investment is covered by the Government of India.

At this preliminary stage of the evaluation and given the absence of detailed information, the financial assessment remains tentative because no provisions are taken regarding the procurement of rolling stocks, taxes or any capital borrowing.

From an operator's perspective, the ML Alternative remains the financially most attractive option, with the highest net project cash flow, the strongest B/C Ratio and only a 3 year payback period. The ML Alternative also starts making profits from the first year of operations via activities on the existing line. However, as in the project-oriented evaluation, no provisions are made also in the operator-oriented evaluation to incorporate the negative impact of construction works and capacity limitations very early during the project lifecycle. Both components are however very important because at present, rail cargo traffic is responsible for 65% and more of annual revenues of Indian Railways. Consequently, maximizing cargo carrying capacity is a priority objective to maximize revenues.

The strong results of the financial indicators do not mean that the ML option should be preferred over the other options and this for many reasons:

1. Maximum capacity of railway tracks for the ML Alternative is reached in the year 2030. This means that a substantial volume of cargo and passengers cannot be accommodated after that time. This is not reflected in the financial analysis, where revenues are compared to cost, but where "lost revenues" are not accounted for.

2. The impact of revenues generated before reaching maximum capacity is almost equal to the revenues generated by the other two alternatives and produces much higher profits early in the project. This distorting impact is further increased if the current prices are converted in net present values, accounting for the high B/C Ratios according to the different NPV values. Furthermore, there are no provisions taken for capacity impacts during the construction period, an impact that will certainly occur for the ML Alternative but not for the two other alternatives where the construction of a new railway line does not interfere with operations on the existing line.

3. Operations on the corridor remain profitable in spite of reaching maximum capacity by the year 2030. Given that there is no accounting in the calculations for "lost revenues" or for congestion costs from the year 2030 onwards, annual revenues remain stable and continue to have a strong positive effect on the overall financial performance of the ML Alternative.

4. Compared to the DFC Alternative, the ML Alternative generates notable lower annual revenues. The DFC Alternative generates over the extended project life cycle till year 2050 over 181,000 RS Crores more revenues than the ML Alternative. While total revenues are similar for both alternatives during the period till the year 2028, the DFC Alternative makes over the period between 2028 and 2032 an average annual amount of 1,700 RS Crores more. Between the period 2032 till the year 2050, this average difference increases to over 9,100 RS Crores, with the DFC Alternative making a total of over 12,600 RS Crores more of traffic related revenues in the year 2050.

Excluding the capital costs from the evaluation substantially improves the financial results of the DFC Alternative. With a FIRR of 53% for the East and West Corridor combined, the project becomes very attractive for the (private) operator, an attractiveness that is also reflected in the stronger benefits (B/C Ratio) and payback period. The results of the DFC Alternative now clearly differentiate from the DPC Alternative.

With above evaluation, a first attempt was made to consider the financial performance from a *project perspective* and from the *operator's perspective*. For the final financial assessment, a more in-depth financial study is required which incorporates a wider range of revenues and costs not yet considered and also includes tax and capital borrowing implications. The comprehensive financial analysis will thus investigate in more detail the financial viability by principal stakeholder, namely the government and the operator, either private or public. The next phase of the financial evaluation will also investigate in terms of revenues for both government and operator the scope for, at least in principle, and the impact of raising additional revenues from those who might benefit indirectly from the construction of the new cargo railway lines, either from improvements in general traffic conditions and accessibility (truck or fuel charges, enhanced business development opportunities, especially in the vicinity of the transit facilities, etc.)

Finally, comparing the results of the financial analyses from an operator and project perspective will provide interesting information on the extent to which the private sector may be willing to get involved in providing funding for elements of the construction and for operating the new railway lines and what would be the necessary financial input from the Government to make the investment attractive for a private partner.

(2) Corridor specific evaluation and comparison

East Corridor

The next Table 11.12 provides a summary of the financial evaluation for the different alternatives focusing the East Corridor from a project perspective.

Table 11.12 Preliminary Financial Results for East Corridor (Project perspective)

Summary of results (YEARS 2007 - 2032)		**Results at various discount rate**				
All values RS Crore (Rs x 10^7) except where indicated otherwise		Current prices	NPV Value			
			FIRR	6%	10%	12%
Alternative	Indicator					
DFC	Total Cash Outflow (cost)	161,472	-48,076	-69,238	-44,575	-36,963
	Total Cash Inflow (revenue)	193,986	48,076	74,971	43,668	34,152
	NET CASH FLOW (benefit/loss)	32,514				
	B/C Ratio (ratio)		1.00	1.08	0.98	0.92
	FIRR (%)	**9%**				
	Payback (No of years)	**20**				
	Saturation of railway capacity	**---**				
DPC	Total Cash Outflow (cost)	165,398	-85,527	-71,997	-46,871	-39,088
	Total Cash Inflow (revenue)	179,527	85,527	69,742	40,722	31,878
	NET CASH FLOW (benefit/loss)	14,128				
	B/C Ratio (ratio)		1.00	0.97	0.87	0.82
	FIRR (%)	**5%**				
	Payback (No of years)	**27**				
	Saturation of railway capacity	**2029 (except for long distance passenger traffic that continues to grow moderately)**				
ML	Total Cash Outflow (cost)	132,877	-3,446	-52,659	-31,354	-24,834
	Total Cash Inflow (revenue)	179,261	3,446	69,681	40,698	31,863
	NET CASH FLOW (benefit/loss)	46,383				
	B/C Ratio (ratio)		1.00	1.32	1.32	1.28
	FIRR (%)	**38%**				
	Payback (No of years)	**7**				
	Saturation of railway capacity	**2029 (passenger and cargo transport combined)**				

As it is clearly shown in Table 11.12, the ML Alternative continues to outperform both other alternatives. It is the only alternative with an acceptable rate of return and B/C Ratio. However, it should be stressed again that there were no provisions for hindrance to traffic flows during the 5 year construction period or for reaching maximum capacity on the East Corridor already in 2029 and the loss of traffic or growing congestion costs emerging from that year on.

Both the DPC and DFC Alternative have a FIRR of 5% and 9% respectively and generate a much lower project cash flow of 32.5 and 14.1 thousand RS Crores in current prices. Both generate negative revenues in case the current prices are adapted to a 10% or 12% NPV value. The DPC Alternative also generates negative revenues when adjusted to a 6% NPV.

<u>West Corridor</u>

The results of the financial evaluation for West Corridor from a project perspective are presented in Table 11.13.

Table 11.13 Preliminary financial results for West Corridor (project perspective)

Summary of results (YEARS 2007 - 2032)		**Results at various discount rate**				
All values RS Crore (Rs x 10^7) except where indicated otherwise		Current prices	NPV Value			
			FIRR	6%	10%	12%
Alternative	Indicator					
DFC	Total Cash Outflow (cost)	217,277	-55,826	-88,100	-54,614	-44,480
	Total Cash Inflow (revenue)	258,442	55,826	95,767	54,341	41,992
	NET CASH FLOW (benefit/loss)	41,164				
	B/C Ratio (ratio)		1.00	1.09	0.99	0.94
	FIRR (%)	**10%**				
	Payback (No of years)	**19**				
	Saturation of railway capacity	**2035 (passenger and cargo transport combined)**				
DPC	Total Cash Outflow (cost)	206,391	-76,090	-87,259	-55,457	-45,675
	Total Cash Inflow (revenue)	232,640	76,090	89,386	51,701	40,271
	NET CASH FLOW (benefit/loss)	26,249				
	B/C Ratio (ratio)		1.00	1.02	0.93	0.88
	FIRR (%)	**7%**				
	Payback (No of years)	**22**				
	Saturation of railway capacity	**2025 (except for long distance passenger traffic that continues to grow very moderately)**				
ML	Total Cash Outflow (cost)	180,325	-3,195	-69,098	-40,211	-31,499
	Total Cash Inflow (revenue)	247,582	3,195	93,230	53,332	41,348
	NET CASH FLOW (benefit/loss)	67,257				
	B/C Ratio (ratio)		1.00	1.35	1.33	1.31
	FIRR (%)	**42%**				
	Payback (No of years)	**7**				
	Saturation of railway capacity	**2028 (passenger and cargo transport combined)**				

The situation on the West Corridor is substantially different from the East Corridor. The financial results are in particular influenced by the higher overall traffic volumes and the rapid growth of container traffic which affects in particular the cash flow and the railway capacity. For West Corridor, each of the alternatives reaches at some point in time its maximum capacity, in the years 2025, 2035 and 2028 for the DPC, the DFC and the ML Alternatives respectively.

As for the other project oriented results, the ML Alternative scores again substantially better than the two other alternatives in terms of rate of return, net cash flow, pay back period and B/C Ratios. However, the financial evaluation does again not consider impacts of reaching maximum capacity already in 2028 or the congestion costs and revenue losses attached to this from that year on.

For the West Corridor, the financial results for the DFC Alternative are all notably better as compared to the DPC Alternative. The DFC Alternative has a rate of return of 10% as compared to 7%for the DPC Alternative, has more than double the net cash flow and its B/C Ratios are each around 3 points better. While the DFC Alternative pays back its capital investment after 19 years, the DPC Alternative needs 22 years to pay back its investment.

(3) Conclusions for the financial evaluation

It should be noted that the following conclusions remain tentative, given that a wide range of influential parameters (such as details of the capital investment, rolling stock needs, detailed engineering requirements, personnel costs, financing structure, etc…) remain unknown and assumptions had to be made.

However, the financial evaluation of the different alternatives and the distinction between the project and operator perspective while keeping assumptions similar for all Alternatives allows identifying with an acceptable degree of certainty the best Alternative:

1. From a purely financial perspective and based upon the B/C Ratio and rates of returns, without taking into account any capacity constraints or negative financial effects thereof, the ML Alternative can be considered as the best solution. It also pays back the capital investment much earlier as the other alternatives, which is of course the result of the very low capital investment as compared to the other two alternatives.

2. The ML Alternative will also quickly reach maximum capacity, a considerable negative effect that is not directly reflected in the financial analysis but should be integrated in the evaluation via some form of congestion cost in the economic evaluation.

3. The DPC Alternative is not a feasible alternative. Its overall financial performance remains very weak and the capital investment of the total project will not be paid back during the entire project life-cycle. Furthermore, the specific nature of this alternative generates in the long term future notable capacity constraints, obstructing by the year 2030 further growth of cargo transport because of its confinement to the existing railway line. This over time is reflected in a negative cash flow.

4. The remaining and probably financially attractive solution must be the development of the DFC Alternative, where the construction of a new dedicated freight line allows the long-term growth of cargo traffic without capacity constraints (except for the West Corridor). The transfer of all cargo transport to the dedicated line also maximizes the potential for growth of passenger traffic on the existing line. Consequently, all financial indicators for the DFC Alternative are notably better than those for the DPC Alternative and the project is able to repay the investment contrary to the DPC Alternative.

Assuming the DFC Alternative is selected as preferred option, the *theoretically* best solution for meeting total traffic demand for both passengers and cargo would be to develop the East and West Corridors simultaneously, therewith maximizing the benefits for both passenger and cargo transport by rail over the entire region. However, financial constraints and technical and engineering limitations could force the Indian Government to decide for a two step approach, building first the dedicated freight line on one corridor, followed in a later stage by the construction of the new dedicated freight line on the remaining corridor.

On the basis of the presently available information, a firm recommendation about the priority of one corridor over the other remains tentative. However, above comparative analysis per corridor for the DFC Alternative gives some indications about the priority for each of the corridors:

1. The West Corridor has more traffic as compared to the East Corridor which is directly reflected in the stronger results of the financial indicators of West over East Corridor although the good score of the latter should not be neglected.

2. When looking at the impact on passenger and cargo transport of each of the alternatives and per corridor with target year 2032 and 2050, the capacity argument is substantiated by the results of the comparative analysis. This evaluation also suggests that the West Corridor should be build first, as it allows accommodating more passenger and cargo as compared to the East Corridor in the period till the year 2032. This assumption is further confirmed by the fact that capacity constraints on the West Corridor emerge only after the year 2035 at the time the East Corridor is capable of accommodating more traffic.

3. The construction of the DFC Alternative for the West Corridor before the construction of the DFC for the East Corridor will also benefit the sustainable development of railway-based international container traffic. At present, only the West Corridor railway system transport significant volumes of containers and its future strong growth warrants the establishment of a dedicated railway line for the efficient transport of containers as soon as possible.

4. It should be noted that the East Corridor is also required to play a very strategic role, that is, to carry coal, material for power generation. To meet the future power demand in major cities and by various industries, it is indispensable to develop an efficient transport system to carry such materials.

11.3.3 Economic evaluation results

(1) Conditions and parameters for the economic evaluation

The Economic Benefits will be derived from comparing the "With Project" case with the "Without Project" case for a time span from 2007/08 till 2032/33, assuming a 5 year construction period and 20 years of operations. The year 2007/08 is not considered as a full year of operations because operations are only initiated during that year. First full year of operations is thus the first year after starting operations.

The economic benefit streams are defined by the benefits generated from increased carrying capacity of the railways for both passenger and cargoes (*incremental benefits*). Incremental benefits are generated as and when line capacity of an alternative is reached in the case "without investments". Therefore, any negative impact of constructions on the line capacity is not considered.

The benefit stream will be capped in the year maximum capacity is reached and no traffic increase is generated. Furthermore, the evaluation in this stage will not consider negative benefits (economic losses) generated by capacity constraints.

The incremental benefits of the Project include following components

1. Operator Surplus
2. Benefits in transportation cost
3. Benefits in travel time of cargoes
4. Benefits of additional cargo carrying capacity
5. Benefits of additional cargo transported by rail

(2) Economic Benefits

Operator Surplus for each year is calculated as follows:

$$OS_n = \partial[(B_t + B_{nt}) - C_o]_n$$

With OS_n = Operator Surplus in year n
∂ = weight to adjust profit to capital investment (see Table 11.6)
B_t = Benefits generated by traffic
B_{nt} = Non traffic benefits
C_o = Operating costs
n = the year in which the calculations are made with n = 1 … 25

These results define the net annual profits of the operator stemming from operations with the new project infrastructure and do not consider the capital investments or any other financial or exceptional costs or benefits.

The benefits are defined as the benefits generated by Indian Railways for a specific Alternative and are calculated from the first year of operations. Benefits are assumed non-existing during the time of construction. It should be noted that the revenues are not capped during the evaluation period because capacity limitations have no erase annual operator revenues but only reduce the annual revenue stream.

However, since the real operation, maintenance and administration costs are not available it is still difficult to estimate the operator's surplus from the financial statement as discussed in the previous section. Accordingly the operator's surplus included in this economic analysis could be overestimated.

Benefits in transportation costs per year are calculated as:

$$TC_n = \Delta\, \partial[(VOC_{pax} \text{ x } Km_{pax}) + (VOC_{ton} \text{ x } Km_{ton})]_n$$

With TC_n = Benefits in transportation costs in year n
∂ = weight to adjust benefit to capital investment(see Table 11.6)
Δ = adjustment factor to include difference between rail and road VOC, set at 60% actual benefits (rail VOC is 40% of road VOC)

VOC_{pax}	= Benefit in vehicle operating costs which is defined as the reduction in the cost of road passenger transport
Km_{pax}	= Number of incremental passenger kilometers
VOC_{ton}	= Benefit in vehicle operating costs which is defined as the reduction in the cost of road cargo transport
Km_{ton}	= Number of incremental ton kilometers
Y_n	= year n in the project life cycle
n	= the year in which the calculations are made with n = 1 … 25

The benefits in vehicle operating costs assume that the transport by rail is more beneficial for both passengers and rail. Therefore, the incremental ton and passenger kilometers generates a benefits as there is no transport by road. The Vehicle operating costs for road transport of passengers and cargo are considered and the value is adjusted to the level of the investment.

It should be clear that the incremental VOC savings can only be counted. For the purpose of this intermediate evaluation, the VOC for rail are assumed 40% of the VOC by road, hence a benefit of 60% of road VOC is calculated. For the final evaluation, when data is available on vehicle operating costs for passenger cars and cargo wagons, a more accurate estimation can be made that considers the *true incremental* VOC benefits (this is the calculated VOC for road minus the calculated VOC for rail).

Benefits in travel time for cargo are calculated as follows:

$$(TS_c)_n = \partial[(V_t \text{ x } T) \text{ x } D]_n$$

With

$(TS_c)_n$	= savings in travel time for cargo in year n
∂	= weight to adjust benefit to capital investment(see Table 11.6)
V_t	= value of time for transport of cargo per ton/km
T	= total ton of cargo transported
D	= average number of days cargo is transported on rail
n	= the year in which the calculations are made with n = 1 … 25

Travel time savings are limited to cargo transport. It is assumed that the savings in travel time for passengers remain unchanged as the schedules for rail passenger is maintained on the existing line during the project life cycle.

It should be noted that many of the parameters defining the incremental benefits in cargo travel time have to be assumed in this stage of the project. The incremental travel time is only calculated until the railway track reaches maximum capacity. Delays due to congestion on the tracks are not considered at this stage of the study. The value of time for cargo transport is in this stage of the Project calculated on the basis of the revenues for cargo transport divided by the total cargo volume transported. The average number of days the cargo travels is calculated on the basis of average container and cargo travel times by rail. At present, the average travel time for a container is 7 days, for general cargo 9 days. It is assumed that by 2032, the travel time for container is reduced to 50% of that time and for general cargo with 20%, and that this improvement is gradual in time.

Given that the principal aim of the project is to increase cargo transport by rail, the last economic benefit that is considered is the *incremental cargo carrying capacity* of the network, calculated as follows:

$$(CC_c)_n = \partial[TKm_{alt} - TKm(_{max\text{-}alt})]_n$$

Wit $(CC_c)_n$ = Cargo carrying capacity benefits in year n
∂ = weight to adjust benefit to capital investment(see Table 11.6)
TKmalt = Total ton kilometers of alternative
TKm(max-alt)= Total tons kilometers transported
Yn = year n in the project life cycle
n = the year of calculations with n = 1 … 25

Contrary to many other economic appreciations and given the extreme divergence in the capital investment for the three alternatives, it is also important to look at the benefits in annual transported cargo. In other words, this approach allows tentatively assessing the benefits of shifting cargo from the road to railways or to ensure that due to capacity limitations, no cargo is forced on the roads with all negative aspects thereof.

The *benefit of additional cargo transported* is calculated as follows:

$$(ACT)_n = \partial[T_{alt} - T_{max}]_n \text{ x } VOC_{ton}$$

With $(ACT)_n$ = benefits of Incremental cargo transported in year n
∂ = weight to adjust benefit to capital investment(see Table 11.6)
T_{alt} = Total ton transported by the alternative
T_{max} = Maximum number of tons transported all alternatives combined
VOC_{ton} = Benefit in vehicle operating costs which is defined as the reduction in the cost of road cargo transport
Y_n = year n in the project life cycle
n = the year in which the calculations are made with n = 1 … 25

Contrary to the above four economic benefit calculations, the economic benefit of additional cargo transported can be negative in case the railway infrastructure is characterized by capacity limitations that do not allow the infrastructure to accommodate total volume of demand. As a consequence, these volumes are transported by road and will generate an economic cost to society.

For the best alternative, i.c., the alternative transporting the highest volume of cargo, the economic benefit is positive and is the benefit as compared to the average cargo lost by the other two alternatives.

<u>East & West combined</u>

The next Table 11.14 provides a summary of the economic evaluation till the year 2032 for each of the three alternatives for the East and West Corridors combined.

Table 11.14 Preliminary Results CBA

East & West Corridor combined		Total economic return	NPV			
	EIRR		6%	8%	10%	12%
ML	negative	(11,050)	(4,325)	(3,632)	(3,208)	(2,935)
DFC	10.1%	138,233	24,063	9,651	344	(5,695)
DPC	3.8%	21,123	(6,436)	(10,334)	(12,883)	(14,501)

Note: figures in parenthesis are negative.

The main objective of the planned Project is to create a railway corridor dedicated to the transport of cargo. In that context, and given the absence of detailed information, the economic evaluation of the alternatives remained limited to benefits generated in terms of cargo transport basically.

