Chapter 6

COMMODITY- INTERDEPENDENCE IN RAILWAY FREIGHT OPERATIONS

6.1 Commodity-Freight Trends on IR

The importance of railways within the infrastructure for freight transportation in India derives largely from the regional spread of resource locations and industrial and agricultural production patterns across the country, and from the particular stress laid over successive FYPs on raising the production of such vital commodities as foodgrains, coal, POL, cement, fertilisers, steel, etc., all of which require bulk-freightage for their distribution across the country. Although in proportionate terms, the overall railway share in freight traffic has declined steadily over the planning period with corresponding expansion in road operations, the physical volume of freight conveyed by IR has witnessed manifold increase since 1950-51, both in terms of originating tonnages and tonne-kilometres traversed. However as noted earlier, the fact that average leads of such traffic have also increased significantly from just 458km in 1947 to well over 700km through most of the 1980s and 1990s also reflects IR's growing specialisation in the handling of longhaul movements in bulk-freight. In consequence, railway freight traffic has almost invariably presented larger increases in tonne-km terms, than in terms of originating tonnages, implying that while tonnage traffic has risen steadily, the same tonnages today are being carried over significantly longer distances than they were in the past.

It is fairly obvious that where such trends exist, underlying adaptations will also have occurred in the freight-mix transported by IR, and that it will be these changes, in fact, which determine the overall character of changes in average traffic leads. It will therefore be the purpose of this chapter to examine freight traffic trends on IR at a disaggregated level, by analysing their gauge and commodity composition as these have evolved over the planning era. Special attention will also be devoted to the phenomenon of railway freight cyclicity, which has been peculiarly characteristic of IR freight performance over the planning era. The root of these phenomena, as earlier mentioned, lies in changes in gaugewise freight capacity arising from increasing specialisation within the IR wagonfleet, which has been the principal reason why IR has been able to sustain its presence in the BG bulk-freight commodity segment of the Indian freight market, while being gradually displaced from the general freight segments once catered to by combined trunk and feeder operations on the BG and MG freight network.

6.1.1 Evolution of the IR Freight-Mix over the Plans

Integrated planning of freight transportation in accordance with national development priorities and industrialisation programmes commenced during the 1FYP and sustained its momentum through the 2FYP and 3FYP. As far as the overall relevance of IR to national planning was concerned, the period thus marked the definitive beginning of a new era for railways in India. Hitherto, the operations of the railways had been organised around small zonal companies whose freight volumes and traffic composition were determined more by commercial considerations than by social obligations, in the sense that they catered to all traffic forthcoming at commercial rates irrespective of its commodity-character, and entered into open competition for the same. The first departure from prior practice was signalled by the nationalisation of railway companies, which ensured common objectives for railway operations. The second departure, following from the institution of planning in India, ensured a longterm character for these objectives dovetailed within the overall frame of national development perspectives. Although a phase of heavy capital expenditure was entailed by these transformed priorities, the nature of transportation planning uptil the 3FYP postulated freight capacity expansions at levels capable of handling the downstream traffic expected to materialise from core-sector investment under the FYPs. Integration of freight capacity with anticipated economic development was achieved at two points: firstly, the projected capacity had to be sufficient to handle the immediate transportation requirements of bulk raw materials and bulk finished products from heavy industries such as iron & steel, etc., while secondly, freight-adequacy had to be maintained for the transportation of future commodity streams that would be generated by the supply of core inputs to general industry. Because of the nature of the economic transformation being contemplated in the FYPs, freight-adequacy on IR especially required that freight capacity be projected around a steadily increasing proportion of bulk materials in the railway freight-mix. This transportation scenario held as long as targets were achieved, and was therefore more or less representative of the first planning decade.

From the 1960s, the first aberrations appeared when the freight streams generated by the core sector of the economy proved too limited to match the 3FYP freight targets. Whether this situation resulted from the miscalculation of freight trends, or followed plan failures in the core sector would warrant deeper discussion. It needs to be remembered that where the 2FYP created vast material transportation requirements for construction of core steel-sector projects like the ISPs at Durgapur and Rourkela, as also for several giant power and irrigation projects like those at the Damodar Valley Corporation [DVC], Bhakra-Nangal, Tungabhadra, Hirakud, Rihand,[1] and so on, freight targets for the 3FYP anticipated that downstream production flows would emanate from the heavy industry that had been created over the previous plans. As a result, freight failure during the 3FYP appears to have sprung up mainly from nonmaterialisation of downstream bulk traffic in the anticipated quantities, because of the combination of foreign exchange difficulties, construction delays, and cost overruns in the heavy industry projects initiated by the 2FYP.[2] Further evidence of this is also obtained from comparison of average IR freight leads over the first three plans. While these rose over the 1950s from 513km in 1950-51 to 604km by 1960-61, the next four years of the 3FYP saw average freight leads hovering at just around or under 600km, even as tonnages and traffic-km steadily climbed.*[see ch3, Table 3.3]* This would indicate that tonnage increases during the 3FYP came mainly from the low-bulk and short-lead categories of traffic, while heavy industry and mining failed to provide IR with the levels of bulk traffic anticipated by planners. Another factor behind the lowering of traffic leads was the circumstantial need that arose to freight greater quantities of imported foodgrains to tide over the succession of indifferent harvests that occurred during the period, causing the growth rates of foodgrain production in India to fall well behind the growth rate of population.[3] Although such unanticipated freight demands may well have led to volumetric increase in the freight transported by IR, they would also have displaced other categories of bulk freight, accounting for the failure of IR to achieve 3FYP tonnage targets.

The 3FYP period thus showed that certain vulnerabilities in the Indian transportation network still persisted despite the Planning Commission having made its first essay at national transport coordination through the Committee on Transport Policy and Coordination [CTPC] constituted in 1959. The purpose behind the CTPC report, submission of which coincided with the aborted start of the 4FYP in 1965-66,[4] had evidently been to project the transportation requirements of the plans more accurately, which depended in turn on compilation of accurate databases of economic and statistical indicators which would permit short-term adjustments in freight supply and demand to be made within the intermodal structure of the Indian transportation system. For such flexibility to be practicable, longrun projections of intermodal freight demand were formulated uptil 1975-76, and the anticipated freighting capacity required in each transportation mode was projected for each planning phase to keep pace with the anticipated growth of freight demand in the economy arising from continuous and cumulative development. Slow rates of growth however continued to persist in the economy, along with agricultural uncertainty, through the subsequent Annual Plan period - particularly in core sectors like coal and steel. These in fact derailed the immediate development planning exercise, while also restricting the freight tonnages available to IR. Traffic uncertainties prevailed until the reversal of the agricultural downtrend by the exceptionally good harvest of 1967-68, which also restored buoyancy to the economy permitting resumption of the 4FYP exercise. An uptrend in IR freight was accordingly anticipated and did materialise to an extent that surpassed planners' expectations, leading to launching of the refurbished 4FYP in exceptionally favourable circumstances. IR freight expectations had in fact already been reversed by the recovery in bulk categories of traffic in 1967-68, which raised average freight leads for the first time in six years to the new high of 623km. Optimism on this count caused IR to scale up traffic estimates and revise rolling-stock acquisitions upward to 16,000 wagons, against earlier assessment of the requirement at 10,000 wagons,[5] and also sharply increased IR capital allocations towards route electrification and modernisation of signalling and telecom equipment with the purpose of improving freight transit times substantially.

Despite this buoyancy all around, the 4FYP was soon assailed by prewar and wartime uncertainties aroused by the Bangladesh crisis,[6] and was then completely dislocated in 1973-74 by heavy cost cascades induced by the first Oil Shock, that necessitated all-embracing reformulation of freight economics across the world as well as in India. As earlier noted, this 'plateau' period was undistinguished by any major gain in IR freight tonnages, although average freight leads rose to 699km even as tonnages oscillated wildly till the conclusion of the plan. In terms of the freight-mix handled by IR, such a mixture of trends would reflect retention of traffic share in bulk freight, which could not be transported in any case by means other than the railways, and alternating swings in IR realisations of low-bulk freight. Because economic uncertainty and high rates of inflation also characterised this period, freight downswings in low-bulk traffic reflected indifferent production trends in the originating industries more than any shift of these traffic categories to the roadways.

Another infrastructural characteristic of the economic crisis induced by the first Oil Shock related specifically to the carriage of coal freight by IR. In India as in the UK, both of which till then had no major identified petroleum reserves, the crushing economic pressures caused by the rise in world oil prices induced a wave of oil-replacement technology giving a new lease of life to the coal mining sector, as well as providing a fillip to offshore petroleum exploration which led eventually to the location of significant petroleum reserves in the North Sea (UK) and Bombay High (India). Raisings of coal in India thus rose from only 55.2MT in 1960-61 and 76.3MT in 1970-71 to 263.46MT in 1996-97.[7] Because of the urgent need to develop short-run power capacity in India without making recourse to oil-fired technology, the policy stress veered towards thermal alternatives which demanded that vast quantities of coal be freighted by IR. On the other hand, the slow augmentation of freighting capacity in the 1960s had left IR with very little capacity-margin to handle this suddenly manifested traffic demand. While the high priority accorded to coal transportation from mining pitheads to thermal power plants resulted ultimately in the displacement of other traffic categories from IR because of consequent wagon shortages, availability of wagons during the 4FYP was still not adequate to maintain power generation at desired levels. A vicious circle accordingly ensued, with IR being unable to transport required quantities of coal to maintain power generation, power supply being consequently inadequate to maintain fast electric railway traction, and the inability of IR to transport electrified coal-rakes aggravating the overall shortage of coal at the power plants. Subsidiary impacts also followed from the substitution of electrified rakes by diesel traction which substantially raised IR fuel costs, and from power disruptions that badly affected industrial production across the Indian economy. The ultimate consequence of the revised fuel economics following the first oil shock was the raising of freight tariffs by IR, the sharper increase in tariff rates for non-subsidised low-bulk freight encouraging its subsequent migration to other modes of transport. It becomes quite obvious from the foregoing analysis that the seeds of the eventual IR freight policy turnaround towards the carriage of bulk freight and the specialisation of IR freightage capacity towards this task had already been sown by the end of the 4FYP, even though actual policy reformulation occurred at the beginning of the 1980s.