The evaluation also focused on the *incremental* benefits, which means that only the benefits generated by the alternative as compared to the "do nothing" case have been considered. Furthermore, no economic benefits were considered during the construction period. Consequently, many benefits are generated later in time which has a direct impact on the project's rate of return and on the assessment of the economic return according to different discount ratios.

In spite of the tentativeness of the calculations and the relatively low outcomes of economic benefits, it is clear that the DFC Alternative by far generates the highest economic benefits in terms of cargo transport.

With an EIRR of 10.1%, the DFC Alternative scores more than two times as high as the DPC Alternative which generates a return of only 3.8%. In the economic evaluation, the capacity restrictions and the therewith related economic costs become thus very clear and make that the ML alternative does not generate a positive economic return.

Given the high capital investment and the fact that railway infrastructure investment can generate long-term economic benefits above the assumed 20 year project life-cycle, the economic benefits for the three alternatives were calculated till the year 2050. When looking at the economic benefits till the year 2050, the DFC Alternative provides more positive results, which are with an economic return reaching at 13%, much stronger than the case where the project lifecycle is limited to the year 2032.

With the objective of distinguishing between the two corridors and allow recommending a priority from an economic perspective in the development of the corridors, an economic assessment per corridor was made till the year 2032.

East Corridor

The economic benefits of the East Corridor are summarized in Table 11.15 hereafter.

Table 11.15 Preliminary results CBA for East Corridor (till 2032)

East Corridor			NPV			
	EIRR	Total return	6%	8%	10%	12%
ML	11.7%	9,169	2,100	1,091	407	(58)
DFC	12.2%	96,385	20,687	10,920	4,526	307
DPC	9.6%	57,214	10,082	3,631	(684)	(3,583)

Looking at the economic benefits generated solely in the East Corridor, the DFC Alternative is again the preferred alternative, with an economic return of 12.2% as compared to 11.7% for the ML Alternative and the 9.6% return for the DPC Alternative. This preference is substantiated with over 96,000 RS Crores in economic revenues for the DFC Alternative against 57,000 RS Crores and only 9,000 RS Crores for the DPC Alternative and the ML Alternative respectively.

West Corridor

The DFC Alternative is without doubt the preferred alternative for the East Corridor, generating the best economic rate of return and the highest level of total return during the Project lifecycle till the year 2032. The distinction between the different alternatives becomes even more obvious when the benefits for the West Corridor are compared, see Table 11.16.

Table 11.16 Preliminary results CBA for West Corridor (till 2032)

West Corridor			NPV			
	EIRR	Total return	6%	8%	10%	12%
ML	#	(6,838)	(2,080)	(1,660)	(1,430)	(1,302)
DFC	11.1%	95,413	17,994	8,484	2,418	(1,471)
DPC	#	(9,550)	(9,089)	(9,400)	(9,669)	(9,864)

The higher volumes of cargo transport and the important increase in containerized cargo on West Corridor clearly demonstrates that the construction of a railway line dedicated exclusively to the transport of cargo is by far the best solution.

On West Corridor, the ML and DCP Alternatives again reach maximum capacity before the end of the evaluation period (year 2032) except for long distance passenger traffic that can continue to grow in case of the DPC Alternative. Because of the substantially higher investment for the the DPC Alternative, the results of this alternative are worse that the results of the ML Alternative.

But because the prime objective of the Project is to maximize cargo transport capacity, the constraints of the DPC and ML Alternatives for transporting cargo become rapidly visible and only the DFC Alternative with its dedicated cargo railway line is the only alternative capable of dealing with the growth in cargo and container traffic on the West Corridor. The much better economic performance of the DFC Alternative is expressed in the economic rate of return which is with 11.1%, the only alternative that generates a positive economic return for West Corridor.

(3) Conclusions for the economic analysis

The economic evaluation of the three alternatives undeniably identifies the DFC Alternative as the best solution to meet the future growth of cargo traffic along the two corridors. Both in terms of economic rates of return and total return, it is the DFC Alternative that outperforms the two other alternatives. The important economic benefits generated by the DFC Alternative become even more explicit if the economic evaluation is extended till the year 2050.

Looking at the two corridors separately, the DFC Alternative remains in each case the best solution to meet future cargo traffic growth. In terms of economic returns and rate of return, it is the east Corridor that is the better of the two, suggesting that the construction of the East Corridor should have priority over the construction of the West Corridor, a result that is opposite to the financial evaluation. The limited impact of cash revenues (operator profits) on the overall economic benefits and the fact that only *incremental* benefits are considered can be identified as two important reasons for the different results.

However, it should be made clear that for the two corridors combined, both the financial and economic evaluation identify the DFC Alternative as the preferred option.

11.3.4 Goal Achievement Matrix (GAM): Preliminary Results

(1) Conditions and parameters for the GAM evaluation

The objective of the GAM analysis is to rank the different alternatives according to a wide range of evaluation parameters, which will permit to substantiate and / or fine-tune the results of the financial and economic evaluations and to decide on the development priority of the East and the West Corridor. The parameters used for the evaluation of the three alternatives combined and their two corridors separately are presented in following Table 11.17.

Table 11.17 GAM Analysis: Preliminary Results

GAM evaluation indicators	Role in the evaluation
Financial	***Predominantly important for operator and possible participation of the private sector***
Capital Investment	The amount invested, with the lowest being the best solution
Revenues	The revenues generated with the highest revenues being the best score. Only the *project perspective* is considered
Return (NPV)	The total financial return at 15*% NVP value*. The highest return generates the best score
FIRR-rate	The FIRR generated by the alternatives, with the highest FIRR generating the best score
Economic	***Most important set of values, indicating the benefits for society of each alternative***
EIRR=value	The EIRR value at 12% NPV
Road Transportation costs	Calculated via (TC)n in the economic analysis, the higher the transportation cost savings, the better the score
Container Transport costs	Calculated via (TSc)n in the economic analysis, the higher the savings in vehicle operating costs, the better the score
Cargo carrying capacity	Calculated via (CCc)n in the economic analysis, the higher the capacity to carry cargo, the better the score
Additional cargo transported	Calculated via (ACT)n in the economic analysis, the higher volume of cargo transported, the better the score
Policy & Strategic	***Indicators that assess the level of each alternative to meet the objectives of the Government of India***
5 Year Plans	The 10^{th} and 11^{th} 5 Year Plans put high importance on the realization of cargo transport via railways. Therefore, the higher the cargo benefits, the better the score. The results are calculated as a combination of (CCc)n and (ACT)n in the economic analysis
Cargo transport benefits	The transport benefits are calculated on the basis of the positive scores in above economic and financial parameters. The higher the value the better the score
Cargo forced to alternative mode	The transport benefits are calculated on the basis of the negative scores in above economic and financial parameters The higher the value, the better the score
Reduction of road traffic	Benefits generated by both passenger and cargo transport and fall in line with government's objective to stimulate railways. The higher the value, the better the score

The financial and economic evaluations indicated a clear preference for the DFC Alternative, but generated conflicting results on which of the Corridors should be developed first. For that reason, the GAM analysis will concentrate on the evaluation of overall project performance for the East and West Corridor combined to substantiate the previous results. It will also consider the performance for the East and West Corridor separately to allow formulating some conclusive results for the development priority of East and West Corridors.

The initial settings for the weighting of the decision factors for the GAM Analysis are represented in Table 11.18 hereafter.

Table 11.18 Initial weighting for GAM decision factors

GAM evaluation indicators	initial weight
Financial	10%
- Capital Investment	1.67%
- Revenues	0.83%
- Financial return	2.50%
- FIRR	5.00%
Economic	70%
- EIRR	20%
- VOC improvement	8%
- Travel time savings	8%
- Cargo carrying capacity	18%
- Additional cargo transported	18%
Policy & Strategic	20%
- 5 Year Plans	4%
- Cargo transport benefits	4%
- Cargo forced to alternative mode	4%
- Reduction of road traffic	8%

The initial weighting of each of the decision factors is based upon the assumption that the principal goal of the project is to achieve a maximum volume of cargo transported via railways and that for investments of this magnitude, the economic benefits prevail over the financial returns and short- or medium-term policy aims.

However, to ensure that there is a clear appreciation of the importance (“weight”) of each group of decision factors, various sensitivity tests have been conducted where the group percentages were changed as presented in Table 11.19

Table 11.19 Weighting variations for sensitivity testing

	V1	V2	V3	V4
GAM evaluation indicators	**Weight**	**Weight**	**Weight**	**Weight**
Financial	**45%**	**70%**	**20%**	**33%**
- Capital Investment	7.50%	11.67%	3.33%	5.50%
- Revenues	3.75%	5.83%	1.67%	2.75%
- Financial return	11.25%	17.50%	5.00%	8.25%
- FIRR	22.50%	35.00%	10.00%	16.50%
Economic	**45%**	**20%**	**20%**	**33%**
- EIRR	12.9%	5.7%	5.7%	9.4%
- VOC improvement	4.9%	2.2%	2.2%	3.6%
- Travel time savings	4.9%	2.2%	2.2%	3.6%
- Cargo carrying capacity	11.3%	5.0%	5.0%	8.3%
- Additional cargo transported	11.3%	5.0%	5.0%	8.3%
Policy & Strategic	**10%**	**10%**	**60%**	**34%**
- 5 Year Plans	2.0%	2.0%	12.0%	6.8%
- Cargo transport benefits	2.0%	2.0%	12.0%	6.8%
- Cargo forced to alternative mode	2.0%	2.0%	12.0%	6.8%
- Reduction of road traffic	4.0%	4.0%	24.0%	13.6%

(2) GAM Results – ranking the alternatives

Using the initial weighting of the decision parameters, therewith assuming that the maximization of economic returns has the highest priority, the DFC alternative scores substantially better than the two other alternatives, see Table 11.20.

Table 11.20-a Calculated results (basic setting)

GAM initial values	ML	DFC	DPC
Financial	**62**	**27**	**11**
Capital Investment	0.0000036	0.0000006	0.0000005
Revenues	1,182	671	388
Financial return (npv 6%)	1,296	395	58
FIRR	0.022	0.005	0.0033
Economic	**(565)**	**3,016**	**(86)**
EIRR (value at 6% NPV)	(865)	4,813	(1,287)
VOC improvement	504	3,369	2,692
Travel time savings	406	3,088	2,169
Cargo carrying capacity	(720)	4,739	3,527
Additional cargo transported	(3,358)	5,535	(7,713)
Policy & Strategic	**(63)**	**169**	**(125)**
5 Year Plans	(5)	24	(1)
Cargo transport benefits	27	60	42
Cargo forced to alternative mode	(66)	201	(73)
Reduction of road traffic	(150)	247	(344)
average	**(189)**	**1,071**	**(66)**

Table 11.20-b Ranking (basic setting)

GAM initial values	ML	DFC	DPC
Financial	**1**	**2**	**3**
Capital Investment	1	2	3
Revenues	1	2	3
Financial return (npv 6%)	1	2	3
FIRR	1	2	3
Economic	**3**	**1**	**2**
EIRR (value at 6% NPV)	2	1	3
VOC improvement	3	1	2
Travel time savings	3	1	2
Cargo carrying capacity	3	1	2
Additional cargo transported	2	1	3
Policy & Strategic	**2**	**1**	**3**
5 Year Plans	3	1	2
Cargo transport benefits	3	1	2
Cargo forced to alternative mode	2	1	3
Reduction of road traffic	2	1	3
average	**3**	**1**	**2**
fixed ranking	**2**	**1**	**3**

The ranking of the three alternatives is achieved via two approaches, the first is the ranking based upon the average performance of the calculated combined values for each of the three groups of decision parameters ("average" colored red in the table), the second is the fixed ranking where the actual rank of the three alternatives is taken for each of the groups of decision parameters ("fixed ranking" colored blue in the table).

The DFC Alternative is the only alternative that generates a positive result as compared to the DPC Alternative scoring slightly below zero and the ML Alternative which scores notably below zero. This of course a direct consequence of the higher economic benefits from transporting cargo via rail, which is substantially higher for the DFC Alternative that offers a railway line exclusively dedicated to the transport of cargo, while the two other alternatives run cargo trains on the existing line.

The ranking per individual parameter, per group of parameters and the average result of the GAM evaluation clearly indicates the very stable results for the DFC Alternative, scoring second-best for the financial parameters and on each of the other parameters first.

Changing the weighting, putting equal importance on the financial and economic results combined accounting for 90% of the value and the policy and strategy parameters accounting for the remaining 10% does not affect the preference for the DFC Alternative which remains by far the best option, see Table 11.21.

Table 11.21-a Calculated results (Variation 1 – V1 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**1,254**	**540**	**226**
Capital Investment	0.000016	0.000003	0.000002
Revenues	5,318	3,021	1,746
Financial return	5,832	1,776	262
FIRR	0.100	0.023	0.0149
Economic	**(233)**	**1,246**	**-35**
EIRR	(556)	3,094	(827)
VOC improvement	324	2,166	1,730
Travel time savings	261	1,985	1,394
Cargo carrying capacity	(463)	3,046	2,268
Additional cargo transported	(2,159)	3,558	(4,958)
Policy & Strategic	**154**	**108**	**-14.7**
5 Year Plans	(0.93)	4.99	(0.14)
Cargo transport benefits	389	2,410	1,428
Cargo forced to alternative mode	5,832	1,776	(1,841)
Reduction of road traffic	(75)	124	(172)
average	**392**	**631**	**59**

But contrary to the basic scenario, the ML Alternative now scores better than the DPC Alternative that now positions itself in third and last position. This switch in rank is in particular caused by the much better performance of the ML Alternative in terms of Policy and Strategy parameters, where it scores first as compared to second in the basic case.

The continued strong performance of the DFC Alternative is however less explicit as in the previous case, a consequence of the stronger impact of the financial results on the overall ranking. This can be observed very clearly when looking at the fixed ranking of the alternatives where the DFC Alternative now comes in second place while the ML Alternative is first

Table 11.21-b Ranking (Variation 1 – V1 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**1**	**2**	**3**
Capital Investment	1	2	3
Revenues	1	2	3
Financial return	1	2	3
FIRR	1	2	3
Economic	**3**	**1**	**2**
EIRR	2	1	3
VOC improvement	3	1	2
Travel time savings	3	1	2
Cargo carrying capacity	3	1	2
Additional cargo transported	2	1	3
Policy & Strategic	**1**	**2**	**3**
5 Year Plans	3	1	2
Cargo transport benefits	3	1	2
Cargo forced to alternative mode	1	2	3
Reduction of road traffic	2	1	3
average	2	1	3
fixed ranking	**1**	**2**	**3**

Further increasing the weight of the financial parameters in a second variation to a level of 70% of the total weight finally makes the ML Alternative the best performing alternative, see Table 11.22.

Table 11.22-a Calculated results (Variation 2 – V2 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**3,035**	**1,306**	**547**
Capital Investment	0.000025	0.000004	0.000004
Revenues	8,272	4,700	2,716
Financial return	9,072	2,763	407
FIRR	0.156	0.035	0.0232
Economic	**(46)**	**246**	**(7)**
EIRR	(247)	1,375	(368)
VOC improvement	144	962	769
Travel time savings	116	882	620
Cargo carrying capacity	(206)	1,354	1,008
Additional cargo transported	(959)	1,582	(2,204)
Policy & Strategic	**(0)**	**5**	**(4)**
5 Year Plans	(0.18)	0.98	(0.03)
Cargo transport benefits	70	31	20
Cargo forced to alternative mode	(9)	29	(14)
Reduction of road traffic	(75)	124	(172)
average	**996**	**519**	**178**

In spite the high importance put on the financial parameters (70% of weight), the DFC Alternative remains in second place with the DPC Alternative coming in last position. But the calculated values show that in financial terms the DFC Alternative scores only half the ML Alternative while the result for the DPC Alternative is only 1/8th of the ML Alternative.

Considering the different evaluation indicators individually or in group, the DFC Alternative again becomes the best option while the ML Alternative comes second. Looking at the individual scores, it becomes clear that the focus on the financial indicators generates extremely high financial scores for the ML Alternative, therewith positioning it first while as overall results based upon the fixed ranking, the ML Alternative scores second best.

Table 11.22-b Ranking (Variation 2 – V2 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**1**	**2**	**3**
Capital Investment	1	2	3
Revenues	1	2	3
Financial return	1	2	3
FIRR	1	2	3
Economic	**3**	**1**	**2**
EIRR	2	1	3
VOC improvement	3	1	2
Travel time savings	3	1	2
Cargo carrying capacity	3	1	2
Additional cargo transported	2	1	3
Policy & Strategic	**2**	**1**	**3**
5 Year Plans	3	1	2
Cargo transport benefits	1	2	3
Cargo forced to alternative mode	2	1	3
Reduction of road traffic	2	1	3
average	1	2	3
fixed ranking	**2**	**1**	**3**

Caused by the weighting of the variables, the ML Alternative no longer scores best for the policy and strategy parameters but has dropped again to second place. Given that the policy and strategy parameters are predominantly calculated via averaging positive and negative results for the financial and economic parameters, the weighting of the latter two groups of indicators gives a clear indication of the level each of the alternatives meets policy objectives in financial and economic terms.

Investigating more in detail the impact of the policy and strategy parameters is done in the 3 variation, where 60% of the weight is put on this group of parameters while the combined financial and economic parameters each count for 20%. The results of this third evaluation are presented in following Table 11.23.

Table 11.23-a Calculated results (Variation 3 – V3 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**248**	**107**	**45**
Capital Investment	0.0000072	0.0000013	0.0000011
Revenues	2,363	1,343	776
Financial return	2,592	789	116
FIRR	0.045	0.010	0.0066
Economic	**(46)**	**246**	**(7)**
EIRR	(247)	1,375	(368)
VOC improvement	144	962	769
Travel time savings	116	882	620
Cargo carrying capacity	(206)	1,354	1,008
Additional cargo transported	(959)	1,582	(2,204)
Policy & Strategic	**(57)**	**157**	**(158)**
5 Year Plans	(1.11)	5.91	(0.17)
Cargo transport benefits	125	129	76
Cargo forced to alternative mode	(56)	172	(98)
Reduction of road traffic	(450)	741	(1,033)
average	**48**	**170**	**(40)**

Table 11.23-b Ranking (Variation 3 – V3 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**1**	**2**	**3**
Capital Investment	1	2	3
Revenues	1	2	3
Financial return	1	2	3
FIRR	1	2	3
Economic	**3**	**1**	**2**
EIRR	2	1	3
VOC improvement	3	1	2
Travel time savings	3	1	2
Cargo carrying capacity	3	1	2
Additional cargo transported	2	1	3
Policy & Strategic	**2**	**1**	**3**
5 Year Plans	3	1	2
Cargo transport benefits	2	1	3
Cargo forced to alternative mode	2	1	3
Reduction of road traffic	2	1	3
average	2	1	3
fixed ranking	**2**	**1**	**3**

From a policy and strategy perspective, the DFC Alternative is by far the preferred option, followed by the ML Alternative and the DPC Alternative in last place. Looking at the calculated scores, the DFC Alternative is the only option that truly meets the Governments policy of stimulating cargo transport via the railways. Consequently, the ranking is maintained both according to the average scores, as in accordance with the fixed ranking of each alternative.

Putting the emphasis on the policy and strategy parameters and equal importance on the financial and economic performance, the difference of each alternative in meeting government policies becomes more explicit. The DFC Alternative scores the results for all the policy and strategy parameters and for the economic parameters and is second best in the financial performance. The DPC Alternative positions itself in last place for the policy and financial parameters and second for the economic parameters. Finally, the ML Alternative scores best on each financial parameter, is second for the policy and strategy indicators and last when considering the performance against the economic indicators.

After having investigated in the previous GAM variations the importance of each group of indicators, the final assessment levels all groups of parameters to the same weight and the results are presented in Table 11.24.