The 5FYP accordingly directed that IR improve its bulk handling capabilities and the railways consequently allocated a much higher percentage of plan funds towards this end, spending mainly on the acquisition of modernised wagons and traction. Allocations on rolling-stock also jumped sharply in absolute terms from Rs.587.47 crore to Rs.782.28 crore between 4FYP and 5FYP, the changed freight-mix with a higher component of bulk freight providing some indication of the degree to which IR capacity adaptation had occurred over the 1970s. Several additional hurdles to freight efficiency had however been counterposed by modernisation of IR signalling and communication equipment during the 4FYP under the CTPC recommendations, in the absence of adequate and supportive handling facilities for its optimum utilisation. Elaborating on these inadequacies, the Draft 5FYP document listed loading and unloading difficulties that created impediments to the movement of block-rakes and unduly detained railway wagons at freight terminals; marshalling difficulties that arose from the incompatibility of coupling arrangements between upgraded and traditional IR wagons; periodic power shortages; as well as the physical scarcity of covered wagons which were essential to the movement of foodgrains, fertilisers, cement and other general freight categories. Along with rising railway costs and shifts in traffic patterns, these were held collectively responsible for the slow growth manifested by IR traffic and freight revenues in the immediately preceding period.[8]

The submission of the NTPC report on integrated transportation for India coincided with the launching of the 6FYP. Acknowledging the content of the report, the 6FYP conceded that it would be difficult to precisely match the growth of transportation services with growing transportation demand in the economy, and accordingly endorsed the funneling of infrastructural investment into the transportation sector in large indivisible units that would prevent the recurrence of transportation bottlenecks which had plagued economic performance over the 4FYP and 6FYP.[9] It was noted that these bottlenecks had occurred because insufficient resilience existed on the IR system to cope with sudden and unforeseen freight fluctuations and alterations of traffic patterns. Besides the physical enhancement of IR's freight capacity, the 6FYP thus laid new emphasis on improving railway productivity through better utilisation of IR assets, recommending operational modernisation through the running of heavier and more efficient freight operations with a focus on traffic containerisation and the running of full trainloads.[10] The 6FYP projected an increase of over 40 percent in IR tonnage traffic over the plan, after taking account of changes in traffic leads that would accrue from the relocation of major thermal power projects to mining pitheads as well as the changing regional patterns of production. Since more than four-fifths of this tonnage increase was anticipated to come from core traffic segments such as coal, cement, iron ore and iron & steel, this meant that IR would have to continue to meet the specialised freighting needs of the core economic sectors. Hence, while it was also deemed desirable that IR develop adequate general freight capacity to cover all medium and long-haul freight segments in a longterm perspective, the constraints being experienced in traffic acquisition and plan finance led to the recommendation that piecemeal or 'smalls' traffic in the medium and short-distance segments be left to the roadways sector as an interim measure.[11] A need for greater intermodal coordination was stressed, so that the available IR wagonfleet could be utilised preferentially for the haulage of long-lead freight traffic. In view of this exigency, the 6FYP allowed the deregulation of roadways through liberalisation of the national permit system for roadways freight operators.

Against targeted levels of 5-6 percent p.a, IR freight operations grew by 3.1 percent p.a. in tonnage terms and 3 percent p.a. over the 6FYP period. Seven bulk commodities, namely coal, iron & steel, iron ore exports, foodgrains, POL, cement and fertilisers were found to contribute 80 percent of IR's total originating traffic and 75 percent of total IR freight traffic. Noting that two-thirds of IR freight traffic and half of IR passenger traffic was now being moved along the corridors which connected the 'golden quadrilateral', the 7FYP attributed the growing congestion of IR's HDC routes to longterm alterations in the spatial distribution of economic activity and in the patterns of freight movement.[12] For the spatial rebalancing of IR operations, more importance was accorded by the 7FYP to the development of alternative routes than to addition of freighting capacity to saturated IR routes. On routes other than these, a more cautious approach was suggested, which included the optimisation of freight operations on the IR's long-neglected MG network. In part, this reflected the NTPC's adverse observations on IR's expensive programme of gauge conversions.[13] Grave note was also taken of the growing backlog in the replacement of obsolete and overaged IR assets because of the diversion of physical and financial resources to new IR projects. Observing that railway transportation capacity had frequently lagged behind desired levels of adequacy because of past underinvestment on the IR network, and had led to repression of freight demands in the economy, the 7FYP review pointed out pertinently that nearly half of the IR plan outlay was absorbed in the maintenance of capacity on the system rather than in capacity enhancement, leading to correspondingly high capital needs.[14] In view of the long life of railway assets, increased emphasis was accordingly laid on technological modernisation of the railway infrastructure during the phased process of asset replacement. In physical terms, the 7FYP anticipated an increase of 91MT in IR tonnage freight, against which increased freight realisation over the plan amounted to 70MT in 1989-90.[15] The shortfall was mainly because of short offer of bulk commodities like coal, foodgrains and iron & steel, which could not be adequately made up by reassignment of IR freighting capacity to other commodity freight. It was thus observed that hardly any slack existed on the IR system because of the location-specific nature of railway assets, and that IR plans would have to adopt a systems approach under which freight capacity expansion would have to focus on the development of alternate routes and new traffic regions so as to reduce the overall transport coefficients of the Indian economy.[16]

6.1.2 IR Traffic Performance in the Post-Reform Period

As observed in more recent reviews, railway planning in India has also been severely constrained by the lack of a coherent policy on multimodal transportation. Although certain manifestations of the current crisis, which are visible in the overcrowding of passenger services and congestion pressure on the HDCs from rising volumes of freight traffic have been frequent subjects of comment, the existence of corresponding slack in other parts of the IR network in terms of poorly utilised track, rolling stock, personnel and other physical forms of IR infrastructure has been less noticed. However, hidden slacks of this genre are particularly in the context of IR's fading presence in the general freight market, since vide the Railway Budget in 1997-

98, IR freight revenues contribute Rs.19822 crore or over 70 percent of IR gross revenue earnings of Rs.27855 crores.[17]

Traffic growth in IR's freight operations over the 8FYP was projected at 5 percent p.a, against the annual growth rate of 5.6 percent projected for the national economy over this duration. However, during the period between 1991-94 which coincided with the introduction of structural reforms in the Indian economy, revenue-earning freight tonnages stagnated between 350MT to 358MT, until increased agricultural and industrial production stimulated them to reach the level of 410MT of originating freight in 1996-97, relatively close to the original 8FYP projection of 418.4MT. Commencing in 1997-98, the 9FYP projected this to rise at the rate of 5 percent p.a. to the level of 525MT by the end of the plan.[18] Recurring anomalies in such FYP projections of anticipated IR freight traffic are attributable to the lack of reliable projective data on railway freight offers. Subsequent inadequacies in freight demand frequently put IR freight revenues under severe stress and create pressure for the escalations of IR tariffs in order to make up the revenue shortfall and to finance the internal resource demands of the plans. In the long term, such tariff escalations have served to drive more freight traffic away from IR Thus the steep hike in railway rates and fares in the Railway Budget for 1992-93, which was admittedly the result of the mismatch between IR freight revenue targets and realisations, was also responsible for the subsequent non-realisation of the freight levels targeted by the 8FYP.

In 1980, at the time of commencement of the 6FYP, the NTPC had projected an ultimate modal split of 72:28 in long-distance freight traffic between IR and the roadways at the turn of the century. Subsequent freight performance by IR has not matched these expectations, and the 9FYP review was compelled to acknowledge that the modal share of IR in total freight movements had undergone substantial decline over the planning era, dwindling from 89 percent in 1951 to only 40 percent in 1995. Despite the more energy-efficient and environment-friendly transportation alternative provided to the country by the railways, this freight leeway has been compensated by unplanned expansions in the roadways sector, particularly after deregulation of the roadways and the rapid erosion of IR's erstwhile freight monopolies. Entry of the roadways into the contested freight segments has involved spiralling energy costs as well as rapid increase in atmospherical pollution. The system of administered prices for POL products, particularly for diesel, has contributed until recently to the mushrooming growth of this sector, driven also by the same easy lease-financing market that has increased the demand for the automobile in India.

6.1.3 The Emergence of Intermodal Competition

Apart from the factors just reviewed which have affected freight performance by IR, it is also of critical consequence that the nascent roadways sector in India was able to draw a considerable volume of non-bulk freight away from IR over the planning period, reducing thereby the overall IR share in total freight traffic. The outline of roadways development in India at the commencement of this study had noted that the phenomenal rise in the number of roadfreight vehicles from 82 thousand to 1.61 million between 1950-51 and 1991-92 was accompanied by near-quintupling of the road network within four decades from the institution of planning. While the contribution made by the FYPs towards this growth was limited almost entirely to construction of 1.9 million km of trunk and feeder roads, institutional sharing of the vehicular costs of roadways development through liberal lease-financing of vehicle acquisition led to gradual emergence of the private sector as a major operator on the Indian freight market. Although a large part of the resultant growth in roadfreight capacity was absorbed by the new production streams generated within the economy, it was inevitable that a point would be reached after which the two transportation modes came into serious competition with each other. Such a point appears to have occurred within the second planning decade. Thus over eight years following the 3FYP, the traffic volumes carried by roadfreight had almost doubled from 34 billion tonne-km in 1965-66 to around 65 billion tonne-km in 1973-74. Further corroboration of freight competition is offered by the tonnage trends of revenue-earning IR traffic. Thus while originating tonnages in eight bulk commodities, namely coal, iron & steel, mineral ores, stones, cement, fertilisers, foodgrains and POL, rose from 124.7MT in 1965-66 to 136.4MT in 1971-72, non-bulk tonnages were bid away from IR by the roadways over the period and physically declined from 37.3MT to 33.7MT.[19] The process of traffic polarisation was further accelerated by technological specialisation within IR, as a result of which bulk tonnages climbed to 350.9MT or 96.2 percent of total IR tonnages in 1994-95 against the decline of non-bulk tonnages to just 14.2MT or 3.8 percent. [*cf. ch3, Table 3.4*] The extent of polarisation is made clear by comparing traffic situations across time. While downstream development within the Indian economy has led to expanded production of non-bulk commodities, most of this traffic has been handed over to the roadways sector. Despite offering a competitive rate structure, physical tonnages of non-bulk freight on IR have dropped by over 23MT between the end of the 3FYP and the commencement of the 9FYP. As non-bulk freight also constitutes the most profitable freight segment, the financial gains from traffic specialisation by IR have accrued entirely to the roadways as IR has gradually withdrawn from the competition.

With the narrowing of IR freight services, they have become increasingly tied to the transportation needs of the eight bulk commodities listed above. The share of these commodities in revenue-earning freight tonnages had risen from 58 percent in 1950-51 to over 91 percent in 1989-90. Some commodities - particularly coal, cement, steel and POL - have also traditionally figured as a backward linkage in the non-revenue freight carried by railways by virtue of their being railway important inputs. However, the proportion of non-revenue tonnages in total IR originating freight had already fallen from the high level of 21 percent in 1950-51 to 13.5 percent in 1971-72, mainly because of the lowering of IR coal demands resulting from gradual phasing out of steam traction. It was anticipated during the 4FYP that non-revenue tonnages could be further reduced by the electrification and dieselisation of IR routes during subsequent plans, thus reducing the need for transporting coal to meet the internal demands of traction. Nevertheless, two-thirds of actual non-revenue originating tonnages and nearly 90 percent of non-revenue traffic through the 1970s still comprised coal for traction purposes. Incidentally, coal also accounted for a third of total (*revenue* plus *non-revenue*) freight traffic carried by IR both in terms of originating tonnages as well as tonne-km traffic.[20]

6.1.4 IR Response to Freight Competition

Non-bulk tonnages have invariably registered slower growth rates on IR, their overall physical increase between 1FYP and 4FYP (1971-72) being a mere 3.1MT. Their proportionate share in IR's revenue-earning freight declined from 42 percent to 20 percent over this 20-year period, contributing to the dwindling of railway profits from this high-rated freight segment. Despite offering competitive rates, railway services in India are in any case not in a position to compete directly with the roadways on speed, safety, handling economy and reliability of the freight service extended to high-valued non-bulk traffic. Certain inherent railway freighting constraints arising from limited tracklength and route alignments, restricted availability of railway wagons, and the legal liability to lift all forms of traffic without showing undue preference towards given consignors or given freight consignments have also affected the magnitude of IR responses to intermodal competition. The Preferential Traffic Schedule adopted by IR in fact accords highest traffic priority to consignments belonging to government and to the defense services, as also to essential bulk commodities and strategic industrial raw materials of agricultural and mineral origin.[21] Constraints on IR transportation capacity have also emerged as a result of heavy concentration of freight traffic at a few selected terminals and along busy arterial routes of the so-called High Density Corridor [HDC] - some 10 percent of the freight terminals on the IR system already generating as much as 90 percent of originating freight by the late-1970s.[22]

Successive IR plans have attempted to surmount such constraints through progressive electrification and dieselisation of routes and other technological measures aimed towards increasing the efficiency of utilisation of railway track, wagons and traction, although even technology has failed to offer easy solutions to the problem of recovering freight share for the railways. Since the 1980s however, IR has also occasionally opted for piecemeal measures aimed at recovery of high-rated non-bulk traffic. The strategies so far included in this effort have been the development of a freight-marketing and sales organisation, special running of fast and superfast goods rakes, and consolidation of small parcel loads or traffic smalls into more economic wagonloads and trainloads through introduction of container services by its corporate subsidiary CONCOR [Container Corporation of India] and by the 'freight forwarders' scheme which allows third-party consolidation and consignment of freight to selected IR terminals. Other competitive measures include the adoption of special station-to-station rates for particular freight classes, along with more regularised commitment of wagons in adequate numbers and augmentation of terminal facilities, etc. While no physical recovery of traffic share from the roadways appears to have resulted, initiatives like these at least partially arrested further erosion of traffic share in the profitable categories. The resumed outflow of non-bulk freight to other transportation modes during and after the 6FYP are therefore as much the result of tariff pressures as of traffic constraints.

In sum, the evolution of freight operations in India after the institution of development planning provides strong evidence of polarisation of IR freight services towards the freighting needs of a selected group of bulk commodities. It may be wondered whether this polarisation has been achieved accidentally or through planning intent. Although railway tonnage-tariffs in bulk categories tend to be much lower than other tariff rates, the share of these selected bulk commodities in revenue-earning originating tonnages has increased from 58 percent to nearly 90 percent over the planning period. In spite of traffic polarisation, IR has constantly opted for technological strategies that attract more traffic in bulk categories. Through such means it has consolidated its monopolistic grip over captive traffic, while forcing other freight to leave the railways.

6.2 IR Wagon-loading Trends

The freight flows of an economy are a spatial manifestation of the resource allocation process. Limitations and constraints in the growth of these flows and their directional balance are indicative of the health of the economy which requires these transportation services. Hence freight flow data subsume the sectoral linkages and bottlenecks of an economy. Longitudinal data of credible length are available for wagon loadings of some of IR's freight commodities, which can be utilised to explore the underlying intersectoral relationships. These are presented below in Tables 6.1*a* and 6.2*a*. It may be noted that the wagon-loading series include both originating and transhipment loadings of commodities over the entire IR system. Thus a number of factors that influence the character of railway freight operations are implicitly present in the data. *Ceteris paribus*, the increasing average freight leads observed for most IR freight commodities would imply that the same originating consignments are being carried for progressively longer freighting distances in terms of tonne-kilometres. Transhipment loadings would undergo a decline in such a context. However transhipment loadings on IR are also a relic of the dual gauge system that exists on Indian railways. Where commodity leads are large and the concerned commodity has an all-India distributional character, transhipment of the commodity consignment is often necessary for to reach it to regions not covered by the BG network. Another characteristic implicit within the wagon loading dataset captures the freight impact of the gradual phase-out of MG operations and gauge conversion by IR. Extension of the BG network reduces the need for transhipment and extends commodity leads because of the uninterrupted flow paths offered to long-haul traffic. On the other hand, the crowding of railway freight services by long-haul traffic displaces the short-haul commodity flows that were the mainstay of MG feeder services from the extended network

6.2.1 Commodity-loading Trends: *A Visual Preview*

Because of the consolidated character of data available, the BG and MG wagon loading datasets for IR reproduced in the tables have a certain degree of overlap because of the unavoidable inclusion of freight transhipments along with loadings of originating freight for both IR gauges. Although transhipments may also occur in small measure within a single gauge network, particularly for parcel categories of traffic, the major part of transhipment loadings on IR conducted at notified break-of-gauge points and are inter-gauge in nature because of distinctness between the respective transport domains of the BG and MG networks. Transhipment as such can occur from BG to MG or vice-versa as the need arises. However with rising BG leads and the secular decline of MG operations over the planning period, it is mainly in the latter direction that transhipment still takes place. The volume of freight transhipment in 1991-92 thus amounted to only 5.6 percent of total originating freight, nearly two-thirds of which was transhipped from MG to BG.[23] It may be noted contextually that the gross tonnage-terms in which many of IR's targets and performance statistics are presented also subsume freight transhipment since they include freight loadings at break-of-gauge points as originating tonnage.[24] Overall, however, intergauge transhipments on IR have declined in volume over the 35-year period of study because of factors like bulk-freight specialisation and expanding traffic leads, and because of the extent of gauge-conversion that has occurred over the FYPs to bring efficiency to long-haul freight operations. Another equally contributory factor to the reduction of transhipment has been the rising proportion of upgraded and specialised wagons in the IR fleet, which has in fact reduced IR's capability to cater to heterogeneous commodity-freight. In general, wagon loadings in later periods reflect growing proportions of originating loadings vis-a-vis transhipments, and with increases over time in the average freight-capacity per wagon, unit wagon loadings in more recent periods also imply higher tonnage equivalents.

Table 6.1*a*: Railway Wagon Loadings of Commodities (1955-56 to 1988-89)
BROAD GAUGE ORIGINATING & TRANSHIPMENT LOADINGS
[Thousand wagons: 4-Wheeler Equivalents]