Table 11.24-a Calculated results (Variation 4 – V4 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**675**	**290**	**121**
Capital Investment	0.0000118	0.0000021	0.0000018
Revenues	3,900	2,216	1,281
Financial return	4,277	1,302	192
FIRR	0.074	0.017	0.0110
Economic	**(125)**	**670**	**(19)**
EIRR	(408)	2,269	(607)
VOC improvement	238	1,588	1,269
Travel time savings	192	1,456	1,022
Cargo carrying capacity	(340)	2,234	1,663
Additional cargo transported	(1,583)	2,610	(3,636)
Policy & Strategic	**(16)**	**60**	**(52)**
5 Year Plans	(1.71)	9.12	(0.26)
Cargo transport benefits	117	120	71
Cargo forced to alternative mode	(53)	161	(92)
Reduction of road traffic	(255)	420	(585)
average	**178**	**340**	**17**

Table 11.24-b Ranking (Variation 4 – V4 settings)

GAM evaluation indicators	ML	DFC	DPC
Financial	**1**	**2**	**3**
Capital Investment	1	2	3
Revenues	1	2	3
Financial return	1	2	3
FIRR	1	2	3
Economic	**3**	**1**	**2**
EIRR	2	1	3
VOC improvement	3	1	2
Travel time savings	3	1	2
Cargo carrying capacity	3	1	2
Additional cargo transported	2	1	3
Policy & Strategic	**2**	**1**	**3**
5 Year Plans	3	1	2
Cargo transport benefits	2	1	3
Cargo forced to alternative mode	2	1	3
Reduction of road traffic	2	1	3
average	2	1	3
fixed ranking	**2**	**1**	**3**

This final test with the financial, economic and policy parameters at equal weight confirms that the DFC Alternative is by far the best solution and is the only alternative with a stable performance against each of the parameters.

The DFC Alternative scores best for all economic and policy parameters and second-best for all the financial parameters, compared to the DPC Alternative that has the worst score for the financial and policy parameters and is only slightly better than the ML Alternative when considering the economic indicators. The ranking of the three alternatives is confirmed both according to the average scores and according to the fixed ranking.

Combining all evaluations into a single average appreciation of each alternative once more confirms the strong position of the DFC Alternative as compared to the two other candidates, see Table 11.25.

Table 11.25 Final Ranking (combined results)

	average value ranking			fixed ranking		
Simulation runs:	**ML**	**DFC**	**DPC**	**ML**	**DFC**	**DPC**
Basic settings	3	1	2	2	1	3
V1	2	1	3	1	1	3
V2	1	2	3	3	1	2
V3	2	1	3	3	1	3
V4	2	1	3	3	1	3
OVERALL RESULTS	**2**	**1**	**3**	**2**	**1**	**3**

Both according to the ranking on the basis of average values and on the basis of the fixed ranking, the DFC Alternative scores best in each of the evaluations, except when the weight of the financial performance is increased to 70% in which case the DFC Alternative scores second-best after the ML Alternative. On average, the DPC Alternative scores weak, coming last in all both the basic settings. The ML alternative scores second best except when the financing is prioritized or according to the basic settings where economic parameters are prevailing.

Highly notable also is that for most evaluations, the DFC Alternative is the only alternative that generates a positive overall result, while both the ML and DPC Alternatives have many times negative scores for the group of policy and strategy parameters and the group of economic parameters. When considering the fixed ranking of each alternative, the impact of these negative scores becomes more obvious, putting several times the DFC Alternative in first place while this alternative was in second place when ranked according to average calculated values.

The GAM evaluation strongly advocates:

- That only the DFC Alternative is an attractive option to realize the Government's policy and that it is the only option to ensure that a major capital investment also brings benefits to the Indian population. If the aim of the investment is to maximize the transport of cargo via rail, building a new and dedicated railway line to transport this cargo is the best and most beneficial way to achieve results.

- That the DPC Alternative should certainly not be selected because the high capital cost of the project does generate only a low increase of cargo transport. The low and many times negative benefits of the DPC Alternative do certainly not allow the implementation of the most expensive alternative.

- That the ML Alternative displays the best financial results while presenting mixed results for the other indicators. The GAM results for the ML Alternative clearly suggest that if the financial resources are not available, strong results can be achieved with limited capital investments. But the results also suggest that these benefits remain limited and that they cannot match the high benefits that can be generated with a substantial capital investment.

The GAM results thus indicate without any doubt that for maximizing the transport of cargo by rail, the only way to achieve this goal is to develop a dedicated railway line for the transport of cargo, in other words, to implement the DFC Alternative. Improving the existing line provides only minor benefits and only has real positive effects on the financial side.

Assuming that the DFC Alternative is selected, and given the conflicting results on the priority for East and West Corridor, emerging from respectively the financial and economic evaluation, the GAM analysis is used to investigate the two corridors according to the settings above.

Table 11.26 Results for basic settings

	score		ranking	
GAM initial values	**EAST**	**WEST**	**EAST**	**WEST**
Financial	**10.36**	**13.37**	**2**	**1**
Capital Investment	0.0000018	0.0000003	1	2
Revenues	271	343	2	1
Financial return (npv 6%)	143	192	2	1
FIRR	0.0046	0.0049	2	1
Economic	**2,519**	**2,109**	**1**	**2**
EIRR (value at 6% NPV)	4,137	3,599	1	2
VOC improvement	1,301	2,067	2	1
Travel time savings	1,530	1,558	2	1
Cargo carrying capacity	5,486	2,772	1	2
Additional cargo transported	5,535	5,069	1	2
Policy & Strategic	**71**	**149**	**2**	**1**
5 Year Plans	20	17	1	2
Cargo transport benefits	32	27	1	2
Cargo forced to alternative mode	160	195	2	1
Reduction of road traffic	21	226	2	1
average	**867**	**757**	**1**	**2**
		FIXED RANK	**2**	**1**

By adopting the same weighting patterns for the previous analysis, Table 11.27 was prepared. The results are mixed and vary according to the weighting emphasis as can be observed in Table 11.27.

Table 11.27 Summary of the results

	weighted values		fixed rank	
Simulation runs:	**EAST**	**WEST**	**EAST**	**WEST**
Basic settings	1	2	2	1
V1	1	2	2	1
V2	2	1	2	1
V3	2	1	2	1
V4	1	2	2	1
OVERALL RESULTS	**1**	**2**	**2**	**1**

Table 11.27 demonstrates that the East Corridor is the preferred corridor on the basis of calculated weighted values. This preference is predominantly caused by the impact of cargo volumes transported, a volume much higher on East Corridor than on West Corridor. But the West Corridor is preferred if the two corridors are compared on the basis of the actual ranking according to each decision parameter and according to each of the three groups of parameters. Thus even when the two corridors are evaluated using a multi-criteria approach and a range of different weighting levels, the uncertainty that emerged from the financial and economic evaluations remains unchanged and the preference for East and West Corridor interchanges depending upon the perspective applied.

To allow formulating a final and argued recommendation regarding the corridor that should be developed first, the cargo related parameters for the two corridors are compared to differentiate between both, see Table 11.28.

Table 11.28 Cargo based evaluation for selected years

Difference WEST / EAST	2007	2020	2032	2007-2032
Volume of cargo transported	(7,440,501)	(5,469,851)	7,195,525	(91,842,798)
Total Ton/Km	8,999,937,381	47,605,678,727	153,368,770,017	1,534,584,493,380
Total Cargo related revenues	2,199,851,873	21,398,561,126	74,790,948,590	708,727,865,131

The above table clearly demonstrates the difference in cargo performance between the East and the West Corridor. The East Corridor transports some 91 million tons of cargo more than the West Corridor between the years 2007-2032. But as suggests the positive number for year 2032, the volume becomes more important on West Corridor in the long-term future.

Containers are predominantly transported via the West Corridor and this transport is not important in terms of tonnage (volume), but is extremely important when looking at the ton kilometers and cargo-related revenues. Over the entire period, the West Corridor generates some 1,500 million more ton kilometers and over 708 billion rupees in revenues more than the East Corridor.

Combining the results of the GAM analyses with the performance the ton kilometer and generated revenues for each corridor, the West Corridor should undeniably be build before the East Corridor because:

1. In absolute weighted values, the West Corridor scores better than the East Corridor in 2 out of 5 variations;

2. In fixed ranking, reflecting the score against the individual decision parameters, the West Corridor is the first option for each of the variations;

3. When considering the cargo volumes transported via each corridor, the West Corridor transports a rapidly growing number of containers together with a continuously growing number of bulk cargoes. The growth of container and bulk cargo combined will generate in the long-term future (by the year 2032) higher volume of cargo that will be transported via the West Corridor as compared to the volumes transported via the East Corridor.

4. Container transport is very important in terms of ton kilometers and with1,500 million ton kilometers more transported, West Corridor becomes by far the preferred corridor; and

5. With over 70,000 RS Crores more in cargo-related revenues, the West Corridor is undisputedly preferred over the East Corridor.

11.3.5 Risk Analysis

(1) Settings for the Risk analysis

The conclusion of the above financial, economic and GAM analysis is that

- The DFC Alternative is by far the preferred alternative; and
- The West Corridor should be developed first in case the two corridors are not constructed simultaneously.

This conclusion is reached on the basis of a range of assumptions, estimations and forecasts and stretches over a period till 2032 (5 years construction and 20 years of operations) or till the year 2050 according to the extended appreciation.

Formulating conclusions under these conditions are characterized by a level of uncertainty. To minimize the impact of uncertainty in the evaluations, a Risk Analysis is performed as final step in the evaluation. This analysis will be applied to the results of both the financial and economic analyses.

Given that the financial, economic and GAM-based evaluations each demonstrated a clear preference for the DFC Alternative, it is assumed that this alternative will be implemented by the Government of India. For that reason, the Risk Analysis will be applied only for the DFC Alternative and for the East and West Corridors combined.

It should also be noted that in this stage of the Project, a comprehensive Risk Analysis is not possible because many relevant sets of information are not yet available. But even the limited risk analysis of which the results are presented hereafter gives already some interesting outcomes[2].

In a first general risk assessment, the impact on the benefits of changes in the costs and revenues and the results of the analysis (*outputs*) are the changes in total benefits. Following risk evaluation settings were used for costs and revenues (*inputs*):

(1) The variation in financial cost:

RiskNormal(389,176, 10,000, RiskTruncate(389,176,))

A normal distribution with best fit costs of 389,176 RS Crores increasing the costs per 10,000 Crores via truncating the distribution in the beginning with 389,176 RS Crores;

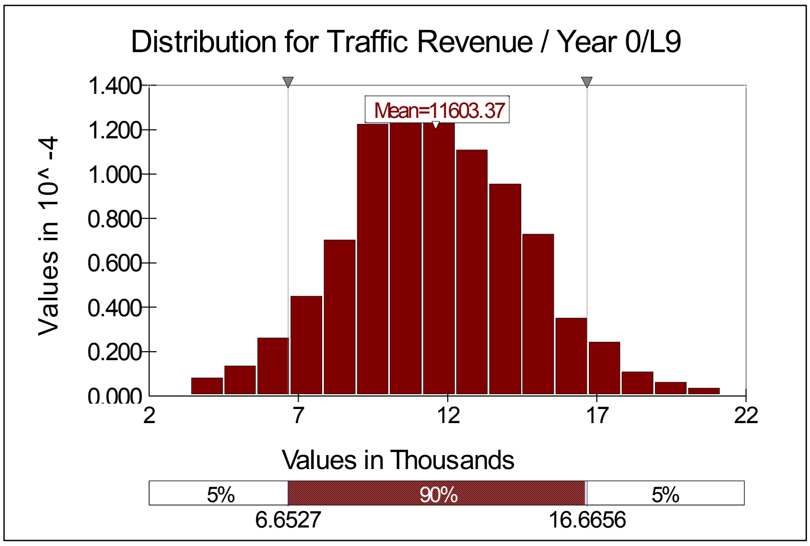
(2) The variation in financial revenues:

RiskNormal(469,741, 10,000, RiskTruncate(, 469,741))

[2] The risk analysis is performed using the @RISK Software

A normal distribution with best fit benefits of 469,741 RS Crores decreasing the revenues per 10,000 Crores via truncating the distribution at the end with 469,741 RS Crores.

The more detailed risk assessment evaluates the project's financial performance via random annual variations in costs and revenues (using a standard normal distribution) and the effects thereof on the FIRR, the B/C Ratios at NPV of 6%, 10% and 12%. In the detailed risk assessment, the traffic revenues and the costs are set as follows (see Figure 11.1):



$\text{RiskNormal}_n(\text{Revenue}_n - \text{Cost}_n, 3000)$

Figure 11.1 Example for distribution of annual costs and revenues

(2) Risk evaluation with variable cost and revenues

This evaluation assesses the variations in total revenues for the DFC Alternative for the period till the year 2032 with changing costs and revenues. The summary of the evaluation results is presented in following Figure 11.2.

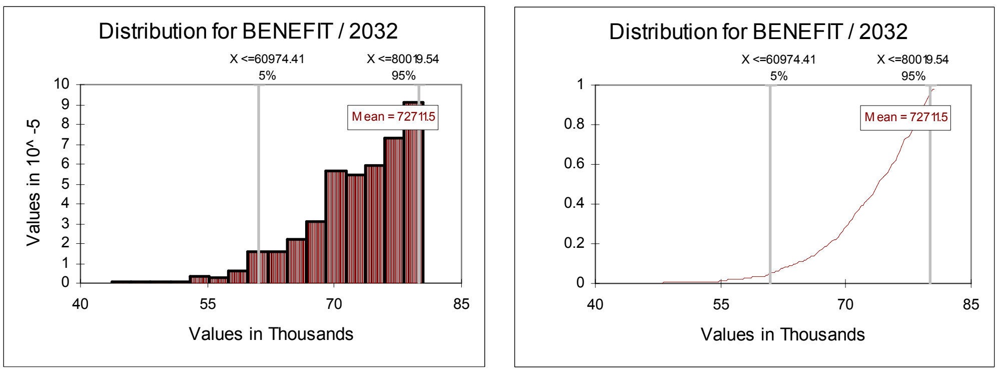


Figure 11.2 Evolution of benefits with variable costs and revenues

Increasing the costs of the project or decreasing the revenues does not generate negative total revenues. The average total revenue for the DFC Alternative is 72,711 RS Crores. The results do not vary much in the case that only the costs or the revenues change.

The minimum revenue generated is 43,709 RS Crores and the maximum is almost double with 80,539 RS Crores. The mean is 72,711 RS Crores. But the standard deviation, calculated as the root mean square (RMS) deviation of the values from their arithmetic mean, is high, meaning that there is a large variance in possible revenues. But to investigate to what level this large spread has a negative impact on total revenues, the detailed variations need to be investigated (Table 11.29).

Table 11.29 Evolution of total revenues detailed results

Summary Statistics			
Statistic	**Value**	**%tile**	**Value**
Minimum	43,709	5%	60,974
Maximum	80,539	10%	64,039
Mean	72,711	15%	66,504
Std Dev	6,133	20%	68,024
Variance	37614276.93	25%	69,292
Skewness	-1.082891193	30%	70,257
Kurtosis	4.309206455	35%	71,157
Median	73,847	40%	72,172
Mode	80,189	45%	73,204
Left X	60,974	50%	73,847
Left P	5%	55%	74,820
Right X	80,020	60%	75,624
Right P	95%	65%	76,218
Diff X	19,045	70%	76,820
Diff P	90%	75%	77,691
#Errors	0	80%	78,414
Filter Min		85%	78,891
Filter Max		90%	79,412
#Filtered	0	95%	80,020

Eliminating the two extremes, i.e., considering only the results between the percentiles of 5% and 90%, the revenues vary between 60,974 and 79,412 RS Crores for the 5% and 90% percentile respectively. The revenues thus remain highly positive is spite the high standard deviation.

(3) Detailed risk evaluation with variation of annual cost and revenues

To get a more detailed insight in the robustness of the results, a more detailed assessment was made in which cost and revenues were changed annually and the effects observed on the FIRR, and the B/C Ratios at 6%, 10% and 12% of NPV Value.

The following Figure 11.3 presents the results for the FIRR.

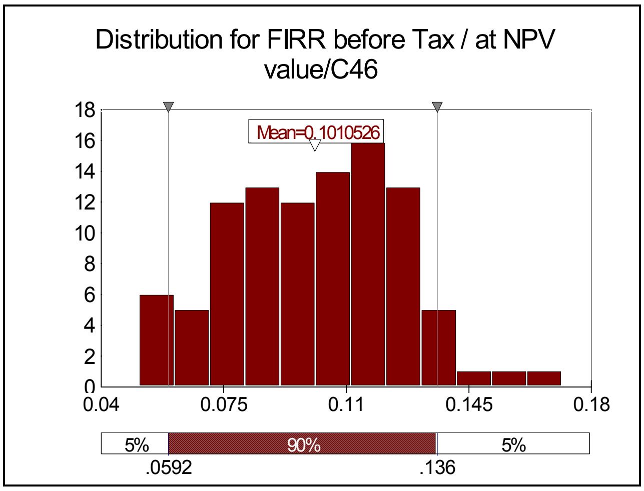


Figure 11.3 Risk analysis for FIRR

Considering the 90% of results, the evaluation suggests that the DFC Alternative will with a high level of certainty generate positive financial results with a minimum FIRR of 5% and a maximum of 17%, see Table 11.30.

Table 11.30 Evolution of FIRR detailed results

Summary Statistics			
Statistic	Value	%tile	Value
Minimum	5%	5%	6%
Maximum	17%	10%	7%
Mean	10%	15%	7%
Std Dev	2%	20%	8%
Variance	0.00057797	25%	8%
Skewness	0.054262117	30%	9%
Kurtosis	2.794923341	35%	9%
Median	10%	40%	10%
Mode	11%	45%	10%
Left X	6%	50%	10%
Left P	5%	55%	11%
Right X	14%	60%	11%
Right P	95%	65%	11%
Diff X	8%	70%	11%
Diff P	90%	75%	12%
#Errors	0	80%	12%
Filter Min		85%	13%
Filter Max		90%	13%
#Filtered	0	95%	14%

The detailed evaluation of revenues with randomly changes of annual revenues and costs gives a more reliable insight in the possibility of generating positive results. The minimum FIRR is 5% and the maximum 17% with a mean of 10%. Excluding the highest and lowest 5% of results, the FIRR varies from 6% to 14%, with a very acceptable standard deviation of 2% and very low skewness of 0.054, suggesting a very narrow spread of the results.

However and in spite of the above positive indications, a detailed assessment of the B/C ratio's suggests that there remains a true risks to generate a financial cost. The results for the benefit over costs at 6%, 10% and 12% NPV value respectively are represented in next Figure 11.4.