Year	GPulses	OSeeds	Tea	RCott	CottMf	RJute	JuteMf	SCane	Sugar	CCoke	MnOre	OMOre	IOre	ISteel	Cement	Total BG Loadings
1955-56	346.6	68.6	14.3	40.9	25.5	54.3	11.3	79.3	51.6	955.6	64.6	8.7	180.3	168.4	149.6	2219.6
1956-57	357.6	68.1	14.7	40.4	23.1	73.0	9.1	96.9	60.0	1021.6	78.5	16.6	195.4	187.7	160.1	2402.8
1957-58	418.2	66.1	12.1	37.5	20.9	73.6	8.7	84.3	64.2	1069.4	85.2	16.9	214.6	231.2	188.0	2590.9
1958-59	445.9	62.2	11.4	33.4	15.0	74.2	7.6	48.0	54.4	1187.9	47.5	10.6	237.9	248.8	176.5	2661.3
1959-60	468.9	62.2	13.5	31.0	15.0	74.5	8.2	61.9	53.9	1195.6	54.7	12.5	362.3	275.6	211.3	2901.1
1960-61	454.9	59.1	13.4	30.4	13.3	56.1	7.6	65.5	55.5	1336.8	57.7	12.4	446.4	310.2	213.0	3132.3
1961-62	430.2	55.8	12.8	22.6	11.2	62.5	6.2	60.7	59.0	1442.7	59.7	16.7	509.0	344.9	206.1	3300.1
1962-63	427.2	59.6	13.2	23.5	10.8	76.3	7.5	48.9	67.0	1639.7	58.8	30.5	623.9	406.5	209.0	3702.4
1963-64	506.3	63.9	11.3	22.4	9.9	75.1	7.1	38.0	59.4	1771.3	52.1	30.6	650.4	466.4	226.5	3990.7
1964-65	462.3	51.2	10.4	19.6	5.5	60.0	7.9	39.7	54.5	1731.9	62.7	35.1	653.4	481.8	249.0	3925.0
1965-66	488.6	56.2	13.7	26.0	5.6	76.7	8.7	34.6	58.4	1983.5	65.4	39.2	747.8	453.6	283.2	4341.2
1966-67	574.8	52.2	13.1	25.4	5.2	74.8	7.4	22.2	62.5	1978.2	55.5	41.4	778.3	415.5	286.8	4393.3
1967-68	523.6	48.0	12.0	24.4	5.2	98.2	8.8	23.7	41.1	2026.5	51.2	45.4	813.0	394.8	302.3	4418.2
1968-69	564.2	59.9	16.8	26.3	5.6	66.8	9.9	25.2	30.9	2174.7	49.8	55.2	904.2	423.8	320.1	4733.4
1969-70	532.5	53.9	10.4	25.5	5.3	75.0	10.4	36.7	37.7	2274.2	52.5	61.2	930.1	423.8	375.4	4904.6
1970-71	537.3	46.3	11.8	19.9	4.7	69.9	13.3	36.3	51.2	2102.8	49.2	60.2	942.1	401.9	387.1	4734.0
1971-72	542.2	44.4	16.9	25.3	5.2	71.8	16.2	22.2	48.8	2178.1	48.6	54.9	926.0	414.1	387.2	4801.9
1972-73	527.9	49.7	8.6	22.0	5.2	51.3	17.9	20.3	47.0	2247.3	47.6	52.8	952.8	448.1	368.1	4866.6
1973-74	503.1	37.4	9.8	23.7	4.1	48.3	14.6	19.8	51.9	2089.9	32.2	41.3	905.7	409.5	347.7	4539.0
1974-75	475.6	36.5	8.9	17.0	3.6	37.2	12.9	17.5	57.5	2410.9	40.8	46.0	974.4	427.2	325.3	4891.3
1975-76	558.2	45.2	5.4	19.4	3.6	45.2	21.0	19.0	74.3	2726.4	46.5	53.0	1128.3	461.4	418.2	5625.1
1976-77	656.3	46.3	5.1	10.8	1.7	41.9	14.6	16.4	65.1	2853.1	42.8	58.1	1178.6	534.7	492.8	6018.3
1977-78	626.4	29.4	3.8	12.4	1.7	36.7	12.7	16.9	52.7	2945.3	41.0	51.2	1192.3	490.1	465.2	5977.8
1978-79	550.5	29.9	3.3	15.6	1.2	30.2	12.1	21.0	53.1	2732.1	40.3	52.2	1192.7	471.1	412.7	5618.0
1979-80	604.0	30.7	2.5	17.4	0.6	29.7	16.4	9.1	39.6	2669.9	38.8	56.7	1120.1	443.3	312.1	5390.9
1980-81	616.6	25.0	3.5	18.2	0.5	21.5	20.0	11.2	52.4	2736.6	39.0	54.5	1178.0	450.7	303.2	5530.9
1981-82	747.9	23.1	1.9	10.2	0.6	14.7	16.5	10.6	52.3	3220.8	38.8	57.7	1238.0	511.8	339.2	6284.1
1982-83	866.4	20.4	1.4	12.2	0.3	19.0	18.3	11.7	59.4	3530.7	35.7	61.3	1221.3	492.1	417.9	6768.1
1983-84	876.4	18.6	1.4	9.0	0.3	11.5	14.6	7.5	67.6	3810.0	31.8	63.1	1124.0	426.3	516.4	6978.5
1984-85	748.9	19.5	0.6	7.2	0.2	6.7	15.0	4.0	62.7	3928.7	35.4	69.0	1223.9	439.4	583.3	7144.5
1985-86	857.2	21.7	1.3	11.5	0.3	7.8	15.7	2.5	107.9	4337.7	39.9	71.4	1305.4	471.7	631.4	7883.4
1986-87	1003.7	20.0	3.5	14.5	0.3	8.1	14.0	3.1	80.8	4582.1	38.7	74.0	1390.8	495.4	697.7	8426.7
1987-88	1024.8	12.0	3.5	8.4	0.1	6.4	7.6	3.7	79.7	4920.8	37.6	73.9	1384.2	501.3	780.9	8844.9
1988-89	873.5	9.0	1.6	7.0	0.3	5.7	9.6	3.1	62.8	5273.5	43.1	80.7	1465.7	501.5	936.5	9273.6
1989-90	822.5	11.4	5.1	6.3	0.5	2.6	7.8	3.0	71.0	5474.3	44.7	79.3	1596.0	497.2	1009.1	9630.8

Source: Compiled from various years *Basic Statistics Relating to the Indian Economy*, Central Statistical Organisation, Ministry of Planning, Government of India

Commodity Code:

GPulses = gram & pulses
OSeeds = raw jute
Tea = manufactured tea
RCott = raw cotton
CottMf = cotton manufactures
RJute = raw jute
JuteMf = jute manufactures
SCane = sugarcane
Sugar = manufactured sugar
CCoke = coal & coke
MnOre = manganese ore
OMOre = other metallurgical ores
IOre = iron ore
ISteel = iron & steel
Cement = cement

Table 6.1*b*: Inter-Commodity Correlation Matrix
BG WAGON LOADINGS

	GPulses	OSeeds	Tea	RCott	CottMf	RJute	JuteMf	SCane	Sugar	CCoke	MnOre	OMOre	IOre	ISteel	Cement
GPulses	*1*														
OSeeds	*-0.879*	*1*													
Tea	*-0.773*	*0.870*	*1*												
RCott	*-0.814*	*0.894*	*0.831*	*1*											
CottMf	*-0.726*	*0.820*	*0.707*	*0.902*	*1*										
RJute	*-0.820*	*0.900*	*0.884*	*0.791*	*0.624*	*1*									
JuteMf	*0.300*	*-0.435*	*-0.532*	*-0.363*	*-0.475*	*-0.454*	*1*								
SCane	*-0.775*	*0.843*	*0.723*	*0.881*	*0.959*	*0.676*	*-0.501*	*1*							
Sugar	*0.520*	*-0.385*	*-0.424*	*-0.365*	*-0.171*	*-0.490*	*0.052*	*-0.223*	*1*						
CCoke	*0.934*	*-0.927*	*-0.788*	*-0.873*	*-0.763*	*-0.860*	*0.285*	*-0.814*	*0.502*	*1*					
MnOre	*-0.675*	*0.780*	*0.716*	*0.778*	*0.820*	*0.681*	*-0.555*	*0.871*	*-0.127*	*-0.667*	*1*				
OMOre	*0.829*	*-0.847*	*-0.696*	*-0.850*	*-0.878*	*-0.696*	*0.462*	*-0.888*	*0.266*	*0.896*	*-0.696*	*1*			
IOre	*0.831*	*-0.907*	*-0.782*	*-0.922*	*-0.928*	*-0.779*	*0.491*	*-0.930*	*0.298*	*0.911*	*-0.785*	*0.956*	*1*		
ISteel	*0.659*	*-0.695*	*-0.624*	*-0.873*	*-0.929*	*-0.537*	*0.366*	*-0.876*	*0.202*	*0.707*	*-0.672*	*0.815*	*0.877*	*1*	
Cement	*0.842*	*-0.829*	*-0.645*	*-0.781*	*-0.656*	*-0.753*	*0.149*	*-0.710*	*0.479*	*0.956*	*-0.547*	*0.843*	*0.837*	*0.617*	*1*

Table 6.2a: Railway Wagon Loadings of Commodities (1955-56 to 1988-89)

METRE GAUGE ORIGINATING & TRANSHIPMENT LOADINGS

[Thousand wagons: 4-Wheeler Equivalents]

Year	GPulses	OSeeds	Tea	RCott	CottMf	RJute	JuteMf	SCane	Sugar	CCoke	MnOre	OMOre	IOre	ISteel	Cement	Total MG Loadings
1955-56	280.8	75.4	19.1	29.2	16.0	40.9	6.1	189.1	66.5	208.3	19.2	8.2	26.0	33.9	113.1	1131.8
1956-57	307.4	83.0	22.9	26.9	11.8	61.1	6.1	220.2	75.8	221.4	22.7	7.9	36.0	44.0	107.1	1254.3
1957-58	393.7	81.9	22.9	30.4	10.3	71.2	7.5	215.0	84.4	250.1	23.3	17.5	44.9	53.0	126.6	1432.7
1958-59	403.9	81.5	22.4	25.2	5.7	72.2	7.8	178.3	75.2	279.0	18.0	17.0	55.7	51.6	129.6	1423.1
1959-60	405.9	74.4	22.1	22.2	4.7	73.5	7.8	216.1	74.9	277.0	21.9	19.7	68.4	52.1	160.6	1501.3
1960-61	381.8	72.7	19.4	21.8	2.5	59.8	6.8	227.3	72.7	254.3	20.8	22.3	75.1	63.6	188.1	1489.0
1961-62	373.1	59.1	21.3	16.9	2.8	66.0	6.0	232.0	70.8	262.6	15.8	23.5	69.4	72.1	193.0	1484.4
1962-63	365.2	65.4	19.1	19.8	3.0	74.4	6.5	201.7	76.3	283.6	15.9	24.4	70.2	80.9	175.9	1482.3
1963-64	406.9	72.1	17.7	18.6	2.8	68.4	5.2	135.2	65.3	308.6	12.8	18.4	99.8	83.7	186.8	1502.3
1964-65	398.3	57.6	15.4	16.6	1.5	50.6	6.9	185.3	58.9	273.4	18.4	9.8	114.4	81.3	205.7	1494.1
1965-66	395.5	59.2	16.1	24.1	1.4	63.8	7.0	209.3	66.1	325.7	12.2	10.9	123.9	87.7	214.5	1617.4
1966-67	400.6	50.6	20.5	23.0	1.0	54.7	6.1	151.4	68.2	331.7	11.6	11.0	97.8	74.8	205.6	1508.6
1967-68	361.5	49.0	19.9	23.6	0.8	68.8	6.9	79.0	46.0	356.0	12.2	8.1	88.2	62.4	226.7	1409.1
1968-69	375.5	61.3	20.3	24.1	1.1	48.4	7.5	118.0	35.3	338.4	15.1	11.4	84.8	59.3	230.1	1430.6
1969-70	369.3	54.6	21.7	24.4	1.4	51.6	6.8	154.2	45.0	390.8	15.8	13.0	76.5	60.7	263.4	1549.2
1970-71	326.3	47.4	18.1	29.7	1.1	55.6	8.1	178.3	49.9	340.9	18.2	12.0	78.6	54.8	295.6	1514.6
1971-72	320.4	42.0	27.2	24.3	1.3	57.5	8.5	105.7	49.5	329.9	15.2	12.8	94.6	59.4	285.6	1433.9
1972-73	300.7	50.1	19.0	21.0	0.9	47.7	8.1	84.4	42.9	312.4	15.1	10.4	80.5	59.7	260.0	1312.9
1973-74	266.8	39.4	19.4	20.0	1.0	37.4	9.3	103.5	42.9	255.2	16.6	8.3	66.2	51.3	237.6	1174.9
1974-75	232.6	36.9	16.7	14.6	0.3	29.6	8.1	99.4	45.6	309.9	19.9	9.6	72.8	43.3	201.3	1140.6
1975-76	254.2	36.8	8.3	14.1	0.2	43.7	11.3	80.7	53.3	342.4	13.4	9.7	93.4	34.8	243.5	1239.8
1976-77	341.5	39.5	8.7	13.9	0.2	36.1	8.8	78.5	44.8	321.8	14.3	10.9	65.6	42.3	288.9	1315.8
1977-78	316.9	32.6	7.4	9.7	0.6	34.9	5.8	80.2	41.6	326.6	9.5	8.8	37.6	37.4	287.7	1237.3
1978-79	262.4	30.8	6.8	12.8	1.3	31.9	5.4	102.2	38.5	285.6	12.0	9.6	24.5	34.0	272.0	1129.8
1979-80	256.3	34.2	6.2	13.9	0.3	30.6	6.1	66.4	28.5	222.7	12.8	8.5	26.0	35.2	201.1	948.8
1980-81	226.5	29.2	6.6	12.7	0.4	23.1	6.7	57.5	31.4	191.5	11.0	8.1	31.1	29.4	196.8	862.0
1981-82	264.3	26.5	4.4	6.7	0.3	18.0	7.8	65.1	22.2	202.8	7.9	8.5	27.5	26.7	203.1	891.8
1982-83	311.9	24.7	2.6	7.6	0.5	15.7	6.0	82.5	27.4	226.6	7.8	7.3	23.2	24.5	192.3	960.6
1983-84	315.5	19.7	1.2	5.3	0.4	8.4	4.3	81.6	32.9	251.2	8.7	9.1	17.8	16.6	236.8	1009.5
1984-85	284.1	21.0	0.7	4.7	0.3	4.0	2.7	40.4	29.5	206.9	13.9	6.1	16.6	18.2	199.3	848.4
1985-86	304.3	19.9	0.1	5.9	0.4	6.0	2.2	57.6	34.7	193.5	10.6	8.4	26.2	14.8	201.3	885.9
1986-87	382.5	18.1	0.1	8.0	0.6	4.8	1.4	57.5	39.0	207.0	6.2	10.9	40.3	13.1	223.5	1013.0
1987-88	379.1	13.8	0.2	5.9	0.1	3.0	1.1	71.3	39.0	201.7	8.5	10.8	32.2	12.9	269.3	1048.9
1988-89	318.9	9.6	0.3	4.2	0.1	3.5	1.5	67.0	29.3	236.5	7.6	7.8	29.2	9.8	308.4	1033.7
1989-90	298.6	11.8	0.2	3.7	0.1	2.2	0.7	65.5	29.1	193.7	10.0	3.9	38.4	7.0	315.1	980.0

Source: Compiled from various years *Basic Statistics Relating to the Indian Economy*, Central Statistical Organisation, Ministry of Planning, Government of India

Commodity Code:

GPulses =	gram & pulses	CottMf =	cotton manufactures	Sugar =	manufactured sugar	IOre =	iron ore
OSeeds =	raw jute	RJute =	raw jute	CCoke =	coal & coke	ISteel =	iron & steel
Tea =	manufactured tea	JuteMf =	jute manufactures	MnOre =	manganese ore	Cement =	cement
RCott =	raw cotton	SCane =	sugarcane	OMOre =	other metallurgical ores		

Table 6.2b: Inter-Commodity Correlation Matrix

MG WAGON LOADINGS

	GPulses	OSeeds	Tea	RCott	CottMf	RJute	JuteMf	SCane	Sugar	CCoke	MnOre	OMOre	IOre	ISteel	Cement
GPulses	*1*														
OSeeds	*0.497*	*1*													
Tea	*0.392*	*0.862*	*1*												
RCott	*0.366*	*0.867*	*0.921*	*1*											
CottMf	*0.140*	*0.696*	*0.478*	*0.592*	*1*										
RJute	*0.515*	*0.900*	*0.907*	*0.862*	*0.421*	*1*									
JuteMf	*-0.089*	*0.521*	*0.644*	*0.615*	*0.131*	*0.640*	*1*								
SCane	*0.556*	*0.862*	*0.744*	*0.740*	*0.618*	*0.791*	*0.339*	*1*							
Sugar	*0.585*	*0.876*	*0.746*	*0.729*	*0.643*	*0.832*	*0.352*	*0.895*	*1*						
CCoke	*0.300*	*0.339*	*0.565*	*0.517*	*-0.179*	*0.589*	*0.585*	*0.229*	*0.260*	*1*					
MnOre	*0.180*	*0.808*	*0.771*	*0.757*	*0.625*	*0.689*	*0.528*	*0.744*	*0.724*	*0.222*	*1*				
OMOre	*0.598*	*0.626*	*0.551*	*0.429*	*0.212*	*0.681*	*0.250*	*0.693*	*0.716*	*0.238*	*0.453*	*1*			
IOre	*0.484*	*0.471*	*0.640*	*0.555*	*-0.122*	*0.672*	*0.528*	*0.432*	*0.472*	*0.739*	*0.326*	*0.365*	*1*		
ISteel	*0.534*	*0.738*	*0.809*	*0.719*	*0.148*	*0.876*	*0.561*	*0.686*	*0.674*	*0.640*	*0.503*	*0.600*	*0.839*	*1*	
Cement	*-0.175*	*-0.661*	*-0.379*	*-0.409*	*-0.717*	*-0.413*	*-0.178*	*-0.538*	*-0.595*	*0.297*	*-0.523*	*-0.343*	*0.076*	*-0.245*	*1*

Wagon loadings in the dataset are actually truer indicators of the magnitude of freight-handling operations on IR, since unlike tonnage-based railway indicators, they are not subject to upward biases over time on account of the higher proportions that IR bulk-freight handling has assumed. The point is important enough to merit further explanation. In the changing freight scenario of the railways in India, complacency about IR freight performance might easily develop around the visible uptrends in originating tonnages and net tonne-km [*see ch3*] that are often cited by railway authorities. But the overwhelming freight dominance acquired by a few bulk commodities during the planning period innately colours traffic assessments that are made in these terms, because identical tonnage and traffic levels at points widely separated in time can easily conceal the displacements made of low-bulk freight in order to accommodate these commodities. The truth of the matter may well be that identical tonnage handling in a changing freight scenario progressively involves a lowered quantum of wagon loadings if these represent loadings of bulk freight in replacement of lighter freight commodities. Again, identical net tonne-km levels, which in any case can also mask the secular increase in freighting leads, are further biased when bulk specialisation occurs.

The spatial and sectoral character of IR freight-flows also becomes manifest when crossgauge comparisons are made within the dataset. Because of locational confinement of the MG network to specified regions of the country, distinct differences may be observed between BG and MG freight-loading patterns, with presence or absence of heavy industrial raw materials and products in the regional railway freight-mix reflecting the level of development in the region served. In face of the overall constraint on IR freight capacity, the relatively less-developed regions served by MG freight operations appear to retain the older preindustrial freight configuration of the colonial railways with a higher presence of agricultural traffic, which regions served largely by BG operations have been forced to shed because of the swing to bulk freight. Sectoral input-output relations also appear between wagon loadings on both BG and MG networks, with increases in bulk raw material loadings on the former being matched further downstream by rising trends in the loading of heavy industrial products. A similar but converse association governs loadings of commodity inputs and outputs sourced from agriculture, which are seen to have been better retained by the MG network while being lost from the former. Visual insight into this phenomenon is provided in the grouped dataplots for freight-flows under the three sorted sectoral categories of mining & heavy industrials [*Fig 6.1a*], agricultural products and industrial raw material [*Fig 6.1b*], and light industrials [*Fig 6.1c*]. Aggregate [AG] wagon loadings for the third category show generally decreasing trends over the 35-year longitudinal timeframe, while the bulk category of mining & heavy industrials shows a phenomenal increase, indicating how the producer-goods segment of the economy has progressively become the principal client of IR, and how freight loadings in the mining category have come to dominate all IR freight-flows. More specific analyses of these spatial and sectoral freight patterns are however left to the next chapter.

6.2.1a Mining & Heavy Industrials

Along with iron & steel and cement as finished products, commodities included in the mining & heavy industrials category in the dataplots comprise the ore-group made up of iron, manganese and other metallurgical ores as well as coal & coke - all of which hold special importance as inputs for the steel sector. With the single exception of manganese ore, wagon loadings for the group show pronounced upward time trends on the BG network. It may be noted also that the major part of BG bulk loadings in this commodity group is made up of coal & coke, iron ore, cement and iron & steel, in declining order. However, except for coal traffic which had attained freight dominance even at the commencement of the 2FYP when it comprised 43.1 percent of the BG loadings in the dataset, it is seen that the uptrend in loadings of the other three commodities is more recent and can in fact be ascribed to the developmental thrust provided by the Indian FYPs. However while coal & coke, iron ore, cement and iron & steel collectively comprised 65.5 percent of BG loadings in 1955-56, they reached a level of 89.1 percent by the end of the 7FYP, with individual proportions of 56.8 percent, 16.6 percent, 10.5 percent and 5.2 percent in BG wagon loadings. The most phenomenal increase is observed for BG loadings of iron ore where the proportion has more than doubled, indicating the degree to which the BG freight operations of IR have come to depend on traffic to and from the steel sector.

An observation might also be made in relation to the loadings of coal & coke. While at one time the railways were major consumers of coal for traction, their in-house consumption contributing coal tonnage of 19.5MT to non-revenue earning traffic at the beginning of the 3FYP, this had fallen by 1981-82 to 3MT,[25] and after

Figure 6.1 : Commodity Freight Trends on Indian Railways [1955-56 to 1989-90]
SECTORAL ANALYSIS