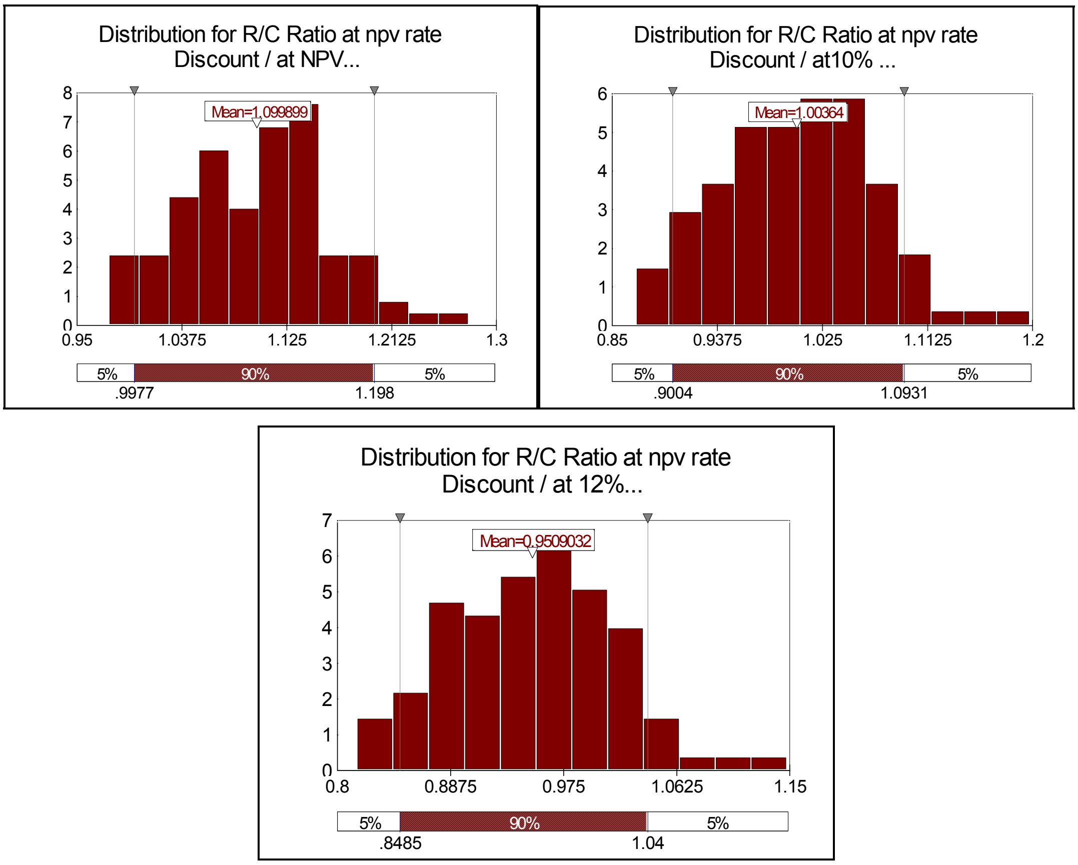


Figure 11.4 B/C ratio at NPV (6%), 10% and 12% NPV value

The results for the B/C ratio at varying NPV rates suggests that the higher the expectations expressed in the level of the NPV value, the higher the risk that the costs will surpass the revenues and the B/C Ratio becomes negative. At 6% NPV, the mean B/C Ratio is just above 1% although only the lowest value is negative. At 10%, the mean remains at 1% but 40% of the results are negative, while at 12%, only 20% of the results remain positive. But in spite of these results, the overall appreciation of the DFC Alternative from a financial perspective is positive and it can be expected that there will be a true return on the investment. Furthermore, the possibility of a negative result occurring should not be over-dramatized because such result is not unexpected given that the evaluation was made with a *project-perspective* (without government contribution) and that railway infrastructure investments are generally not profitable or have a very limited profitability rate.

(4) Evaluation of the economic risks

More important than the financial risks are the economic risks because a major investment in railway infrastructure, known to generate low financial benefits, should generally create a much higher economic benefit. A high risk of negative economic benefits would indicate that the realization of the planned Project should be reconsidered.

The deviation of the revenues for each year simulates extreme deviations and has been adjusted in accordance with the level of revenues as follows:

1. for the values below 1,000 the deviation is set at 100 RS Crores;
2. for the values below 10,000 the deviation is set at 1,000 RS Crores; and

3. for the values above 10,000 the deviation is set at 5,000 RS Crores.

In terms of total economic benefits, the average expected revenues are 138,127 RS Crores, as demonstrated in Figure 11.5.

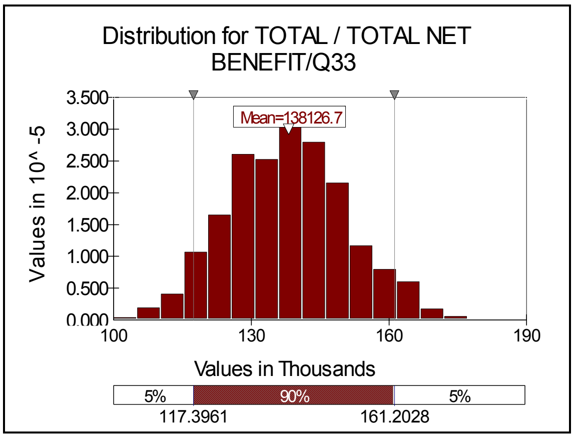


Figure 11.5 Expected total economic revenues (current prices)

The shape of the graph is satisfying, with a strong concentration of results focused around the mean value and only low numbers of cases falling outside the central area of the graph. The Table 11.31 confirms this strong positive result.

With a minimum economic revenue of 100,000 RS Crores and a maximum of 180,000 RS Crores, most of the results fall between 117,000 RS Crores and 161,000 RS Crores, confirming above observation that there is a strong concentration of results in the area of the mean value.

Table 11.31 Detailed results for total economic benefits

Summary Statistics			
Statistic	**Value**	**%tile**	**Value**
Minimum	100,047	5%	117,396
Maximum	182,431	10%	121,530
Mean	138,127	15%	124,823
Std Dev	12,929	20%	126,984
Variance	167164825.9	25%	128,793
Skewness	0.146778792	30%	130,493
Kurtosis	2.855825138	35%	132,296
Median	138,302	40%	134,040
Mode	139,976	45%	136,513
Left X	117,396	50%	138,302
Left P	5%	55%	139,839
Right X	161,203	60%	141,202
Right P	95%	65%	143,051
Diff X	43,807	70%	144,856
Diff P	90%	75%	146,540
#Errors	0	80%	148,648
Filter Min		85%	151,364
Filter Max		90%	155,042
#Filtered	0	95%	161,203

The good spread of results is also corroborated with the low values of both skewness and Kurtosis. The results according different percentages of NPV of the revenues are presented in Figure 11.6.

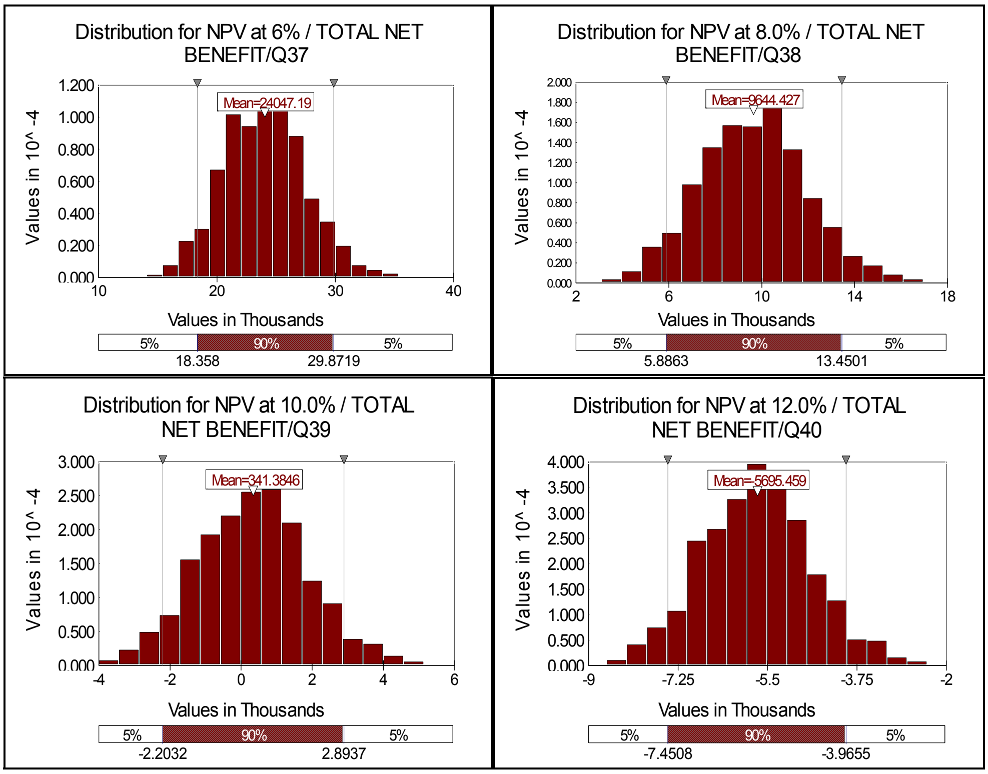


Figure 11.6 Economic revenues (different NPV values)

The higher the NPV value, the higher the risk of reduced and even negative economic revenues. However, this appreciation is again very extreme, assuming that the originally estimated economic revenues all deviate with an extreme range and furthermore with a wide spread. In terms of NPV adjusted economic returns, the DFC Alternative will guaranteed generate positive returns at 6% and 8% NPV value. With 10% or 12% NPV assumed, the risk of generating negative results increases. With a 10% NPV value, 40% of the revenues are negative while there is a 60% change of achieving positive results. Of course with a 12% NPV value, there are no longer positive economic returns.

(5) Conclusions on the Risk Analysis

The risk analysis was conducted for the DFC Alternative under the assumption that this alternative will be selected for implementation. The analyses to assess the risks of the project remain tentative because much relevant information that can increase or decrease the implementation risks is at present still unknown. Further investigation is highly recommended in implementing such a huge project of DFC.

11.4 FINAL CONCLUSIONS AND RECOMMENDATIONS

The evaluation of the three alternatives on the basis of financial and economic performance, and via a multi-criteria and risk assessment to measure performance of the alternatives allowed to get a clear insight in the quality of each alternative.

The evaluation of the alternatives is conducted under the assumption that cargo transport has the highest priority and should be maximized. Although all traffic estimates included both cargo and passenger transport and the financial analysis considered traffic as well as non-traffic revenues, the economic and multi-criteria evaluation concentrated on the performance in terms of cargo transport increases.

In spite many limitations of the evaluation caused by the absence of more detailed information on costs and revenues, the various evaluations allowed to clearly distinguish between the different alternatives and identify without serious doubt the best alternative for implementation, see Table 11.32.

The table 11.32 summary clearly demonstrates that the DFC Alternative is by far the best alternative with the best score in eight out of twelve evaluation parameters. However, this simplified view on the performance of the different alternatives does not reflect the substantial difference between the different options. A more detailed discussion of the results will make clear that the DFC Alternative is by far the best solution.

In terms of cargo traffic, the DFC Alternative will only reach maximum capacity by the year 2038, some ten years later than the two alternatives. Furthermore, maximum capacity is only reached in terms of passenger traffic and container traffic while bulk cargo traffic can continue to grow (on the East Corridor). In the evaluations, performance has been kept stable for each year starting at the year of saturation. This means that each year from the year 2029 on, the DFC Alternative substantially outperforms each of the two other alternatives.

The evaluation of each alternative has been very optimistic, in the sense that at the time maximum capacity of the railway infrastructure is reached, the performance remains stable for each year following the year of reaching maximum capacity. In reality although under present conditions and with the information now available impossible to execute, the performance after the year maximum capacity is reached should be adjusted to reflect congestion effects. Such effects include:

- Delays in departures and arrivals of trains caused by congested infrastructure with reductions in annual volume transported and decreasing revenues;

- Increased personnel costs to manage rising traffic congestion and increased operational and maintenance costs (O&M costs) generated by excessive stress on infrastructure, to over-utilization of equipments, difficulties in infrastructure and equipment maintenance schedules, etc…

- Loss of traffic revenues due to unsatisfied clients who no longer accept delays and other malfunctioning of a congested network and prefer using road transport. Indirectly, the decreasing attractiveness of railway transport will also negatively affect non-traffic revenues.

- Increasing accidents due to an over-utilization of available railway capacity. The increase in accidents generates a wide range of cost increases, from higher insurance premiums, over higher compensations for victims of accidents and increasing repair / replacement costs for infrastructure and equipments. The increasing number of accidents cause further delays in railway traffic which in turn negatively affect total volumes of cargo and passengers transported as well as the therewith related revenues.

Consequently, the difference in performance between the three alternatives will in reality be much higher and have over the long-term more dramatic effects as suggested in the present evaluation results. Independent from the difference in performance the DFC Alternative is the best alternative and outperforms both the ML and DPC Alternative.

In spite having the highest investment and a new railway line, the DPC Alternative does not generate substantial improvements in cargo transport capacity and reaches maximum capacity in 2029, just like the ML Alternative that in spite of the rehabilitation of infrastructure also reaches maximum capacity in that year. But in terms of cargo transport, the investment in rehabilitating existing infrastructure (ML Alternative) allows transporting higher volumes as compared to the DPC Alternative where the capacity of the existing line is not improved and the new railway line is only used for long distance passenger transport.

The ML Alternative scores best in terms of financial performance, where it undeniably outperforms the two other alternatives. But while the difference between the ML and DPC alternatives is important, this difference is "more acceptable" when compared with the DFC Alternative, certainly when considering the substantially different capital investment levels.

Some reasons why the ML Alternative scores substantially better as compared to the two other alternatives are:

- The capital investment is extremely low as compared to the two other alternatives in terms of this preliminary analysis, having a very notable impact on the financial costs and immediately creating a wide difference with the two other alternatives;

- The financial evaluation does not reflect capacity limitations starting from the year 2029 on when traffic revenues no longer change. Only costs continue to slightly rise therewith ensuring continued strong annual profits making overall financial performance very attractive, certainly when considering the operator's perspective;

- The financial evaluation as presently conducted does not consider the undoubtedly substantial negative effects generated by the rapidly emerging congestion of the infrastructure.

The DPC Alternative scores very weak in financial terms because the capital investment is the highest of the three alternatives but the effects in capacity increase remain relatively low. This is caused by the structure of the alternative, creating a new railway line for long-distance passenger transport, leaving commuter traffic and cargo traffic on the non-rehabilitated existing railway line. Given that cargo traffic at present already accounts for approximately 65% of revenues, the limitations on cargo traffic growth have a strong negative effect on overall revenues.

The importance of cargo transport is clearly reflected when looking at the economic benefits for each alternative. The DFC Alternative scores best in all economic evaluation factors and clearly distinguishes itself from the two other alternatives. Focusing on the economic benefits of cargo transport, the DFC alternative has a rate of return that is 3 times better than the DPC Alternative while the ML Alternative has a negative rate of return. In terms of total revenues (both in current prices as according to different NPV Values) the DFC Alternative generates almost twenty thousand RS Crores more.

Looking at the overall evaluation of the alternatives including policy and strategic considerations (GAM Analysis), the DFC alternative clearly outperforms the two other options, both in terms of fixed ranking as in terms of ranking based upon calculated results.

Table 11.32 Summary of evaluation results

Evaluation factor	ML Alternative	DFC Alternative	DPC Alternative	Comments
Maximum Performance for cargo transport (year 2032 horizon)				
Capital investment (RS Cores)	4,659	26,635	30,552	For Infrastructure excluding rolling stocks
Cargo revenues (Rs Crores)	22,313	30,143	19,895	In the year of reaching maximum capacity
Cargo volume (Ton)	87,960,680	119,741,839	79,581,107	In the year of reaching maximum capacity
Ton Km (1000 Ton)	113,791,274	133,086,942	114,178,740	In the year of reaching maximum capacity
Capacity limitations (year)	2029	2038	2029	Year of reaching maximum capacity
Capacity difference (million ton)	(1,873)	HIGHEST	(4,302)	Total period as compared to highest volume
Evaluation Indicators				
FIRR (project perspective)	45%	10%	7%	Strict vision without any assistance
FIRR (operator perspective)	positive revenues from 1st year	53%	39%	Assuming no pay-back of capital cost for infrastructure
EIRR (all parameters)	Negative revenues	10.1%	3.8%	Main focus on cargo transport performance
Economic revenues @ 6% RS Crores)	(4,325)	24,063	6,436	Main focus on cargo transport performance
GAM average rank (fixed)	2	1	3	Ranking based upon the ranking for each individual parameter
GAM average rank (calculated)	2	1	3	Ranking based upon calculated results

(2) Recommendation

Given the objective of maximizing cargo transport by rail, *it is strongly recommended that the DFC Alternative is implemented*. This means it is recommended for the engineering study team to focus on the DFC option rather than other two alternatives in the consequent phase of the study.

In case the development of the DFC Alternative cannot be realized simultaneously, selecting between the two corridors becomes somewhat more complicated. In terms of cargo volumes transported, the economic evaluation, substantiated by the GAM *calculated* ranking (based upon the average score), suggests that the East Corridor should be developed first. But the financial evaluation, corroborated by the GAM fixed ranking (based upon the raking per individual parameter), suggest that the West Corridor should be the first selection.

The distinction between both corridors lies in the substantial difference in cargo volumes which is much higher in East Corridor as compared to West Corridor. The East Corridor transports some 91 million tons of *bulk* cargo more than the West Corridor between the years 2007-2032 and it is only in the long term future that West Corridor will transport higher cargo volumes. Because containers are predominantly transported on West Corridor and its importance is not reflected in cargo volumes but can be observed in ton kilometers and cargo traffic revenues, the West Corridor generates some 1,500 million more ton kilometers and over 708 billion rupees in revenues more than the East Corridor over the period till the year 2050. For that reason, the *new railway infrastructure should be first constructed on West Corridor* after which the railway line on East Corridor can be realized.

CHAPTER 12 REVIEW OF PAST PROJECT EVALUATION IN THE RAILWAY SECTOR

12.1 BACKGROUND

Taking its lengthy alignment and large traffic demand into account, the DFC Project will need to mobilize huge investment sources from various financial institutions and through attractive financial schemes. For resources mobilization, it is of great importance to thoroughly justify the DFC Project, gauging financial robustness, economic contribution to the national economy and proving environmental sustainability. It is therefore that the Inter-modal Strategic Study looks into a set of adequate project evaluation methods besides a set of strategies for inter-modal freight transport system development in India.

Before designing of a suitable set of evaluation tools for the DFC Project, it is deemed important to review past railway projects. The documents of past railway projects are a rich depository to show past essential experiences in project preparation, implementation and monitoring. We can learn more as we long for a successful project more seriously. There is another intention to do such reviewing works. The DFC Project may need to tap various resources into project implementation while each financial institution has to evaluate a possibly financed project by her own method. For effective financial arrangement, there is a strong need for the DFC project implementation body to prepare and justify the project in a manner that could satisfy all project financers' evaluation criteria.

This chapter reviews past project evaluation works in the railway sector. In order to understand evaluation criteria of the international donor community when technically and financially supporting railway projects in developing countries, their previous projects are analyzed by organization as follows:

a. JICA and JBIC, Japanese ODA implementation arms;

b. The World Bank;

c. Asian Development Bank; and

d. Ministry of Land, Infrastructure and Transport of Japan

12.2 JICA AND JBIC

For extending ODA projects to developing countries in the world, JICA is a technical cooperation arm while JBIC (Japan Bank for International Cooperation) is a financial cooperation arm within the Government of Japan.

JICA has been always supportive in identifying desirable railway projects, resulting in 44 development studies in total until 2004. Project evaluation works of representative studies particularly since the 1980s are listed in Table 12.1 and further detailed descriptions are made in selective three (3) studies in the Tables of 12.2, 12.3 and 12.4.

Table 12.1 Representative JICA Railway Development Studies

Project Name	Project Type	Target	Project Period	Economic Analysis		Financial Analysis	Environmental Considerations
				Benefit	Cost		
The study on electrification project of main railway lines in Java in the Republic of Indonesia (master plan)[1]	F/S	Pax	1982-1984	・Saving in travel time ・Saving in vehicle operating costs ・Traffic accident reduction ・Employment opportunity Creation	・Construction cost ・O&M cost ・Remaining value	Revenue and expenditure plan Cash Flow Analysis	-
Feasibility study on Railway Improvement Plan of Transport Capacity and Train Speed on the Delhi Kanpur Section in India	F/S	Pax/ Freight	1987-1988	・Saving in travel time ・Saving in operating & maintenance costs	・Construction cost ・O&M cost	FIRR Cash Flow Analysis	-
Report on urban/ suburban railway transport in "Jabotabek" area, Indonesia	M/P +F/S	Pax/ Freight	1990-1991	・Saving in travel time ・Saving in operating & maintenance costs ・Effective land use	・Construction cost ・O&M cost ・Remaining value	FIRR	
The feasibility study on rail-based commuter services in Klang Valley, Malaysia	F/S	Pax	1990-1991	・Saving in travel time・ ・Saving in operating & maintenance costs	・Construction cost ・O&M cost ・Remaining value	FIRR	
The study on the improvement plan for transshipment facilities at Zamyn-Uud station in Mongolia	F/S	Freight	1992-1993	The direct effect is not measured.			
The feasibility study on rapid Mass Transit in Chongqing, China	F/S	Pax	1992-1994	・Saving in travel time ・Saving in vehicle operating costs ・traffic accident reduction	・Construction cost ・O&M cost	FIRR	
Investment plan for rehabilitation of track & bridges on Hanoi-Ho Chi Minh City main line	M/P +F/S	Pax/ Freight	1994-1996	・Saving in travel time ・Saving in truck operating costs ・Saving in truck rolling stock costs	・Construction cost ・O&M cost	FIRR	EIA Survey
The feasibility study on the rehabilitation project of the Mongolian railway	M/P +F/S	Pax/ Freight	1996-1998	・Disaster recovery ・Saving in travel time ・Saving in truck operating costs	・Economic cost	FIRR	Marginal impacts found
The study on the standardization for integrated railway network of Metro Manila (SIRNMM)	M/P +F/S	Pax	2000-2001	・Saving in travel time ・Saving in vehicle operating costs	・Construction cost ・O&M cost	FIRR	EIA Survey
The master plan study on the development of Syrian railways	M/P +F/S	Pax/ Freight	2000-2001	・VOC（Pax） ・ROC（Pax） ・TTC（Freight）	・Construction cost ・O&M cost	FIRR	EIA Survey

Source: JICA Library, compiled by JICA Study Team

Table 12.2 Project Evaluation Case for the Indian Railway FS
(Delhi – Kanpur Section, 1987-1988)

(1) Demand Forecast	• Evaluation targeted at passengers only • The numbers of passengers forecast by future OD tables using a model split model
(2) Economic Analysis	• Benefit ✓ Benefits were time savings and O&M cost savings. ✓ The income approach method employed for time value calculation. ✓ O&M cost savings incurred from a projected rail share with investments • Cost ✓ Construction cost（infrastructure, rolling stock） ✓ O&M cost（maintenance, labor, electricity costs）
(3) Financial Analysis	• Financial indicators: FIRR, Cash Flow Analysis • Costs were calculated separately by foreign currency and domestic currency.