Fig 6.1a: Mining & Heavy Industrials

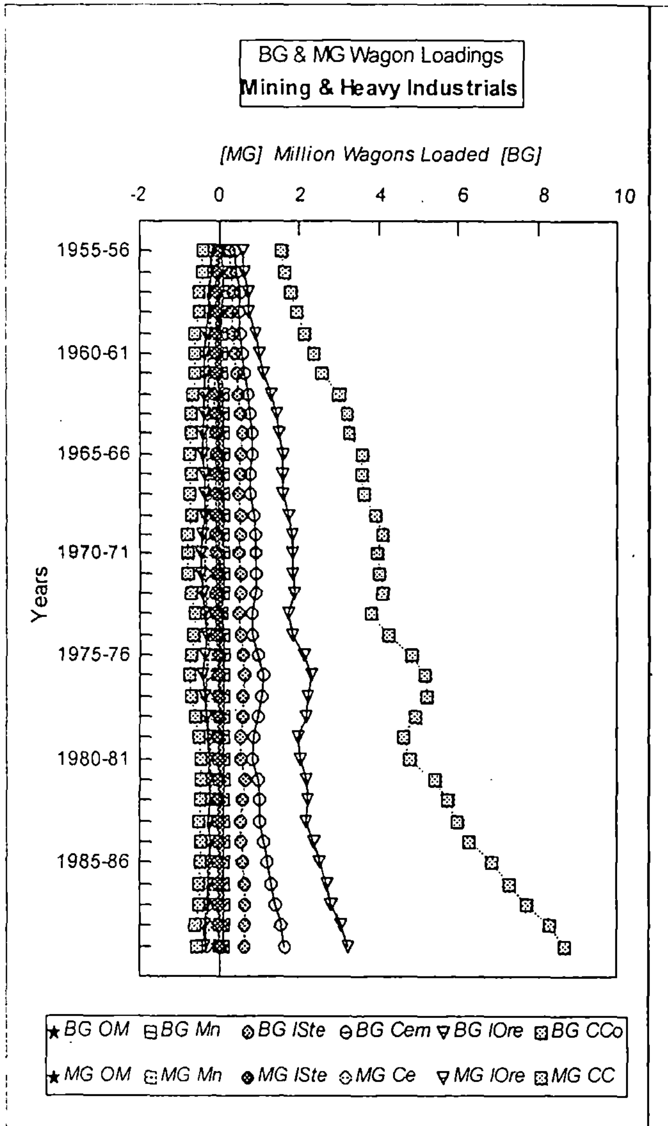


Fig 6.1b: Agricultural Products & Raw Materials

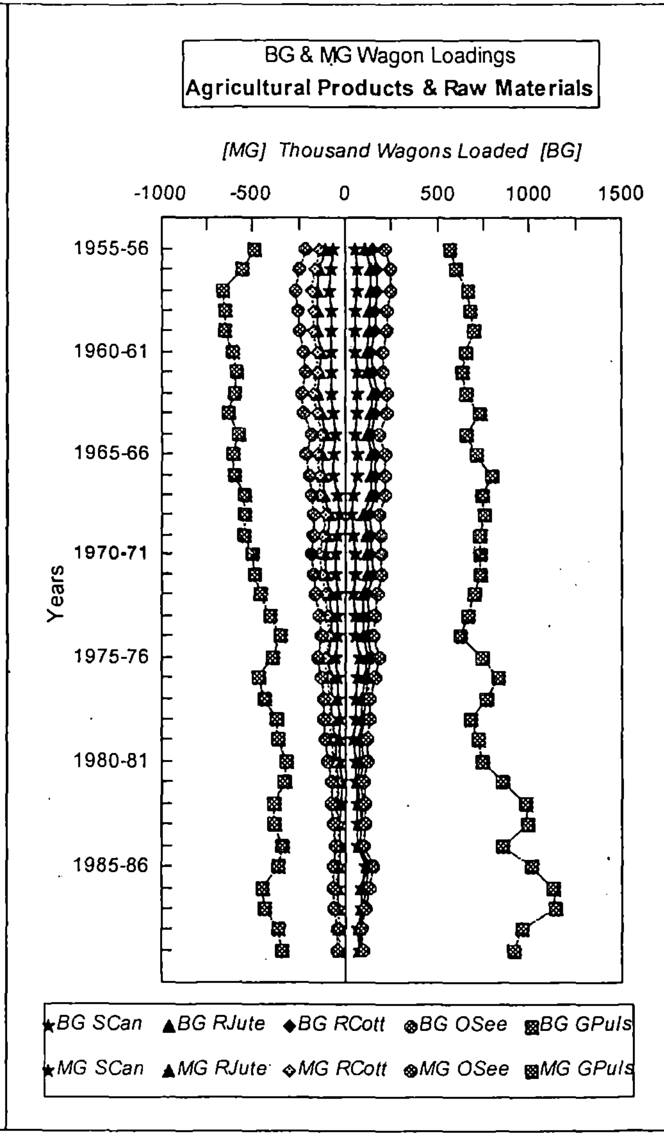
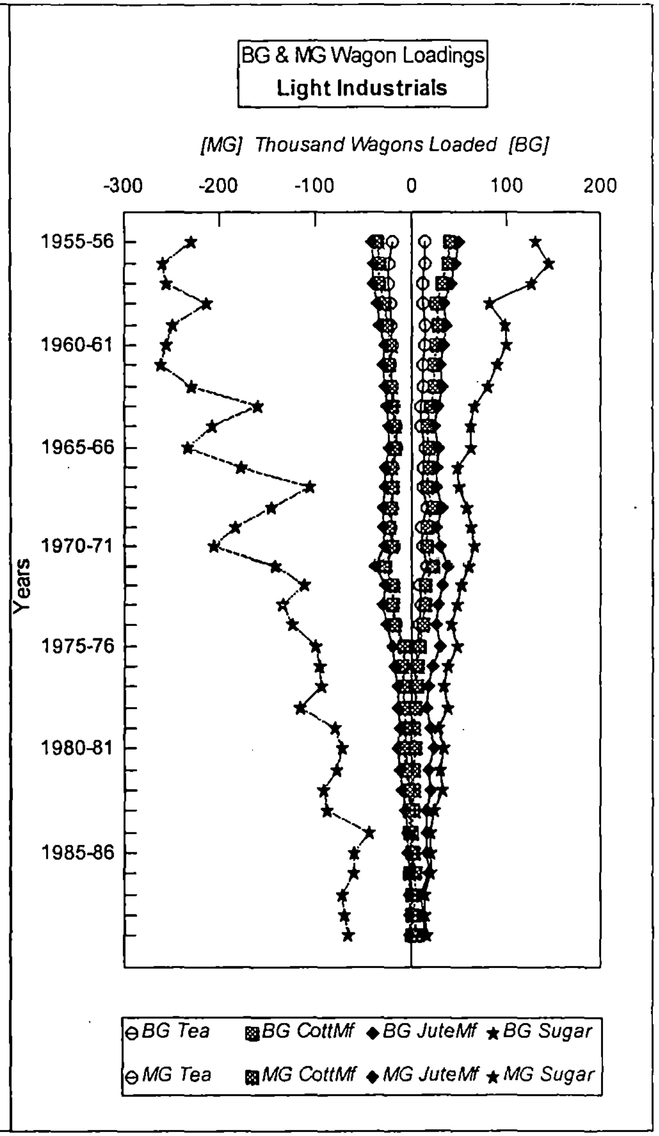


Fig 6.1c: Light Industrials



the virtual phasing out of steam traction has declined to just 0.60MT in 1994-95.[26] Thus while IR alone consumed more than a third of the total coal produced by Indian coalfields at the commencement of this period, its proportion today is not even 0.01 percent. The implication, accordingly, is that while iron ore loadings have risen phenomenally because of the development of the steel sector, the rise in coal & coke traffic has been nearly as phenomenal because of the conversion of sizeable non-revenue loadings of coal by IR for traction purposes into general loadings for downstream industry. After these factors are considered, the extent to which IR freight operations have become polarised around heavy industrials becomes pretty obvious.

Another prominent feature of IR bulk loadings apparent in the dataplot is that the same relative ordering of four major bulk commodities is also preserved by MG freight operations even though the quantum of loadings involved here is smaller. Because of this, the principal direction of transhipment is seen to be from BG to MG, since upstream or originating MG loadings alone cannot explain the huge number of BG wagons loaded. Rather, while the main traffic in the bulk commodities originates on the BG network, a part of it is transhipped onto MG for distribution purposes, and while certain other commodities are loaded as originating freight on MG return journeys, they do not necessarily tranship onto BG. Thus the older feeder role of the MG freight network has been progressively negated.

As has happened in most other countries during a certain phase in their development, the growth of bulk traffic on IR is intimately tied up with the growth of metallurgical industry in India, which while being the second-largest user of coking coal (including imports) in the country, also accounts for traffic in several other bulk commodities including mineral traffic in iron and manganese ores, as well as in limestone & dolomite which is not present in the dataset. By implication from this backward linkage, IR bulk traffic operations form the raw material artery of the Indian iron & steel industry which, after the power sector, accounts for the principal part of total IR freight tonnages and traffic. Over time and with transport policy changes, the linkages of IR freight operations to the Indian steel plants have become progressively closer. However unlike iron ore loadings which increased sharply over the 1980s, loadings of finished iron & steel remain relatively flat, reflecting the rise of iron ore exports during this period as mining capacity has outrun the domestic capacity for steel production.

The process by which this state of affairs has come about deserves special comment because of the serious reflection it has on the dimensions of the infrastructural crisis in India. While the major part in steelmaking capacity in India has come from the introduction of the highly capital-intensive blast furnace [BF] technology at 5 public-sector integrated steel plants [ISPs] that were established at Rourkela, Durgapur, Bhilai, Bokaro and Vishakhapatnam under the FYPs, domestic downstream demands for steel quickly outstripped domestic production, leading to a situation where imports of finished steel rose to 1.9MT in 1995-96 against iron ore production of 65.9MT, even as excess capacity still prevailed in the steel sector.[27] The primary reason for this vertical mismatch was the inability of IR to freight adequate quantities of imported anthracitic and coking coals to the ISPs for the beneficiation processes required to lower ash-content in the Indian coal used in blast furnaces. This combination of circumstances adversely affected the revenues of SAIL which controls the ISPs, and reduced the enthusiasm for new BF and open-hearth based steel plants, especially after political pressures led to the ISPs at Bhilai and Vishakhapatnam being located well outside the ore-belt (the Vishakhapatnam ISP in fact being port-based to dispense with the need for transporting inputs overland). Since the 7FYP, the planning thrust on creating domestic steel capacity has therefore been towards mini-steel plants [MSPs] using electric arc furnace [EAF] technology, in which the private sector is an eligible participant. Once again however, optimum utilisation of this new steelmaking capacity would have rested on IR's ability to freight adequate quantities of coal to the power plants. Rather than taking further chances on this, the national electricity policy was suitably modified to accommodate the establishment of pithead power plants in the Central sector, so that instead of infrastructural limits being posted by the amount of coal & coke freighted by IR, new limits could be set by the amount of electricity flowing along the national grid. From this perspective, the evolution of IR freight operations has differed markedly from that in other industrial countries, even though it resembles other major railway systems in its strong infrastructural linkage to metallurgical industry.