Table 12.3 Project Evaluation Case for the Vietnam Railway Study
(Hanoi – Ho Chi Minh, 1994-1996)

(1) Demand Forecast	• Forecasting of OD tables by passengers and cargo with a model split model between road and rail.
(2) Economic Analysis	• Project Period: 15 years • Economic Cost ✓ Construction Cost, O&M cost and Survival value • Economic Benefit ✓ Saving in travel time, Saving in vehicle operating costs ✓ Saving in capital cost of cargo ✓ Saving in railway maintenance & operating cost • Economic indicator: EIRR
(3) Financial Analysis	• Financial indicator: FIRR • The infrastructure investment is excluded from expense
(4) Environmental Considerations	• Pre- EIA was done,
(5) Remarks	• The following items were evaluated qualitatively. ✓ Social impact, indirect effect, environment ✓ Efficiency, reliability, and safety of rolling stock ✓ Formation of integrated transport system

Table 12.4 Project Evaluation Case for the Syrian Railway Study (2000-2001)

(1) Demand Forecast	• Passenger OD was forecasted by conventional four-step model • Commodity-wise OD tables were developed. • Development of passengers' modal share model from questionnaire survey • Development of cargo modal share model taking account of rail's delayed operation and transport cost
(2) Economic Analysis	• Project Period: 20 years • Economic Cost ✓ Construction Cost, O&M cost • Economic Benefit ✓ Saving in travel time, truck operating cost, railway operating cost • Economic indicators: EIRR, NPV, B/C
(3) Financial Analysis	• Economic indicator: FIRR • Project Period: 40 years
(4) Environmental Considerations	• Pre- EIA was done.

Source: Relevant JICA study reports

The JICA railway development studies in the past allocated considerable professional consultancy input to project evaluation except for the Mongolian railway station study due to likely a narrow project scope, only relocating a cargo transshipment point. Economic evaluation is always the area to put forth consultants' strength at the end of the reports. In most studies, they calculated savings in travel time, vehicle operating costs and railway maintenance and operating costs through a comparison between 'with' and 'without' situations. In order to meet a primary project objective, they undertook unique evaluation criterion such as reduction in traffic accidents because of an alternative rail link to the airport beside the existing road in Indonesia, reduction in disaster recovery costs because of reinforcement of vulnerable rail track foundation in Mongolia. Finally benefit and cost analysis was made, together with cost estimates consisting of initial construction and O&M costs. EIRR is the most popular indicator, followed by B/C ratio and NPV. Similarly financial analysis was made in most cases so as to calculate FIRR dominantly and other use such as cash flow analysis.

Environmental preservation is a growing and keen concern in development. In response to it, JICA designed the guidelines for environmental consideration in conducting development studies in 1994. Since then, JICA development study reports contain environmental considerations such as the results of IEE and/or EIA and relevant recommendations. Today, JICA categorizes projects subject to FS into A, B or C from an environmental viewpoint. In case of Category A projects, likely to have significant adverse impacts, such impacts must be assessed by EIA-level studies including mitigation measures to avoid, minimize or compensate for adverse impacts, an institutional arrangement and a monitoring plan. In case of Category B projects, likely to have less adverse impacts than those of Category A projects, IEE-level studies are required. In case of Category C projects, likely to have minimal or no adverse impacts, no environmental studies are required. In Table 12.1, since 1994, three (3) JICA railway studies were categorized as A while the remaining one (1) study as Category B.

Evaluation methods in three (3) selected JICA studies are analyzed as follows:

1) The previous Indian study: It highlighted only passenger services and thus the report has little implications to the DFC Project. At that time in the late 1980s, the role of freight service was marginal and a key concern was the competition between road and rail in passenger service. The traffic demand model highlighted that point. Conventional economic and financial analyses were made while no environment chapter was allocated (refer to Table 12.2);

2) The Vietnamese study: The study intended to rehabilitate a long rail stretch of approximately 1,700 km from dilapidated conditions under the socialism regime. This long alignment nature is similar to the DFC Project. However, the study only proposed to rehabilitate a long single track and its bridges for reliable and safe operation without drastic capacity expansion. Economic, financial and environmental analyses were made. The significance of railway improvement in national transport system was stressed qualitatively. Shortly after the study both the governments agreed to arrange a JBIC loan for implementation (refer to Table 12.3); and

3) The Syrian study: The study delivered two (2) outputs: master plan report (target year of 2020) and FS report (rail improvement at part of the master plan network). The rail serves for both passengers and freight. Economic, financial and environmental analyses were made. The project duration differed from 20 years for

economic analysis to 40 years for financial analysis. Without a specific concession agreement, it is not a common practice (refer to Table 12.4).

On the contrary to JICA, JBIC has disclosed limited rail project documents to the public. Since 2001 JBIC started to disclose project appraisal documents including EIRR before project implementation. However it is difficult to find good railway loan project samples for reviewing the methods and practices of JBIC's project justification.

From its website, we can understand that JBIC has numerous loan projects in the railway sector. Table 12.5 indicates some of them in the Asian region except India. Major JBIC projects in the railway sector are Calcutta Metro Railway (loan approval in 1983, 4,662 million yean) and Delhi Mass Rapid Transit System I, II, III (loan approval years in 1997, 2001 and 2002, respectively, 50,151 million yen in total)

Table 12.5 JBIC Railway Loan Projects in the Asian Region

Project Name	Country	Interest rate (%)	Repayment period (year)	Grace period (year)	Procurement condition
Railway project (Upgrade)	Mongolia	2.6	30	10	General untied
Railway constriction project	China	1.8-2.6	30	10	
Railway improvement Project	Thailand	2.7	25	7	
Railway improvement Project (Financing)	Thailand	2.2	25	7	
South Java rehabilitation project	Indonesia	2.7	30	10	
Java rehabilitation project (2)	Indonesia	2.7	30	10	
Java rehabilitation & electrification project	Indonesia	0.95	40	10	
South Java rehabilitation project（Ⅱ）	Indonesia	1.3	30	10	
Railway bridge safety improvement project	Vietnam	0.75	40	12	Japan untied
Railway project (Upgrade)	Uzbekistan	2.7	30	10	General untied
Railway constriction project	Uzbekistan	0.4	40	10	Untied
Railway rehabilitation project	Turkmenistan	2.7	30	10	General untied
Railway project (Upgrade)	Kazakhstan	3	25	7	

Source: www.jbic.or.jp

However, it is possible to learn JBIC's method to calculate project IRR from its internal manual prepared in 2002. It is the **IRR Calculation Manual for Yen Loan Projects** (only Japanese version is available) which is composed of five (5) chapters: (I) Introductory Remarks; (II) EIRR and FIRR; (III) Analytical Models and Samples for EIRR Calculation; (IV) EIRR Calculation Tables by Major Project Sectors; and (V) Current Practices of Economic Analysis among International Financial Institutions.

Although the manual is designed to apply a wide range of JBIC loan projects, one section is allocated for railway projects. Besides internationally acceptable methodologies in calculating a project's EIRR as well as FIRR, there are some points worth noting for practical project evaluation as follows:

1). A wide range of project benefits and practical calculation

The manual suggests to identify a wide range of project benefits encompassing cost savings in passenger and cargo transports, induced cargo and passenger traffic (a certain portion of additional value from a growing market attributable to the project), reduction in passengers' travel time, reduction in O&M costs, reduction in VOC of road users, reduction in traffic accidents, betterment of environment due to reduced vehicle exhaust emissions, and spill-over effects from a project to regional economy.

However those benefits mostly rely on the result of traffic demand forecast. For quantitative calculation, in practice, the manual recommends to employ main benefits accruing from a railway project consists of cost savings in passenger and cargo transports, reduction in passengers' travel time, and induced demand. Other benefits may be given qualitative descriptions provided that those are small in quantity.

2). Project monitoring and post-project evaluation

During a project formulation phase, it is suggested that benchmark indicators be designed not only for project justification prior to implementation but also for project monitoring during a designed project lifecycle and post-project evaluation. Adequate benchmarks for railway projects are passenger and cargo traffic demand (person-km and ton-km), transport costs (monetary value per person-km and ton-km), travel time (distance and speed) of a railway project, rolling stock utilization rate, alternative road traffic (person-km and ton-km) and traffic costs (monetary value per person-km and ton-km).

Those benchmarks should be easily collected or processed during project monitoring and post-evaluation phases. A project's EIRR should be finally confirmed at the post-project evaluation. It is assumed that a railway project's life is more or less 25 years.

3). Lessons from previous railway projects

Lessons from previous railway projects financed by not only JBIC but also the World Bank and ADB reveal that there are mainly two reasons when some of those projects could not enjoy expected economic benefits in implementation. They are:

- Railway demand was not increased as expected due to rapid development in road transport; and

- Railway business suffered from inefficiency.

12.3 THE WORLD BANK

The World Bank has been eagerly financing railway projects in developing countries. There is convincing evidence of 13 project appraisal reports uploaded at the website. Those documents were compiled between 2002 and 2006 (refer to Table 12.6).

Judging from the recent project appraisal documents, the World Bank has laid stress on railway restructuring and modernization of railway business management. Among them, there is no project to undertake only physical railway development, e.g., rehabilitation, improvement and capacity expansion. Hard and soft components are combined in a project. Another point is to support railway together with road transport in some projects such as Romania, Tanzania, Mali, Madagascar and India (Mumbai). Today, it seems that the World Bank focuses development agenda in the railway sector on efficient railway business management including privatization and competitive and supplementary railway service to road transport.

The Mumbai Urban Transport Project, amounting to US$ 358 and two third of which is allocated for urban railway, is a new World Bank rail project after the Third Railway

Modernization Project approved in 1988. The project was duly evaluated at seven (7) areas as shown in Table 12.7.

Table 12.6 Major Recent Railway Projects Financed by the World Bank

Project Name（Country）	Project Profile	Appraisal Year	Economic Analysis	
			Benefits	Costs
East Africa Trade and Transport Facilitation Project (Africa)	Railway service improvement	2006	・Saving in vehicle operating cost ・Saving in travel time	・
RAILWAYS REFORM (Macedonia)	Improvement of railway business management	2006	Only financial analysis was done.	
Railways Restructuring Project (Turkey)	Improvement of railway service productivity (Including expansion of freight line capacity)	2005	・Additional income by induced traffic	・Construction Cost ・O&M Cost
Transport Restructuring Project (Romania)	Improvement of railway business management with road sector	2005	Only financial analysis was done.	
Beira Railway Project (Mozambique)	Rehabilitation of existing railway line	2004	・Direct Impact ・Indirect Impact (employment) ・External impact (environment, safety, etc.)	・Construction Cost ・O&M Cost
Second National Railways Project (Zhe-Gan Line) (China)	Improvement of mainline passenger service	2004	・Travel time saving ・Reduction in operation cost by electrification	・Project Cost ・Supplemental Cost
Central Transport Corridor (Tanzania)	Improvement of highway and railway management Rehabilitation of highway	2004	・VOC saving ・Induced demand	・
Transport Corridors Improvement Project (Mali)	Trunk infrastructure development to seaport with railway business management reform	2004	・VOC saving	・
Rural Transport Project (Madagascar)	It is rehabilitation project for a traffic environment Improvement in the local provinces	2002	・VOC saving ・Reduction in highway O&M cost	・
Railway Concession Project (Cameroon)	Rehabilitation of railway infrastructure and management modernization	2002	・Reduction in railway operating cost ・VOC saving ・External benefits (road safety, etc）	・
National Railway Project (China)	Capacity expansion by double-tracking and improvement of existing electrified railway lines	2002	・Generation of railway service related additional value on raw materials and products for the heavy chemistry industry such as petroleum product, ore, nonferrous metals, and fertilizers ・Qualitative benefit for regional development	・
Transport Development Project (Mongolia)	Improvement of highway and railway management, Rehabilitation of highway	2000	Only financial analysis was done.	
Mumbai Urban Transport Project (India)	Introduction of urban transport system consisting of highways and railways, focusing on suburban passenger rail service	2002	・Saving time for passenger and alleviation of rail coach congestion ・VOC saving ・Rail operation cost saving due to new rolling stock ・Improvement of air quality	・Construction Cost ・O&M Cost

Note 1 : All the documents contain uniformed financial analysis – FIRR and its sensitivity
Note 2: EIA surveys were conducted separately.
Source: www.worldbank.org

Table 12.7 Project Evaluation Case for the Mumbai Urban Transport Project (On-going since 2002)

(1) Project Evaluation	• Project evaluation was done at the following seven areas: (1) Economic Analysis, (2) Financial Analysis, (3) Technical Analysis, (4) Institutional Arrangement, (5) Environment Consideration, (6) Social Consideration, and (7) Safeguard Issues
(2) Economic Analysis	• Identified benefits for the urban railway (passenger service) component include: ✓ Saving in travel time of railway passengers ✓ Alleviation of rail coach congestion ✓ VOC saving due to traffic diversion from road to rail ✓ Improvement of air quality ✓ Reduction in rail operating cost due to newly procured electric rolling stock • Cost estimates ✓ Initial cost（Infrastructure and rolling stock） ✓ O&M cost（maintenance, labor cost, electricity, etc.）
(3) Financial Analysis	• Financial indicator: FIRR
(4) Environmental & Social Considerations	• A separate EIA survey was conducted, including resettlement by highway and railway development.

Source: www. worldbank.org/

12.4 ASIAN DEVELOPMENT BANK

ADB has extending its technical and financial services in the railway sector to several countries such as Uzbekistan, India, Bangladesh and China. Although the number of recent railway projects, e.g., 6 projects since 1998, is smaller than the World Bank, ADB has serving from railway rehabilitation, upgrading and new rail development to institutional improvement in a wide range (refer to Table 12.8).

Reviewing the project appraisal documents, it can be understood that ADB tries to explore induced economic development by railway and subregional linkage. In China and India, the relevant ADB project reports identified induced traffic from coal mines, the cement industry and other natural resource related economic activities and then counted benefits attributable to the projects. In Uzbekistan, the ADB project expected foreign currency income from cross-border rail operation. It is to be noted that ADB published the “Handbook for the Economic Analysis of Subregional Projects, 1999”.

In India, the railway sector has received considerable external support over an extended period. Historically, the World Bank was the leading source of external assistance, having provided more than $2.1 billion of loans for 18 projects of Indian Railways between 1959 and 1988. In addition, ADB provided loans to assist Indian Railways in 1987 and 1991 with a combined value of $415 million. After that time, external assistance was reduced as international financial institutions such as the World Bank and ADB became concerned that investments would not achieve their potential impacts until MOR implemented institutional and policy reforms to address key obstacles to sector performance.

Therefore, the on-going ADB project to Indian Railways or the "Railway Sector Improvement Project" is a new challenge to improve sector performance and show absorptive capacity to receive further external assistance. The project implementation was justified from economic, financial, institutional and environmental viewpoints. The most important point was institutional reforms committed by MOR. Although the project includes four (4) infrastructural subprojects covering new rail link, second bridge, third line and double tracking, those investment components of the project is categorized as a "B" project in accordance with ADB's Environmental Assessment Requirements. The reason is that the investment component is not subject of the environmental impact assessment of the Government. MOR submitted relevant IEE reports to ADB for approval.

Table 12.8 Major Recent Railway Projects Financed by ADB

Project Name	Country	Appraisal Year	Economic Analysis		Financial Analysis
			Benefit	Cost	
Railway Rehabilitation Project	Uzbekistan	1998	・O&M cost reduction ・Reduction in operating cost and travel time saving ・Foreign currency income by increasing cross border operation ・Reduction in rolling stock cost ・Reduction in truck operating cost ・Qualitative benefits incl. increased efficiency of railway operation	・	FIRR and Its sensitivity analysis
Railway Sector Improvement Project	India	2002	・Reduction in railway O&M costs ・Reduction in rolling stock cost ・Travel time saving ・Other benefits incl. increasing resource productivity due to railway capacity expansion	・Construction Cost ・O&M Cost ・Land expropriation	
Jamuna Bridge Railway Link Project	Bangladesh	2005	・Reduction of railway O&M cost ・Reduction of highway O&M cost ・Saving cost of road constriction ・Environmental improvement by traffic accident reduction ・Cost reduction by ferry abolition	・Construction Cost ・O&M Cost	
Jing-Jiu Railway Technical Enhancement Project	China	2000	・O&M cost reduction of road ・Market value creation by promoting coal and cement industries	・Construction Cost ・O&M Cost	
Ganzhou-Longyan Railway Project	China	2001	・Saving in passenger and cargo costs ・Regional economic development and added value from increased cargo ・VOC saving at access road ・Reduction in highway O&M cost ・Sightseeing promotion ・Qualitative benefits incl. poverty reduction	・Including land acquisition	
Guizhou Shuibai Railway Project	China	1998/ 2005	・Saving in transport cost ・Market value creation by promoting coal industry ・Qualitative socio-economic benefits incl. employment, access to health and education, etc.	・	

Source: www. adb.org

12.5 MINISTRY OF LAND, INFRASTRUCTURE AND TRANSPORT, JAPAN

The Ministry of Land, Infrastructure and Transport (MLIT) of Japan is mandated to administer railway system development through approval of railway projects, provision of subsidy and issuance of operation license. Since MLIT is keen on railway projects evaluation, the ministry published the "Evaluation Manual for Railway Projects" in 1997 and revised twice in 1999 and 2005 to meet the railway development environment in Japan. The latest version introduced a comprehensive project evaluation framework and a new public management (NPM) method in order to enhance project accountability to the stakeholders. The core methodology of project evaluation, cost and benefit analysis, was also revised to include positive and adverse environmental impacts on railway development.

MLIT's concern is not limited to domestic railway development. MLIT provides policy and technical advice on bilateral economic cooperation projects in the railway sector. For instance, MLIT contributed to evaluating the high-speed railway project between Beijing and Shanghai in China by a bilateral experts meeting in 2002. The evaluation framework is outlined as follows:

1) Objectives

The survey is titled as the "Technical Survey on High-speed Railway Project in China (Economic and Financial Analysis)" which was conducted between 2001 and 2002. The survey was managed by the bilateral experts meeting in order to apply Japanese experiences and methodologies of economic and financial analysis in railway development to China with due consideration of Chinese conditions.

The survey dealt with economic analysis, financial analysis and economic impact (multiplier effect) analysis. On the other hand, environmental considerations were out of the scope.

2) Economic analysis

The survey estimated the project costs and benefits. The costs, amounted to RMB 73 billion, consist of construction cost, O&M cost, rolling stock cost and re-investment. Similarly, the benefits, totally accrued to RMB 160 billion over the project period, consist of users' benefit (savings in transport cost and travel time), supplier's benefit (earnings of a railway operator) and environment improvement benefit (reduction in noise, air pollutants, CO_2 and traffic accidents).

The economic analysis works are illustrated in Figure 12.1. The results are expressed in EIRR (17.4%), CBR (2.2) and NPV (RMB 86.5). Those economic indicators are also subject to sensitivity analysis in terms of social discount rate and revenue earning.

3) Financial analysis

Financial analysis was done by different implementation schemes (separated implementing bodies of infrastructure and operation, and a combined body). Major concerns are FIRR and breakeven years in operating account and capital account. Those indicators are subject to sensitivity analysis in the cases of different inflation and tariff increase rates and different revenue earnings.

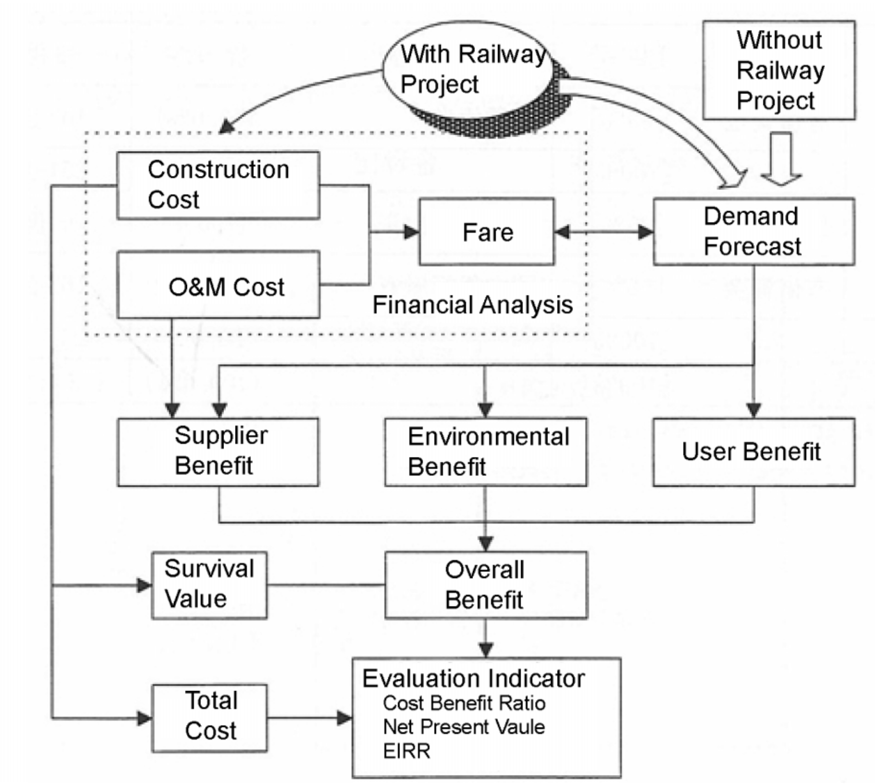


Figure 12.1 Flow of Economic Analysis

Source: Technical Survey on High-speed Railway Project in China (Economic and Financial Analysis), MLIT of Japan, 2002

4) Economic impact (multiplier effect) analysis

The survey estimated the project's economic impact or multiplier effect at three (3) measurable impact areas during the construction period by using input-output model. Their coverage and estimated results are as follows (refer to Table 12.9):

- Induced impact to production: It adds indirect impact which is calculated by the equilibrium model to direct impact (project investment cost without land acquisition). The survey estimated an overall induced impact to production at RMB 260.2 billion. It is 2.4 times higher than the project investment cost (RMB 106.5 billion at the 1997 constant price).

- Induced impact to value added: This is part of induced impact to production. Additional value in the economics term means additional services in the processing work from raw materials to final products and it can be measured from company profit and worker income. The survey estimated it at RMB 82.9 billion or approximately 1% of Chinese GDP at the 1997 constant price. In regard to sectoral contribution, the project accounts for 23% in the machinery manufacturing sector and 24% in the construction sector, respectively.

- Induced impact to employment: Induced impact to production may create additional employment opportunities. This employment impact during the project's construction phase is estimated at 4.8 million which is equivalent to approximately 2% of urban employment in China as of 1997.

Table 12.9 Measurement Results of Induced Project Impact for the Chinese High-speed Railway Project during the Construction Phase

Measurement Area		Direct Impact	1st Indirect Impact	Total
Induced Impact to Production (RMB billion)		99.9	160.3	260.2
	Induced Impact to Value Added (RMB billion)	28.3	54.6	82.9
Induced Impact to Employment (‘000 persons)		1,720	3,110	4,830

Note: Exclusive of the 2nd direct impact due to database limitation
Source: Technical Survey on High-speed Railway Project in China (Economic and Financial Analysis), MLIT of Japan, 2002

12.6 SUMMARY

This section summarizes various and numerous experiences and lessons from railway project evaluation practices by major donor agencies. Since agency-wise analysis has been done, this section highlights essential topics in evaluation: economic analysis, financial analysis, environment considerations, and economic impact.

1) Economic analysis

- All the donor agencies employ cost and benefit analysis as a core method of economic evaluation when they support railway infrastructure development. Its reliability heavily depends on accurate figures of investment costs and traffic demand forecast. It has been reported that many railway projects could not enjoy projected traffic demand due to a fierce competition with road transport.

- Benefits items are sometimes different by project and by donor agency. Although all the projects calculate savings in transport cost (only railway or both rail and road) and travel time (mainly for passengers), ADB prefers to count induced development along the railway corridor and cross-border earnings. MLIT of Japan has recently recommended that environmental upgrading benefit incurred by a railway project be included into a cost-benefit stream such as traffic safety, air quality improvement and others.

2) Financial analysis

- Nowadays all the externally assisting railway projects undertake financial analysis. The World Bank has several experiences of railway sector reforms without infrastructure financing. In those cases, only financial analysis was done to gauge improved efficiency of railway business management. Popular intervention tools are privatization, introduction of public-private-partnership (P-P-P) scheme, hiving off non-core businesses from railway business, etc.

3) Environment considerations

- It is a growing concern and, in the last decade, institutional set-up has been done to response it among donor agencies. Today, conduct of EIA-level survey is likely an obligatory requirement when involving donor agency into a railway infrastructure development project.

4) Economic impact analysis

- It is a useful tool to gauge induced impact to the economy. As long as an input-output table is available, economic impact (or multiplier impact) analysis is meaningful. Although no donor assistance reports have tackled this methodology at least in the railway sector, MLIT recommends it particularly to assess a sizeable railway project compared with its national economy.

5) Others

- JBIC suggests selection of project benchmarks which are easily collected and processed not only for project formation and justification but also for monitoring during project life and conducting post-evaluation after project life is terminated.

CHAPTER 13 IMPLICATIONS TO THE DFC PROJECT FOR EVALUATION

13.1 INTRODUCTION

After reviewing previous railway projects particularly technically assisted and financed by donor agencies, the previous chapter concluded that the DFC Project needs to be satisfactorily justified by internationally acceptable methodologies in terms of financial, economic and environmental viewpoints. In addition, project evaluation works can contribute to better project formation to meet sufficient financial profitability, economic effectiveness, environmental sustainability and other requirements, by addressing sector-wise development issues and incorporating corridor-wide development opportunities into the project.

This chapter aims at suggesting desirable project evaluation methodologies and related remarks for the JICA assisted feasibility study on the DFC Project which is being undertaken and will be completed by the mid-2007. Therefore, this chapter deals with only evaluation methodologies and methodologies' related descriptions. Among evaluation areas, environmental evaluation is excluded in the chapter since JICA and the C/P agency agreed to treat the DFC Project as Category A that is likely to have significant adverse impacts. Such adverse impacts should be assessed by a EIA-level study. As results, this chapter's concerns are the following:

For financial analysis:

- Review the RITES pre-F/S report;
- Calibrate business viability of the DFC Project in competition with road transport; and
- Incorporate sector improvement measures for modern business management.

For economic analysis (refer to Figure 13.1):

- Highlight investment characteristics or costs and benefits' relations when identifying the project's economic impact during operation phase;
- Give any suggestions to EIRR calculation in an internationally acceptable manner; and
- Gauge induced project impact or multiplier effect during construction phase independently taking account of the magnitude of investments.

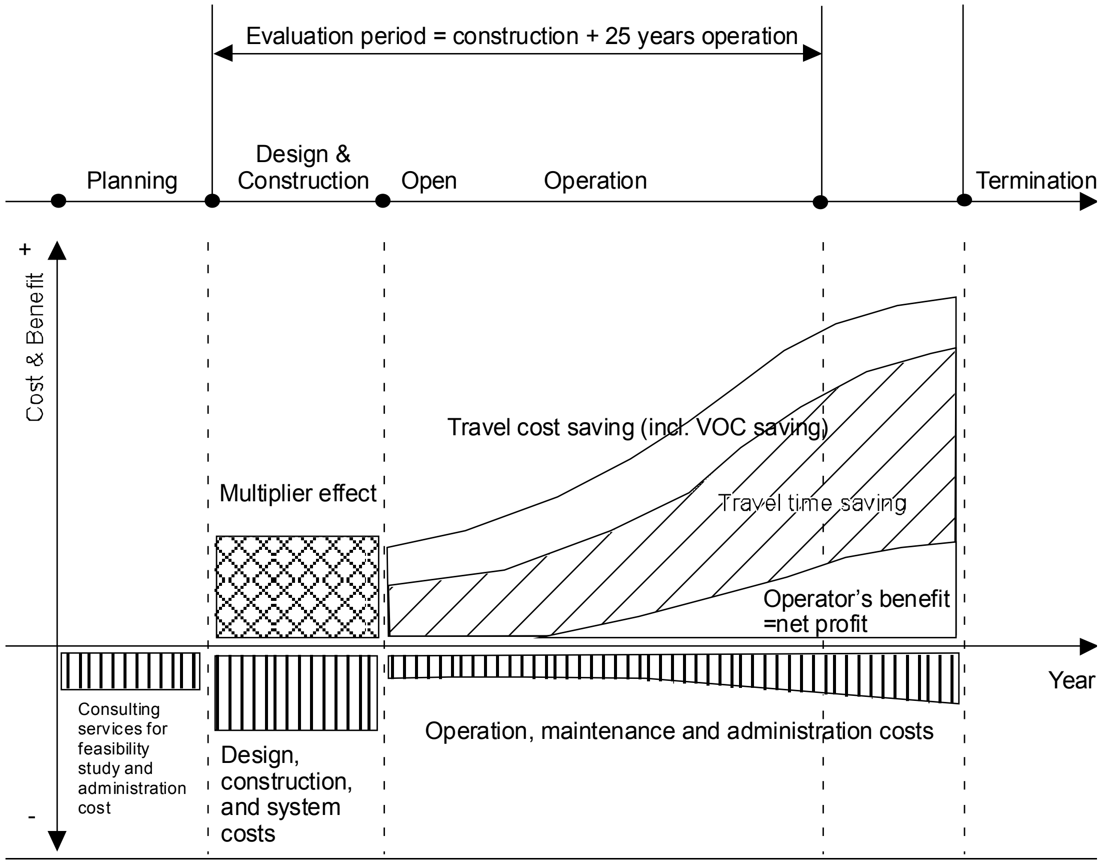


Figure 13.1 Concept of Costs and Benefits during Project Life

13.2 FINANCIAL ANALYSIS

RITES Limited submitted the pre FS phase I (Delhi – Howrah route) report to MOR in January 2006. RITES is scheduled to submit another pre-FS report concerning the phase II (Delhi – Mumbai route) by the end of 2006. The two reports share almost the same table of contents where financial analysis constitutes one of nine (9) sections in the reports. Since both the documents are very important and worth scrutinizing, this project research report gives several suggestions towards a full-scale FS of the DFC Project.

(1) FIRR calculation related issues

FIRR by Implementation scheme: The RITES report calculated FIRR from the Indian Railway's viewpoint. Overall project FIRR is always necessary. In the DFC Project, however, a conventional railway development scheme will not be applied. The investment component will be implemented by a special purpose vehicle (SPV) that will be established under the Company Act 1956 for the purpose of the DFC Project on behalf of MOR. Therefore, FIRR should be calculated by SPV and other players in the project, separately.

Cost estimates: The RITES report uses cost items in a broad sense and does not include or specify some important items such as resettlement cost, tax, asset depreciation or the Depreciation Reserve Fund historically managed by Indian Railways. In conducting a full-scale FS, it is desirable to use detailed cost itemization which are popular among the donor agencies' committed projects. Table 13.1 shows one sample in comparison with the RITES report.

Table 13.1 Comparison of Financial Cost Items

	Cost Items of RITES	Preferred Cost Items of FS	Remarks
Construction Period	Civil, Electrical, Mechanical Costs*, Signaling & Telecommunication	Civil, Electrical, Mechanical Costs	
		Working Expenses	• Working expenses for construction
	-	Land Acquisition	• Land acquisition and resettlement cost • RITES assume construction in right of Way. But it will be assumed land acquisition if necessary.
		Additional Cost	• Additional cost for O&M.
		Consultant Fee	• Fee of international consultant and local consultant.
		Import Tax	• Import tax for construction material and international consultant.
		Reserve fund (rise in prices)	• Reserve fund for design and specification change • Reserve fund for rise in prices
Operating Period	Rolling Stock Requirement, Working Expenses	O&M Cost	
		Renewal cost of infrastructure	• Renewal cost of infrastructure during project life
	Residual and Replacement Costs	Depreciation cost	
	-	Tax	• Common carrier tax of fare box revenues • Corporate income tax

Note: * Maintenance facilities for Rolling Stock
Source: JICA Study Team

Tariff setting: The RITES report uses the present freight tariff in accordance with the published goods tariff No. 44 applicable since April 2005. However, the freight tariff is distorted by the cross subsidy to passengers. In May 2002, the Minister of Railways submitted a status paper on Indian Railways to Parliament. This paper drew attention to the need for reform including the need for lowering freight rates and removal of cross subsidy of passenger tariff with any subsidy to be met through a public service obligation mechanism. In this sense, SPV is remarkable since it is financially independent from Indian Railways. Therefore the current tariff distortion should be adjusted in the DFC FS. In practice, however, such tariff adjustment works seem cumbersome. For reference, the ADB's Railway Sector Improvement Project took the following way to estimate operating revenues:

"In the financial evaluation, the incremental revenue was based on freight revenue with and without the Project. Freight tariff rates were assumed to decrease by 0.8% in real terms annually for the first 5 years (due to eliminating cross-subsidy), and to remain constant thereafter." (Project Appraisal Report, ADB 2002)

Revenue projection and FIRR/EIRR: The RITES report has not analyze the future modal share between rail and road, and the relation between rail freight setting and rail freight traffic especially for container haulage. It is one of critical points to confirm the project feasibility. The following works are deemed necessary for the optimum rail fare setting:

- Develop a traffic demand forecast model where a modal split model of rail and road is incorporated;
- Find the highest FIRR with its fare setting; and
- Calculate EIRR at the highest FIRR condition. If the EIRR could not meet the benchmark, say 12%, the most compromising fare level would be found.

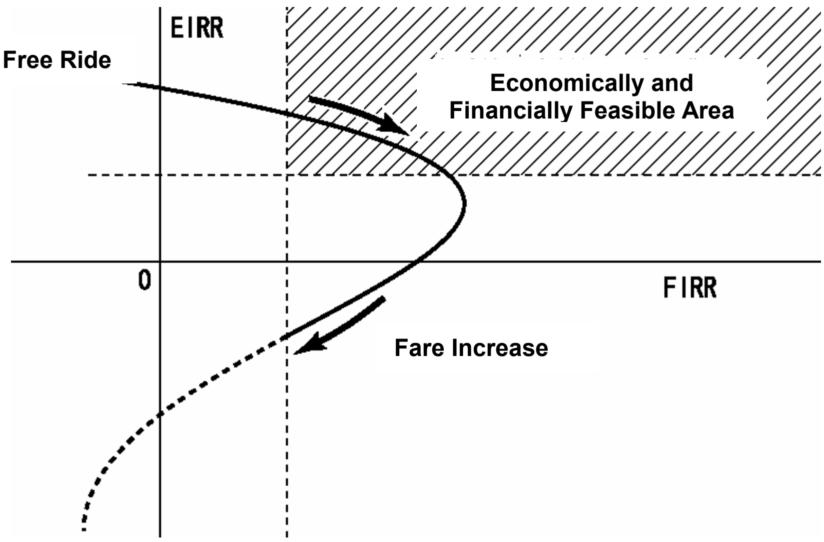


Figure 13.2 Relation between EIRR and FIRR

Depreciation: The financial statements of IR have several accounts that are different from generally accepted accounting principles. For example, IR adopts a unique method for fixed asset accounting as it maintains the acquisition value of fixed assets, rather than depreciating them. Instead, IR appropriates a certain amount in the “Depreciation Reserve Fund”, which is credited when IR replaces its fixed assets. Therefore, the provision of depreciation is well below actual requirements. In the DFC FS, depreciation of investment assets should be calculated in a generally accepted manner.

FIRR benchmark: To assess financial viability the FIRR was compared with the weighted average cost of capital (WACC). In an ODA finance project, it is likely to combine ODA soft loan and domestic public fund as the counterpart fund. In general, ODA soft loan is attractive due to low interest and long repayment period but the borrower should consider a long-term exchange risk. In the DFC Project, there is a possibility for the private sector to participate in. Currently, rolling stock financing on a lease arrangement is available through Indian Railways Financing Corporation with an interest rate of 13% per annum. Therefore it is difficult to project all capital sources in terms of amount and conditions to be tapped into the project. According to the Indian Public Finance Statistics 2005-06, the loan interest from the central government to a public corporation having equity capital exceeding Rs 1 crore for industrial and commercial undertakings is set at 12.5% per annum. Roughly speaking, we may expect that the DFC project can show a better financial performance than that level.

(2) Designing of implementing body

One of the important tasks in financial analysis is to design a suitable implementing body. Nowadays, in not only India also other countries, railway sector reform issues concentrate on an inefficient and historical national railway company. For example, the World Bank's railway sector reform TAs have made only financial analysis to check the degree of improvement or productivity of a railway company.

Indian Railways have overdue reforms. Therefore, the DFC FS in financial analysis should address those sector reform issues together with a project implementing body. It is strategically important to obtain financial support from many agencies. For reference, the on-going ADB's Railway Sector Improvement Project is tackling the following reforms:

- Design and introduce computerised accounting system capable of providing government accounts and commercial accounts by 2004, and complete training and adaptation by 2006
- For core business, accounting separation of principal lines of business as cost/profit centers, with breakdown for individual services by 2005
- Accounting separation and establishment of non-core activities as cost/profit centers by 2005
- Introduce concessions for operating loss-incurring lines and private sector terminal services and competition in rail container services by 2004
- Implement decision on public service obligation mechanism to compensate IR for having to operate loss-incurring services by 2005
- From FY 2003 to FY 2007 MOR to implement tariff rationalization to improve the profitability and competitiveness of its passenger and freight services
- Net staff reduction of 2% per annum in 2002-2010, leading to staff strength of 1.41 million in 2005 and 1.18 million in 2010

Since the DFC Project establish a SPV as a project implementing body, hiving off non-core businesses from a core business (meaning SPV in the project) can be achieved. To institutionalize sector reforms, there is a strong need for SPV to meet other issues such as computerised accounting system, introduction and expansion of private sector participation under SPV, adjustment of distorted fare system and continuous rationalization of labour force.

(3) Coverage of financial analysis

Considering a new SPV scheme and huge investment requirements, only FIRR calculation is not sufficient to confirm project business viability. Thus rather a comprehensive financial analysis framework is prepared as depicted in Figure 13.3. In essential, SPV needs to project its financial statements and FIRR calculation is further analyzed by sensitivity analysis, risk analysis and break-even analysis.