The fourth major bulk commodity in IR freight loadings, *i.e.* cement, is interesting because of the high presence it records in freight operations on both railway gauges. The need for transporting cement over long leads arises from the presence of basic construction demand in all regions of the country, while production of the commodity is localised in a few limestone-rich areas. Since most of the output from regional cement units is absorbed by local demand from within the region, transportation of cement to regions lacking mineral reserves and cement production facilities has to be made from a few states like Madhya Pradesh where settlement rates are low and production surpluses exist. Cement nevertheless is a difficult commodity to transport without the protection of covered wagons and intersects in this respect with other high-rated general freight. Increased IR loadings of cement are therefore liable to eat into the freighting capacity available for transporting general freight in both railway gauges, while also coming up against shortages in wagons of the desired type because of specialisation of the IR wagonfleet around the special wagons required for handling coal, iron ore, etc. The results can be paradoxical. Cement, with its long reverse leads, higher rates and full trainloads, and spatially well-dispersed freight demand becomes an important traffic category from the perspective of IR's revenues. However following IR's recent exercises at raising internal resources through the escalation of tariffs, cement traffic has become so sluggish - both on account of overpricing of the freight service and dearth of covered wagons - that IR in its recent Railway Budget has been compelled to offer a 10 percent discount on rates to the industry for freighting cement in non-specified or open wagons, in order to retain cement within its freight-mix and reduce the incidence of empty wagon-haulage.[28]

6.2.1b Agricultural Products & Raw Materials

Freight commodities under the second group, which are all sourced from the agricultural sector, comprise wagon loadings of grams & pulses and oilseeds in the category of foods, and raw cotton, raw jute and sugarcane in the raw material category. The position of grams & pulses is important to the purposes of the study. Although foodgrains constitute a principal part of IR freight movements under social objectives and are also accorded rate preference in this respect, loading figures for cereals like rice and wheat were unavailable. Hence, the freight patterns of grams & pulses can yield a partial picture of the impact of social constraints on IR freight operations, which is probably even more magnified in the case of cereals. To a lesser extent, this is also true for oilseeds and sugarcane, although these have to be freighted to mills for conversion before they become foods fit for public consumption. Edible oils thereafter become a constituent of higher-rated packaged freight. Although sugarcane resembles oilseeds in these characteristics, it is freighted over shorter leads to mills located in growing areas for industrial conversion to sugar and ultimately yields an unbranded freight product.

The two fibre commodities have been important traditional constituents in railway freight since the inception of freight services in India, and provided the backbone for industrialisation in the pre-Independence years. Railway movements of these commodities have influenced the location of industry in diverse ways. Weaving and cotton cultivation, once widespread in pre-industrial India, have gradually tended to concentrate on the West Coast because of the high productivity of cashcrops on its black cotton soils. Carriage leads in the raw fibre have consequently declined over time because of the location of textile industry close to growing areas. In the case of jute fibre, both cultivation and manufacturing were localised on the East Coast for natural reasons. However the carriage leads of the finished manufactures, which are part of the third group, have tended to expand because of high crosscountry demands for cotton textiles and gunny cloth.

From visual inspection it is clear that freight loadings of grams & pulses continue to retain importance in IR freight. This bears accord with the historical freight and rate priorities given to foodgrains transportation in a country where railways became the principal means of preventing the recurrence of famines. Evidence also obtains of the transference of grams & pulses loadings to the BG network as IR's MG operations were gradually circumscribed. Such evidence is not observed for the other commodities, except to a limited degree for oilseeds loadings. In more general terms, the presence of agricultural commodities and raw materials in IR freight traffic has declined steadily in proportional importance, except when these have been favoured by adequate wagon commitment and special rate concessions, and by freighting leads that run in reverse to the general traffic trend. Although grams and pulses are not distributed to consumers via India's PDS [public distribution] system, the position would hold even more strongly for government cereal stocks that are freighted almost entirely by railway to food-deficit states .

The decline of IR's feeder freight services following the downsizing of MG operations can also be taken visual note of. Freight operations on the MG network have been noticeably dominated by agro-commodities, which today have nearly vanished from IR freight. While the logic for this shift has evidently arisen within the development planning process which has placed a high premium on industrial freight, it has also meant that the spread of railway freighting services has retreated to the principal industrial corridors of the country. In view of the spatial character of transportation infrastructure in India where the MG network has served regions not attended to by BG freight, loss of MG freight loadings by IR has meant yet another gain for the Indian roadways, while also distorting the regional basis of equity in economic development. The rise in heavy industrial freight which has offset this freight-loss has also not accrued to the less-served regions, bringing about further inequities in regional development.

6.2.1c Light Industrials

Commodities in this category, which were all prominent industrial constituents of railway freight in the pre-Independence period, include jute and cotton manufactures as well as sugar and tea. Because of widespread demand, they have traditionally been freighted by IR over long leads from their localised points of manufacture. Of the four commodities, only sugar is accorded rate priority as an essential commodity and hence has been an important constituent in both BG and MG freight till recently. Along with grams & pulses, retention of this commodity has also been better on the MG network because of widespread demand and the rate priorities offered for PDS loadings. Wagon loadings of jute manufactures have also maintained a presence in BG freight because of widespread use of jute for packaging. On the other hand, the highly-rated freight loadings of tea and cotton manufactures have virtually disappeared. Recent railway traffic leads in these commodities have been remarkably high, indicating that except for very long-haul consignments, these have shifted over to the roadways.

6.2.2 Freight Adaptation & the IR Commodity-freight Mix

In the overall situation of freight restriction, there is considerable complexity in the manner in which IR's commodity flows have related to each other. The position is best summarised by considering the backward and forward linkages of railway freight flows. Against the mining outputs which feed raw materials to heavy industry, heavy producer-goods outputs are also fully catered to by IR since in most cases, the lead directions are also suitable. Saturation of the freight sectors served by these dominant commodities causes displacements elsewhere. The primary direction of freight displacement is witnessed in the industrial sector where light industrials have gradually been elbowed out of the IR freight-mix by heavy industrials because of the dearth of appropriate freighting capacity. The light industrial sector has strong backward linkages with the agricultural sector, and commodities such as textile manufactures and sugar have drawn considerable raw material support in the past from railway freight operations. Thus with the withdrawal of both forward and backward freight support, downstream growth in this economic sector is adversely affected. Considering that production targets for the heavy industrial sector have been set under the FYPs on the assumption of appropriate downstream growth, the mismatch between light and heavy industrials leads to coordination failures and to the accumulation of producer-goods inventories in a process somewhat reminiscent of Metzlerian cycles.[29] Thus even if IR freight operations are not the direct source of macroeconomic disequilibrium, they aggravate it by introducing downstream production cycles in the economy.

More complexity is added to the evolutionary patterns of freight by longterm economic development and consequent traffic change. Thus the freight patterns of commodities observed above have evolved around the achievement of foodgrains self-sufficiency during the 1970s. Despite this landmark, internal food surpluses originating in the northern breadbasket region still have to be freighted by railway to feed the rest of the country, and at times of agricultural adversity, these have also been supplemented by foodgrain imports carried over reversed leads from the major Indian ports. In spite of the progress of Indian agriculture, wide divergence in agroclimatic conditions over the Indian landmass ensures regional specialisation in production of agricultural commodities. Hence balancing movements of freight in critical agricultural commodities must still take place from surplus to deficit regions. Instead being further reduced therefore, the average lead of IR freight movements of foodgrains has climbed steadily to over 1300km in 1994-95,[30] and the increasing wagon loadings of grams & pulses in the dataset provide partial evidence of this.

The escalations in IR wagon-loadings observed over the 35-year period are nevertheless stronger for industrial commodities than for commodity freight in the agricultural group. An economic underpinning for this evolving

Table 6.3a: Commodity-Influence on Gauge-wise IR Freight Loadings
OLS & Cochrane-Orcutt Adjusted Multiple Regression Results