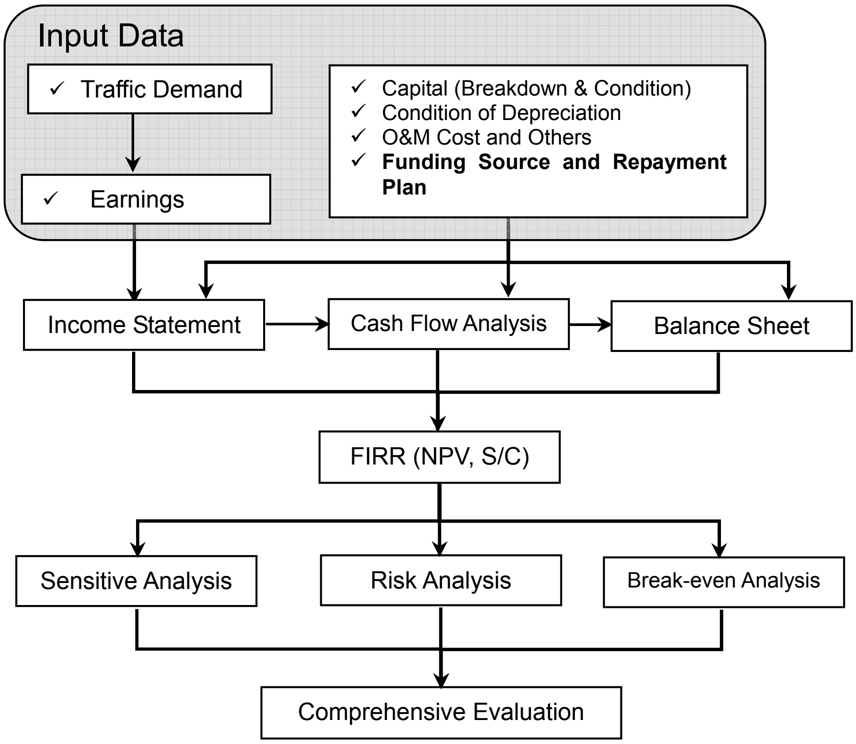


Figure 13.3 Flow Chart for Financial Analysis

13.3 ECONOMIC ANALYSIS

(1) Benefits and Beneficiaries

The DFC Project will need huge investment which can be divided into four function-wise components: (i) construction of DFC infrastructure or substructure of DFC railway; (ii) procurement of rolling stock; (iii) introduction of computerised railway control and electrification; and (iv) development of intermodal transport facilities such as ICD and rail-port interconnection facility. Broadly, the (i) and (ii) components intend to expand freight railway capacity while the (iii) and (iv) components are designed to enhance operational efficiency and reliability and thus competitiveness.

As above-mentioned, the DFC Project will generate various project benefits. It is important for economic analysis to grasp those benefits quantitatively or qualitatively. Particularly, quantitative core benefits are essential in cost-benefit analysis. The followings are suggested as the DFC project benefits to be measured in the FS.

A. Freight Service

A1. Savings of operation and maintenance costs of rail and road

Railway operation cost savings can be expected from faster travel times and efficient rail operation including the elimination of rail detention times to give priority to passenger trains. Railway maintenance cost savings can be largely arrived from replacement of dilapidated railway assets.

In parallel with railway freight users, road users will enjoy the project benefit since substantial trucks along the DFC corridor are diverted to railway and thus road congestion is eased and road damage becomes slight.

A2. Savings in cargo time cost

Saving in cargo time cost means the time savings resulting in working capital expenses for the goods being transported. Rail goods have different values and available durations particularly for perishable goods. Therefore commodity-wise calculation is practical.

B. Passenger Rail Service

Railway passengers will be able to gain benefit since the DFC Project allows passenger trains to be assigned until the full capacity of the existing rail tracks. If capacity limitation would become severe under the 'without' case, a considerable amount of benefit could be expected under the 'with' case.

C. Railway Business

C1. Savings in rolling stock arising from better utilization

The DFC Project can allow a railway operator to make a train diagram with optimum efficiency. The benefit can be measured by specific indicators such as the number of running trains per day and average daily running distance per train. Although this benefit is directly linked with the procurement cost of rolling stock, it also unites with others on the savings in railway operating and maintenance costs. Thus, it is not recommended to put this benefit into a cost-benefit stream to avoid double counting.

C2. Current (pretax) profit of railway operator

Even after providing better transport services and spreading project benefits categorized as the above-mentioned 'A' to users, a DFC operator may enjoy some current (pretax) profit which is considered as part of the project benefit. In the case of many railway projects, however, operators suffer from huge debt in initial several years and profits later on become marginal in a cost-benefit stream under an adequate social discount rate.

D. Others

D1. Enhancement of railway safety

According to the MOR statistics, the total number of train accidents per million train km was 0.64 in 2001. The majority of accidents were derailments, 344 cases in 2001. Other accident types included collisions, grade crossing accidents, and fires in trains. There is an increasing tendency. One of the contributing factors leading to increasing accidents is that many of the assets, such as track and bridges, are reaching the end of their economic life and need to be replaced.

The DFC Project will develop new rail infrastructure with brand-new rolling stock. It has been proved in other countries that railway electrification and computerised control is effective to secure safe operation. If Indian Railways could not find good examples within its territory, railway safety achievements in other countries would be used to estimate the 'with' condition.

D2. Upgrading of environment and reduction in GHG emission

Compared with road transport, railway is definitely an environment friendly mode. Local people along the corridor may enjoy lower noise and better air quality such as NOx, SOx and SPM. Nowadays greenhouse gas emission (GHG) becomes a global concern. Traffic conversion from truck to rail can reduce GHG considerably.

It is possible to trade GHG reduction by a project if this project is registered as a CDM project at the UN CDM Executive Board and the board issues certified emission reduction (CER). According to the World Bank, the price of CER per CO2 ton equivalent ranged from \$3 to \$7 during the period January 2004 to April 2005. The market shows an upward trend.

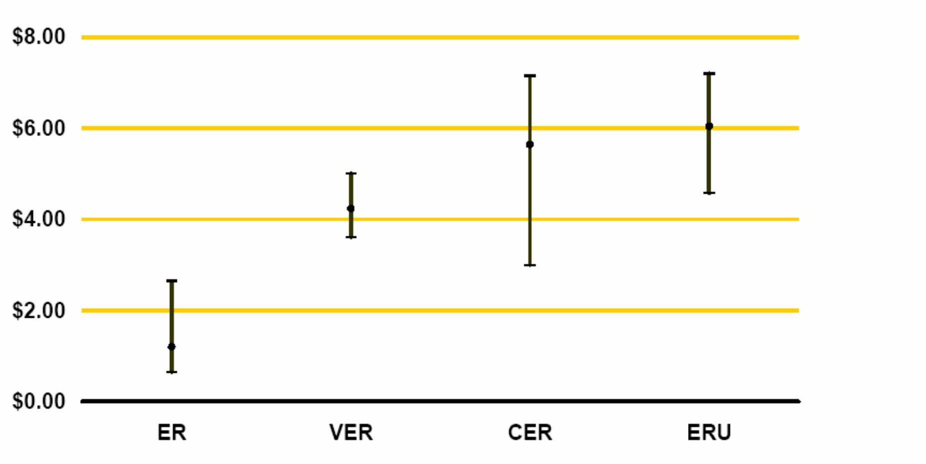


Figure 13.4 Prices of GHG Emissions
(in US\$, per tCO_2e, January 2004 to April 2005)

Source: 'State and Trends of Carbon Market 2005', the World Bank

D3. Induced corridor-wise economic development

If there is a specific railway-cum-area development project along the DFC, the project FS should identify induced traffic such as additional production of minerals made possible by improved railway services.

D4. Contribution to poverty reduction

In a broad sense, the investment component will contribute to poverty reduction by (i) contributing to national economic growth that will increase employment and income-earning opportunities for the poor; (ii) facilitating employment creation and income-earning opportunities for poor people living in areas previously without efficient transport links; and (iii) providing employment opportunities for poor people during construction.

For the DFC Project, poverty incident rate or poverty population along the corridor can be found from the statistics. The project's induced impact on employment during the construction phase can be estimated by the economic impact (or multiplier impact) analysis (refer to Section 13.4).

Corresponding to those explicit benefits, possible beneficiaries can be grouped into seven (7). They are (i) rail freight users, (ii) road users and operators including public road administration, (iii) rail passengers, (iv) DFC operator(s), (v) railway related service providers such as ICD and CFS operators, (vi) railway infrastructure constructors and railway equipment manufacturers, and (vii) local economies and people along the DFC corridors.

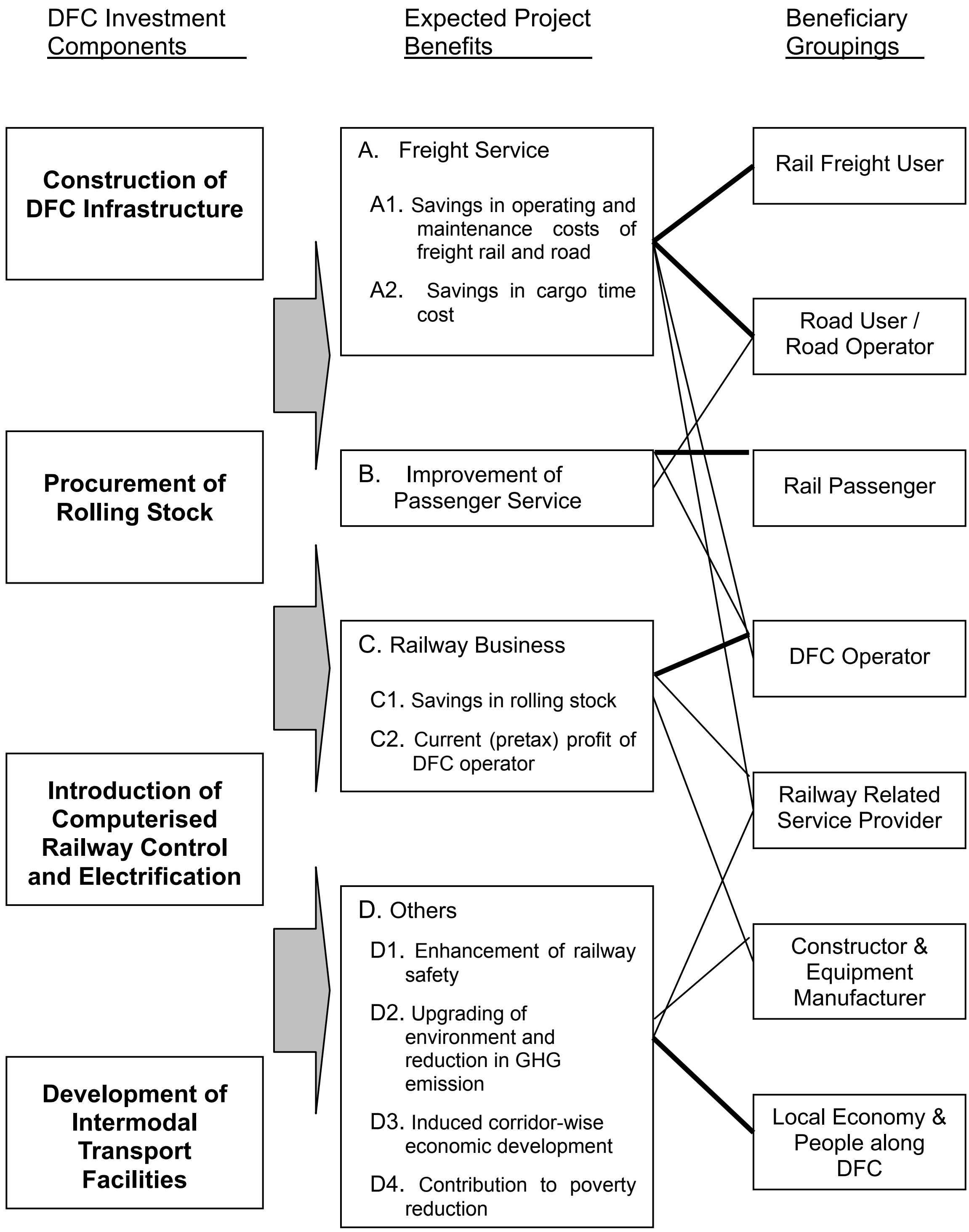


Figure 13.5 Expected Benefits and Beneficiaries of the DFC Project

(2) Economic Cost and EIRR Calculation

Economic costs exclude price contingencies, taxes, duties, subsidy and interest during construction. Indian taxation system is outlined in Table 13.2. Effective tax rates are slightly higher than regulated ones because of surcharge fee and education purpose tax (2%) which add on most of the taxes.

In order to simplify the conversion works from financial costs to economic costs, the on-going ADB project, "Railway Sector Improvement Project", adopted a standard conversion factor of 0.85 to financial costs of non-trade inputs. In the case of imported equipments and materials, however, it is necessary to calculate economic costs since import duty has four-staged rates, ranging from 0% to 12.5%.

Taking account of previous external assisted projects, the lowest EIRR benchmark can be set at 12%. A project of having less than 12% EIRR can not be regarded as an economically significant project.

Table 13.2 DFC Project Related Taxation in India

Item	Coverage and Rate
Value Added Tax (VAT)	Mostly 12.5%, exceptionally 20% for refined oil products and alcohol, 4% for specific parts and raw materials. VAT is refunded from exported goods.
Central Sales Tax (CST)	4% for inter-provincial goods sales
Excise Duty	8%, 16% and 24% depending on manufactured goods
Service Tax	12% for any services. In railway services, rail container service is taxable but the regulated freight tariff is free from service tax.
Customs Duty	0%, 5%, 10% and 12.5% depending on imported goods
Company Tax	30% for domestic and 40% for foreign companies

Source: Japan External Trade Organization (JETRO)

13.4 ECONOMIC IMPACT (MULTIPLIER EFFECT) ANALYSIS

(1) Theoretical Framework

In the case of any infrastructure project, when a project starts, an implementing body hires workers, procure goods, buy external services and make contracts with construction companies and others. Those investments are regarded as initial final demand or direct impact. In real economies, however, the direct demand will induce further demand or first direct impact. And output or production requirements occurring from the first indirect impact will induce further demand. It is like endless and inter-relational economic transactions. To make it simple, the linkage is illustrated as follows:

From (Investment) – (Direct Impact) – (Production) – (Income) – (Consumption) – (Production) to further economic linkage

In the process, employment, tax income and external trade will be also generated and intensified. Therefore it is an important viewpoint to quantify economic impact to be brought by a large-scale project like the DFC Project.

We can measure these economic impacts or multiplier effect by use of the Endogenous Household Consumption and Import Input Output Model or so-called the IO model. Figure 13.6 presents the conceptual flowchart of economic impact measurement based on the IO model.

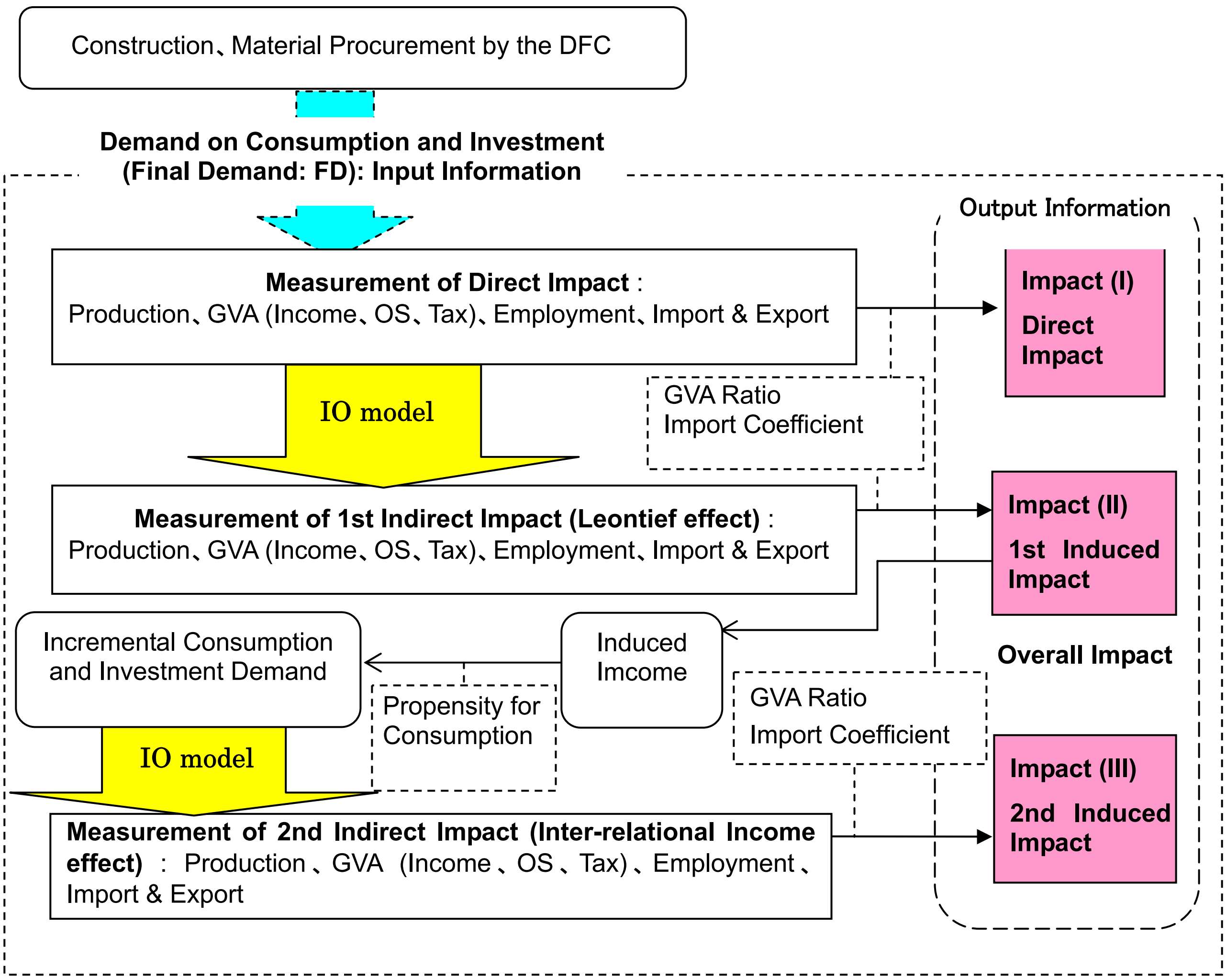


Figure 13.6 Concept of Overall Multiplier Effect

To undertake such exercise, a set of equations to be calculated are as follows:

Induced Impact on Production: $\mathbf{\Delta X = \Delta X_1 + \Delta X_2 = \hat{B}\hat{K}\left[I - \hat{M}\right]\Delta F}$ (1)

Induced Impact on GVA (Income, Tax, OS[Profit]):

$\mathbf{\Delta V = \Delta V_1 + \Delta V_2 = v\hat{B}\hat{K}\left[I - \hat{M}\right]\Delta F}$ (2)

Induced Impact on Employment: $\mathbf{\Delta L = \Delta L_1 + \Delta L_2 = l\hat{B}\hat{K}\left[I - \hat{M}\right]\Delta F}$ (3)

Induced Impact on Import: $\mathbf{\Delta M = \Delta M_1 + \Delta M_2 = \hat{M}\hat{B}\hat{K}\left[I - \hat{M}\right]\Delta F}$ (4)

Induced Impact on Export: $\mathbf{\Delta E = \Delta E_1 + \Delta E_2 = \hat{E}\hat{B}\hat{K}\left[I - \hat{M}\right]\Delta F}$ (5)

wherein;

$\hat{\mathbf{B}} = [\mathbf{I} - (\mathbf{I} - \mathbf{M})\mathbf{A}]^{-1}$ is Leontief Inverse Matrix (Macro Multiplier Matrix);
$\hat{\mathbf{K}} = [\mathbf{I} - (\mathbf{I} - \mathbf{M})\mathbf{CVB}]^{-1}$ is Keynesian Inverse Matrix or Inter relational Income Multiplier Matrix;
$\Delta\mathbf{F}$ is Vector of Final Demand;
$\Delta\mathbf{X}_1$, $\Delta\mathbf{L}_1$, $\Delta\mathbf{V}_1$, $\Delta\mathbf{M}_1$, $\Delta\mathbf{E}_1$ are Vectors of Induced Impact[Direct and 1st indirect spillover effect];
$\Delta\mathbf{X}_2$, $\Delta\mathbf{V}_2$, $\Delta\mathbf{L}_2$, $\Delta\mathbf{M}_2$, $\Delta\mathbf{E}_2$ Induced Impact (2nd indirect induced impact);
$\hat{\mathbf{M}}$, $\hat{\mathbf{E}}$ are Coefficient Matrix of Import and Export;
$\mathbf{C}$ is Consumption Expenditure Ratio Matrix;
$\mathbf{v}$ is GVA Ratio Matrix; and
$\mathbf{l}$ is Labor Input Coefficient Matrix.

(2) Tentative Impact Measurement

Since it is popular in neither India nor the donor agencies, the economic impact of the DFC Project is tentatively measured based on the RITES pre-FS report with some assumptions. It is expected to measure again based on the final output of the project FS to confirm the magnitude of the project's economic impact during the construction period.

1) Preparatory Works

JICA Study Team collected and processed plenty of data for the IO Model calculation as shown in Table 13.3. Measurement assumptions are made as shown in Table 13.4.

2) Tentative Results

The calculation results show the following characteristics (refer to Tables 13.5 and 13.6):

Induced impact on production: The total output requirements induced by the DFC Project are amounted to Rps 618.3 billion. The impact amount is bigger than the project investment by 3.9 times and is equivalent to 2.1% of the 1998 total gross output in India.

Induced impact on gross value added (GVA): The total GVA requirements induced by the DFC Project are amounted to Rps 311.1 billion. The impact amount is bigger than the project investment by 1.9 times and is equivalent to 1.9% of the 1998 total gross output in India.

Induced impact on employment and income: It is part of the Project's spill over effect to the stakeholders. As results, the employment opportunities created by the DFC Project are amounted to 5.0 million which is equivalent to 1.3% of the total labor population. Meanwhile, the induced impact on household income is estimated at Rps 156.7 billion or equivalent to 2.9% of the total employees' income in India.

Induced impact on operating surplus: The DFC Project will create numerous business transactions and bring about reasonable profits or operating surplus among contracted firms directly and indirectly. The total sum of the induced impact on operating surplus is estimated at Rps 112.9 billion which accounts for 69% of the total DFC investment or equivalent to 1.3% of the national business surplus.

Induced impact on tax revenue: This exercise estimates tax revenue from the domestic business sector starting from the DFC Project investment. The result indicates Rps 13.4 billion or 8% of the DFC investment. It is equivalent to 2% of the national income revenue.

Overall contribution to national economic development: It is a summarized exercise to understand the overall impact of the DFC project to the national economy. The project could contribute to national economic growth by 0.37% annually during the 5-year construction period when it would be implemented in the economic conditions of the 1998-99 IO table. The DFC Project seems an effective means to stimulate the national economy because its investment is much effective than the national average, i.e., a high elasticity rate of 5.47 (the project's contribution to economic growth / average national investment contribution to economic growth).

Table 13.3 Collected and Processed Data

		Using Data source (×:Not Exist、●:Exist)					
		General Economic Indicators		Input Output Table (National IO table)		Employment Statistics(By Industry)	
		Collecting Data	**Processing data (Year 1998-99)**	Collecting Data (Year 1993-94, 1998-99)	**Processing data (Year 1998-99)**	Collecting Data	**Processing data (Year 1998-99)**
A. Items of Induced Impact	I.Production (Billion Rps)	×	×	●(115 Sectors)	**●(9 Sectors)**	×	×
	II.Gross Value Added (GVA; Billion Rps)	×	×	●(115 Sectors)	**●(9 Sectors)**	×	×
	(1)OPERATING SURPLUS(Firm's Profit)	×	×	×	**●(9 Sectors)**	×	×
	(2)Income(Compensation to Employees: CE)	×	×	×	**●(9 Sectors)**	×	×
	(3)Tax (Net Indirect Tax)	×	×	×	**●(9 Sectors)**	×	×
	(4) Others(Depreciation)	×	×	×	**●(9 Sectors)**	×	×
	III.Employment (Person)	×	×	×	**●(9 Sectors)**	×	**●(9 Sectors)**
	IV.Import, Export (Billion Rps)	×	×	●(115 Sectors)	**●(9 Sectors)**	×	×
B. Using Related Economic Indicators	IV.Consumption Propensity	×	●	×	×	×	×
	V.Component rate of Concumption Expenditur	×	×	×	×	×	×
	VI. GVA Rate (Total)	×	×	●(115 Sectors)	**●(9 Sectors)**	×	×
	(1) OPERATING SURPLUS(Firm's Profit)	×	×	×	**●(9 Sectors)**	×	×
	(2) Income(Compensation to Employees: CE	×	×	×	**●(9 Sectors)**	×	×
	(3) Tax (Net Indirect Tax)	×	×	×	**●(9 Sectors)**	×	×
	(4) Others GVA (DEPRECIATION)	×	×	×	**●(9 Sectors)**	×	×
	VII. Import, Export Coeffient	×	×	●(115 Sectors)	**●(9 Sectors)**	×	×
	VIII. Labor Input Coefficient (Person/Billion Rps)	×	×	●(115 Sectors)	×	●(8 Sectors)	**●(9 Sectors)**
	IX. Others						
	(1) GDP	●	×	×	×	●(18 Sectors)	**●(9 Sectors)**
	(2) GSDP	●	×	×	×	●(19 Sectors)	×
	(3) Number of Employment	●	**●(9 Sectors)**	×	×	×	**●(9 Sectors)**
	(4) Others	●	×	×	×	●	×
Source, Compiler		IndiaStat、CSO	**JICA Study Team**	Indiastat、CSO	**JICA Study Team**	Indiastat、CSO	**JICA Study Team**

Note 1) CSO: Central Statistics Organization

Note 2) IndiaStat is the authentic source for Indian statistics collected from the best sources for information and statistics on India. Within huge database of www.indiastat.com you can easily surf through half-a-million pages that contain socio-economic statistical data and useful information on India.

Note 3) JICA Study Team had technical discusstion with IO specialist in India and other 3rd Parties Countires. And they found characteristics of Indian IO table and made effort to revise IO table with statistical consistency.

Table 13.4 Tentative Assumptions

Item	Assumptions
1. Setting Input Information based on Achievement	1) Project Budgets:572.3BillionJPY 2) DFC Construction Terms: 5 Years 3) Allocation ratio of Investment by Industry: : Construction (409.5Billion JPY) and Manufacturing (162.8Billion JPY), respectively 4) Average Consumption Propensity:0.75 5) Exchange rate: 2.855(JPY/Rps, in 1998-99)
2.Classification of Impact's items	1) Economic Unit: Household, Firm, Government, 2) Geographic Scale: Nationwide 3) Others: partial external trade
3.Analytical Points	I. Comparison between Input Item and Output Item: 1) Comparison within Cost Item vs Economic Impact item 2) Measurement of Multiplier (Unit; Times or person/Billion Rps) 3) Measurement of DFC Investment's contribution to Economic Growth. II. Economic Indirect Impact is decomposed into "1st Induced Impact" and "2nd induced Impact". "2nd induced impact" is interpreted as "interregional Income effect".
4. Input and Output Information	(Input Information) 1) Demand of Consumption and investment [Final Demand] by DFC Project (Exogenous variable) 2) Demand of Consumption and investment by Induced Income (Output Information) 1) Nationwide: Induced Impact on Production, GVA 2) Industry: Induced Impact on Profit(Operating Surplus) 3) Household: Induced Impact on Income, Employment 4) Government: Induced Impact on Tax Revenue

Source: JICA Study Team

Table 13.5 Summary of Tentative Measurement Results

(Value)

(Unit: Rps billion)

			National Scale in 1998-99		Economic Impact			
			By Total Demand	By Domestic Investment	Direct Impact	1st Induced	2nd Induced	Total
Nationwide		Production	29,982.4	6,321.0	163.4	276.4	178.5	618.3
		GVA	16,657.7	2,949.9	68.3	135.7	107.0	311.0
Economic Unit	Government	Tax	676.5	176.4	3.2	7.2	3.0	13.4
	Firms	Operating Surplus	8,859.0	1,220.3	17.4	50.9	44.6	112.9
	Others	Depreciation	1,680.7	316.7	1.7	6.4	5.9	13.9
	Households	Income	5,441.6	1,236.5	43.2	63.8	49.7	156.7
		Employment	396.8*	5.5*	1.1*	2.5*	1.4*	5.0*

Note: * Million persons

(Share and Induced Coefficient)

			National Scale in 1998-99		Share (%)		Induced Coefficient (times)
			By Total Demand	By Domestic Investment	By Total Demand	By Domestic Investment	
Nationwide		Production	29,982.4	6,321.0	2.1	9.8	3.88
		GVA	16,657.7	2,949.9	1.9	10.5	1.90
Economic Unit	Government	676.5	176.4	176.4	2.0	7.6	0.08
	Firms	8,859.0	1,220.3	1,220.3	1.3	9.3	0.69
	Others	1,680.7	316.7	316.7	0.8	4.4	0.08
	Households	5,441.6	1,236.5	1,236.5	2.9	12.7	0.95
		396.8	5.5	5.5	1.3	90.3	3,045.8**

Note: * Person / billion Rps
Source: JICA Study Team

Table 13.6 Estimated Contribution of the DFC Project to National Economy (Tentative)

Item of Economic Indicators	National Scale in 1998 - 1999	By DFC Project (In Construction Terms, Annual Average)
A. GDP (Billion Rps)	16657.7	-
B. Annual Difference of GDP (Billion Rps)	1265.2	62.2
C. Economic Growth Rate (%)	7.60	0.37
D. Contribution of Economic Growth (%)	100.0	4.9
E. Annual Domestic Investment (Billion Rps)	3635.2	32.7
F. Share of Domestic Investment (%)	100.00	0.90
G. Elasitisity of D and F (E/F)	-	5.47

Source: JICA Study Team

CHAPTER 14 THE WAY FOREWARD

14.1 RECOMMENDATIONS

It is safe to say that the engineering study team should make further investigation on the DFC alternative rather than other two alternatives in the consequent study activities in Task 2. In the case that the two corridors cannot be developed at the same time, GAM finally suggested the West corridor should be developed first.

In the following sections, suggestions by the intermodal research group are summarized for further study.

14.1.1 Demand Forecast

It is safe to say that the freight demand forecasting work and its result, studied by the intermodal research group, can provide a practical guidance for justification of DFC project. It also provides the essential ideas in selecting one of the alternatives. However, the model still needs to be upgraded for further detailed study.

(1) Issues to be addressed

Some of the limitation in the preliminary demand forecasting work by the intermodal research unit should be noted.

First and foremost, as the demand forecast model, studied in this chapter, is based on state-wise analysis, it cannot provide the detailed information on the commodity flow, e.g., Station-to-station OD, which cannot allow the operation planner to study the optimal operation plan of DFC project.

Secondly, as the decent forecasting result requires reliable and up-to-date data, some of the freight information analyzed in this study are outdated, especially that on the freight surveys in 1987 and 1997.

Thirdly and lastly, justification of port selection of the container cargos should be examined, since container traffic production/attraction was estimated under no-capacity-constraint assumption.

The modal split model in this Study also has some limitations: For instance, the model encompass the level of service of the line-hole transport but limits to include the service level of the access/egress (e.g., the travel time from ICD to consignee).

(2) Necessary improvements

Accordingly, the implications for Task 2 Study, we suggest, are noted below:

- Freight demand forecasting analysis in the next phase should focus on more detailed OD, such as Division-to-Division OD or Station-to-Station which can allow engineers to do the more detailed engineering study.

- In Task 2 Study, data updating will be required. One of the essential information can be obtained from the Total Transport Systems Study, of which the survey is now being carried out by the Planning Commission, GOI.

- The port and ICD development plans, including conceptual plans, in India should be carefully reviewed and the capacity, which determines the container throughput at each port/ICD, should be studied in view of both efficiency and physical capacity improvements (e.g., efficiency improvement in loading and unloading cargo and the expansion of container berth).

- The modal split model should be reviewed by obtaining sufficient amount of traffic information, including the level of service of line-hole transport and access/egress. To be specific, the supplemental freight survey, which interviews the port/ICD operators and transporters, should be taken into account in order to obtain the sufficient LOS data of the access/egress transport.

- Regarding bulk cargos, there seems no chance to transfer such cargo like coal and ore, from rail transport to road transport, because the origin (production) and destination (consumption) of those commodities is rigid usually connected by rail, while road transport can be more competitive when transporting food-grain. In that sence, the establishment of modal split model should be carefully examined in Task 2 Study.

14.1.2 Project Evaluation

The intermodal study unit has suggested a step-wise evaluation procedure as follows:

① Preliminary evaluation to select a preferred project scheme from the three alternatives;

② Precise project evaluation at a feasibility study (FS) level of detail, with more accurate information produced by the engineering study; and

③ Detailed project evaluation to investigate the project implementation scheme including funding structure, financing scheme, project implementation schedule. The risk analysis should also be performed in this stage.

At the same time it should be noted that the evaluation should be performed for two different sets of the project components, namely, the rail segment itself and the freight transportation system of the entire corridor from the ports to final destination as indicated in Figure 14.1.

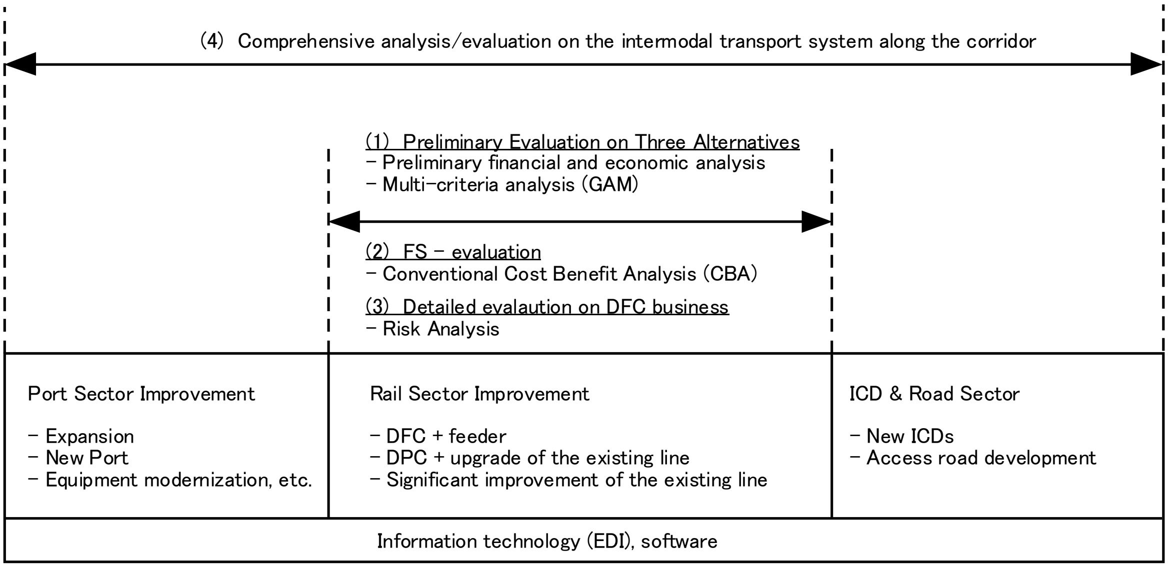


Figure 14.1 Objectives of the Project Evaluation

The preliminary project evaluation has been already carried out by the intermodal study unit as explained in this report. The engineering study team is expected to do the following two evaluation/analysis, namely, (2) Detailed project evaluation (conventional CBA analysis with accurate information) and (3) Detailed project analysis on the DFC business to find a better project implementation scheme in term of business structure and financing. In addition to the analysis on the rail segment, a comprehensive evaluation on the whole intermodal system including associated development of ports, ICDs, and access roads should also be performed to insure the overall benefit of the intermodal development project including DFC.

GAM was especially effective in comparing alternatives of different development concepts at the initial evaluation stage.

In order to see the impacts of some uncertainties in the development of DFC, the Risk Analysis must be effective. One of the most influential factors to the project is demand forecast, accordingly the engineering study team should prepare different scenarios in demand forecast for sensitivity tests in the risk analysis. The Risk analysis is also effective for further study on the project implementation scheme by changing several financial factors such as interest rates and revenue.

In addition to the impacts during operation, it is suggested to estimate the impacts of DFC during its construction (multiplier effect). Considering the scale of investment to the DFC, its impact to the macro economy cannot be ignored.

The idea of the benefit generated by the DFC project is shown in Figure 14.2. As the DFC provides additional cargo carrying capacity, associated facilities such as ports, ICDs and roads should be improved in an integrated manner. The benefit would be observed in two terms, namely, time & cost saving and the capacity expansion.

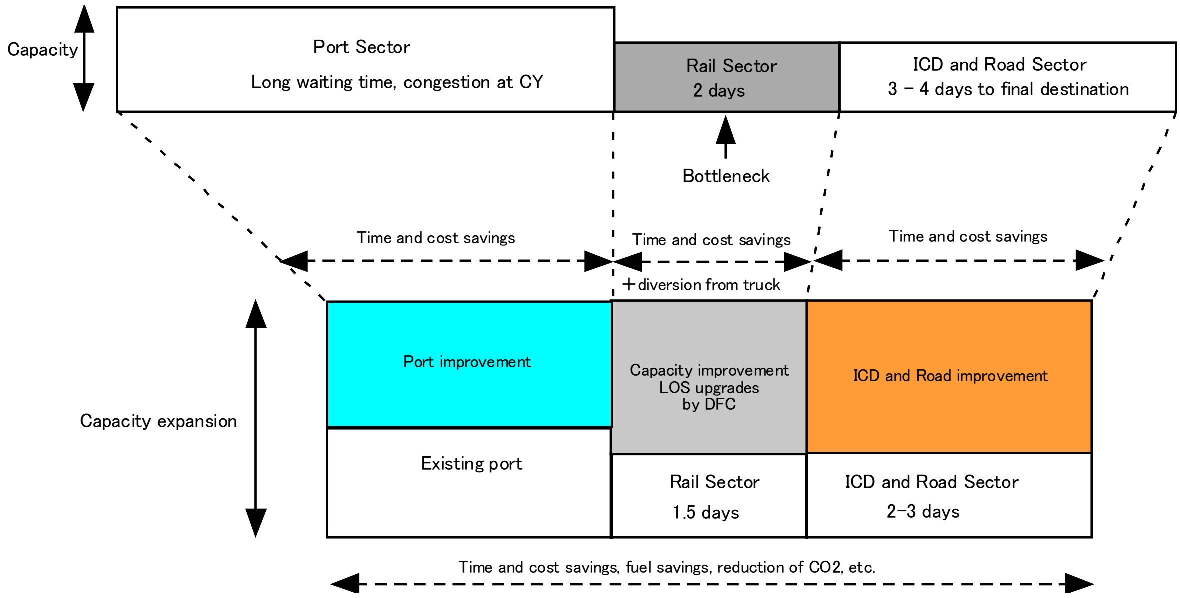


Figure 14.2 Benefit of the DFC Project

14.1.3 Intermodal Development

The trunk transport systems such as inter-state highways, and the Dedicated Freight Corridor Project are in progress. In addition, some important improvements at major intermodal points such as port improvement in Mumbai area, new port development in Gujarat state, and IDC development projects by private sectors in Delhi metropolitan area are to be made in near future. However, some minor but very necessary improvement such as access road to ICDs and arterial road network development in the urbanized areas is far below the expectation to develop effective freight transport services. Intensive use of information and communication technology in the field of freight transport business is also rapidly developing through the private sector’s participation. In light of this situation, it is highly recommended to study city planning, arterial road development plans and industrial estate development plan of each state along the DFC corridor, and to review more detailed design of the DFC, such as the location of the stations along the DFC.

Regarding the intermodal transport technology, mainly the cases practiced in Europe were introduced and compared to those in India, suggesting the intermodal development policy. Further case study should be made with special attention to Japanese technologies, including that are developed by JR and are expected to contribute to the intermodal development in India.