		COMMODITY COEFFICIENTS															
		$\hat{b}_0$ Constant	$\hat{b}_1$ GPulses	$\hat{b}_2$ OSeed	$\hat{b}_3$ Tea	$\hat{b}_4$ RCott	$\hat{b}_5$ CottMf	$\hat{b}_6$ RJute	$\hat{b}_7$ JuteMf	$\hat{b}_8$ SCane	$\hat{b}_9$ Sugar	$\hat{b}_{10}$ CCoke	$\hat{b}_{11}$ MnOre	$\hat{b}_{12}$ OMOre	$\hat{b}_{13}$ IOre	$\hat{b}_{14}$ ISteel	$\hat{b}_{15}$ Cement
ALLGAUGE ON BROADGAUGE [AG/BG]																	
OLS	$\hat{b}_i$	**672.38**	**1.49**	**7.84**	**8.07**	**-0.30**	**-33.54**	**4.60**	**-1.11**	**5.81**	**0.83**	**0.81**	**1.66**	**-1.47**	**0.70**	**1.69**	**2.20**
	$t(\hat{b})$	2.74	6.77	2.75	1.50	-0.06	-3.29	3.41	-0.20	2.55	0.75	7.39	0.65	-0.57	3.10	3.32	8.30
		*	**	*			**	**		*		**			**	**	**
C-O	$\hat{b}_i$	**648.40**	**1.46**	**7.27**	**8.01**	**0.43**	**-43.11**	**5.36**	**0.70**	**8.27**	**1.03**	**0.83**	**0.54**	**-1.71**	**0.61**	**1.76**	**2.26**
	$t(\hat{b})$	2.77	7.10	2.82	1.63	0.09	-3.92	3.61	0.14	3.37	1.02	7.63	0.22	-0.75	3.03	4.02	9.87
		*	**	**			**	**		**	*	**		*	**	**	**
Change		*-23.98*	*-0.03*	*-0.57*	*-0.06*	*0.73*	*-9.57*	*0.76*	*1.81*	*2.46*	*0.20*	*0.02*	*-1.12*	*-0.24*	*-0.09*	*0.07*	*0.06*
ALLGAUGE ON METREGAUGE [AG/MG]																	
OLS	$\hat{b}_i$	**6965.47**	**3.94**	**-17.52**	**-31.08**	**-2.74**	**-26.36**	**-5.43**	**-169.08**	**-1.58**	**-3.94**	**-0.10**	**-23.14**	**17.54**	**17.55**	**-31.01**	**7.69**
	$t(\hat{b})$	6.63	1.52	-0.95	-1.14	-0.10	-0.38	-0.39	-3.02	-0.52	-0.27	-0.04	-0.63	0.61	2.70	-2.95	2.76
		**							**						*	*	*
C-O	$\hat{b}_i$	**7244.25**	**2.45**	**-24.25**	**-45.09**	**9.33**	**145.11**	**-16.43**	**-164.91**	**-1.87**	**-15.67**	**1.33**	**-36.71**	**54.14**	**24.04**	**-24.85**	**7.41**
	$t(\hat{b})$	8.14	1.10	-1.56	-1.93	0.41	1.78	-1.35	-3.50	-0.74	-1.21	0.59	-1.19	1.99	4.07	-2.73	3.14
		**							**						**	*	**
Change		*278.77*	*-1.49*	*-6.73*	*-14.01*	*12.07*	*171.47*	*-10.99*	*4.17*	*-0.29*	*-11.74*	*1.43*	*-13.57*	*36.60*	*6.49*	*6.16*	*-0.28*
BROADGAUGE ON ALLGAUGE [BG/AG]																	
OLS	$\hat{b}_i$	**-109.43**	**0.74**	**-1.31**	**-0.83**	**-0.35**	**9.41**	**-1.10**	**-0.15**	**-0.12**	**0.73**	**1.09**	**1.77**	**1.03**	**1.17**	**0.28**	**0.32**
	$t(\hat{b})$	-0.55	5.99	-1.25	-0.40	-0.16	2.68	-1.82	-0.05	-0.38	1.36	15.90	1.19	0.60	5.75	0.85	2.31
			**				*					**			*		*
C-O	$\hat{b}_i$	**-95.57**	**0.70**	**-1.72**	**-0.91**	**0.97**	**14.94**	**-1.44**	**-0.87**	**-0.12**	**0.64**	**1.08**	**0.20**	**1.19**	**1.17**	**0.55**	**0.34**
	$t(\hat{b})$	-0.54	6.29	-1.81	-0.49	0.47	3.89	-2.55	-0.36	-0.42	1.35	17.60	0.13	0.79	6.46	1.79	2.77
			**				**	*				**			**		*
Change		*13.86*	*-0.04*	*-0.41*	*-0.09*	*1.32*	*5.53*	*-0.34*	*-0.73*	*0.00*	*-0.09*	*-0.01*	*-1.57*	*0.16*	*-0.00*	*0.27*	*0.02*
BROADGAUGE ON METREGAUGE [BG/MG]																	
OLS	$\hat{b}_i$	**6965.47**	**2.94**	**-18.52**	**-32.08**	**-3.74**	**-27.36**	**-6.43**	**-170.08**	**-2.58**	**-4.94**	**-1.10**	**-24.14**	**16.54**	**16.55**	**-32.01**	**6.69**
	$t(\hat{b})$	6.63	1.14	-1.00	-1.17	-0.14	-0.40	-0.46	-3.04	-0.86	-0.34	-0.42	-0.66	0.57	2.55	-3.04	2.40
		**							**						*	**	*
C-O	$\hat{b}_i$	**7245.58**	**1.44**	**-25.22**	**-46.12**	**8.35**	**144.15**	**-17.43**	**-165.98**	**-2.87**	**-16.66**	**0.33**	**-37.71**	**53.06**	**23.03**	**-25.83**	**6.41**
	$t(\hat{b})$	8.14	0.65	-1.63	-1.98	0.36	1.77	-1.43	-3.52	-1.13	-1.28	0.15	-1.22	1.95	3.90	-2.84	2.72
		**							**						**	*	*
Change		*280.11*	*-1.50*	*-6.71*	*-14.04*	*12.09*	*171.51*	*-11.00*	*4.10*	*-0.29*	*-11.72*	*1.43*	*-13.57*	*36.52*	*6.48*	*6.18*	*-0.28*
METREGAUGE ON ALLGAUGE [MG/AG]																	
OLS	$\hat{b}_i$	**109.43**	**0.26**	**2.31**	**1.83**	**1.35**	**-8.41**	**2.10**	**1.15**	**1.12**	**0.27**	**-0.09**	**-0.77**	**-0.03**	**-0.17**	**0.72**	**0.68**
	$t(\hat{b})$	0.55	2.07	2.21	0.88	0.61	-2.40	3.48	0.42	3.52	0.50	-1.32	-0.52	-0.02	-0.82	2.21	4.81
				*			*	**		**						*	**
C-O	$\hat{b}_i$	**54.01**	**0.29**	**2.73**	**1.53**	**0.41**	**-12.73**	**2.51**	**2.13**	**1.16**	**0.35**	**-0.08**	**0.56**	**-0.54**	**-0.13**	**0.46**	**0.66**
	$t(\hat{b})$	0.32	2,58	2.90	0.82	0.20	-3.85	4.24	0.94	4.22	0.80	-1.28	0.36	-0.39	-0.72	1.62	5.66
			*	**			**	**		**							**
Change		*-55.42*	*0.03*	*0.42*	*-0.30*	*-0.94*	*-4.32*	*0.41*	*0.98*	*0.04*	*0.08*	*0.01*	*1.33*	*-0.51*	*0.04*	*-0.26*	*-0.01*
METREGAUGE ON BROADGAUGE [MG/BG]																	
OLS	$\hat{b}_i$	**672.38**	**0.49**	**6.84**	**7.07**	**-1.30**	**-34.54**	**3.60**	**-2.11**	**4.81**	**-0.17**	**-0.19**	**0.66**	**-2.47**	**-0.30**	**0.69**	**1.20**
	$t(\hat{b})$	2.74	2.22	2.40	1.32	-0.27	-3.39	2.67	-0.39	2.11	-0.15	-1.76	0.26	-0.96	-1.34	1.35	4.53
		*	*	*			**	*		*							**
C-O	$\hat{b}_i$	**648.40**	**0.46**	**6.27**	**7.01**	**-0.57**	**-44.11**	**4.36**	**-0.30**	**7.27**	**0.03**	**-0.17**	**-0.46**	**-2.71**	**-0.39**	**0.76**	**1.26**
	$t(\hat{b})$	2.77	2.24	2.44	1.43	-0.12	-4.01	2.93	-0.06	2.96	0.03	-1.55	-0.19	-1.19	-1.94	1.73	5.50
		*	*	*			**	**		**							**
Change		*-23.98*	*-0.03*	*-0.57*	*-0.06*	*0.73*	*-9.57*	*0.76*	*1.81*	*2.46*	*0.20*	*0.02*	*-1.12*	*-0.24*	*-0.09*	*0.07*	*0.06*

*Note: Significances of computed regression coefficients are indicated at 95% confidence by * and at 99% confidence by ***
Theoretical t-values are $t_{19,\,0.05}$ = 2.09 at 95% confidence and $t_{19,\,0.01}$ = 2.86 at 99% confidence for OLS, with 19df. For the C-O regression, the corresponding values are $t_{18,\,0.05}$ = 2.10 and $t_{18,\,0.01}$ = 2.18 with 18df
Changes in commodity-coefficients as a result of applying the C-O correction are indicated for each regression set ..

Table 6.3*b*: Intercommodity Relationships in IR Freight Operations
Significant Freight Coefficients and 95% ConfidenceBands

		COMMODITY COEFFICIENTS															
		$\hat{b}_0$ Constant	$\hat{b}_1$ GPulses	$\hat{b}_2$ OSeed	$\hat{b}_3$ Tea	$\hat{b}_4$ RCott	$\hat{b}_5$ CottMf	$\hat{b}_6$ RJute	$\hat{b}_7$ JuteMf	$\hat{b}_8$ SCane	$\hat{b}_9$ Sugar	$\hat{b}_{10}$ CCoke	$\hat{b}_{11}$ MnOre	$\hat{b}_{12}$ OMOre	$\hat{b}_{13}$ IOre	$\hat{b}_{14}$ ISteel	$\hat{b}_{15}$ Cement
ALLGAUGE ON BROADGAUGE [AG/BG]																	
OLS	(-)	666.64	-12.68	2.08	...	...	-26.66	-2.53	...	0.48	...	-14.66	...	...	-5.79	-5.27	-15.18
	$\hat{b}_i$	672.38	1.49	7.84	...	...	-33.54	4.60	...	5.81	...	0.81	...	...	0.70	1.69	2.20
	(+)	678.12	15.66	13.61	...	...	-40.43	11.73	...	11.14	...	16.27	...	...	7.18	8.65	19.58
C-O	(-)	642.59	-13.46	1.34	...	...	-34.87	-2.22	...	1.19	-1.13	-15.20	...	-0.13	-5.76	-6.68	-18.48
	$\hat{b}_i$	648.40	1.46	7.27	...	...	-43.11	5.36	...	8.27	1.03	0.83	...	-1.71	0.61	1.76	2.26
	(+)	654.21	16.38	13.21	...	...	-51.35	12.94	...	15.36	3.18	16.86	...	-3.29	6.97	10.20	23.00
ALLGAUGE ON METREGAUGE [AG/MG]																	
OLS	(-)	6951.59	...	...	...	...	...	...	-162.76	...	...	...	...	...	11.89	-24.83	1.92
	$\hat{b}_i$	6965.47	...	...	...	...	...	...	-169.08	...	...	...	...	...	17.55	-31.01	7.69
	(+)	6979.35	...	...	...	...	...	...	-175.41	...	...	...	...	...	23.21	-37.18	13.47
C-O	(-)	7227.14	...	...	...	...	...	...	-157.57	...	...	...	...	...	15.48	-19.10	0.81
	$\hat{b}_i$	7244.25	...	...	...	...	...	...	-164.91	...	...	...	...	...	24.04	-24.85	7.41
	(+)	7261.35	...	...	...	...	...	...	-172.26	...	...	...	...	...	32.60	-30.59	14.01
BROADGAUGE ON ALLGAUGE [BG/AG]																	
OLS	(-)		-11.80	...	...	...	3.79	...	...	...	...	-32.18	...	...	-10.87	...	-4.52
	$\hat{b}_i$		0.74	...	...	...	9.41	...	...	...	...	1.09	...	...	1.17	...	0.32
	(+)		13.28	...	...	...	15.02	...	...	...	...	34.36	...	...	13.20	...	5.17
C-O	(-)		-12.52	...	...	...	6.77	3.91	...	...	...	-35.89	...	...	-12.40	...	-5.47
	$\hat{b}_i$		0.70	...	...	...	14.94	-1.44	...	...	...	1.08	...	...	1.17	...	0.34
	(+)		13.93	...	...	...	23.12	-6.80	...	...	...	38.05	...	...	14.73	...	6.16
BROAD GAUGE ON METREGAUGE [BG/MG]																	
OLS	(-)	6951.59	...	...	...	...	...	...	-163.72	...	...	...	...	...	11.21	-25.64	1.67
	$\hat{b}_i$	6965.47	...	...	...	...	...	...	-170.08	...	...	...	...	...	16.55	-32.01	6.69
	(+)	6979.35	...	...	...	...	...	...	-176.44	...	...	...	...	...	21.89	-38.38	11.72
C-O	(-)	7228.48	...	...	...	...	...	...	-158.59	...	...	...	...	...	14.83	-19.86	0.70
	$\hat{b}_i$	7245.58	...	...	...	...	...	...	-165.98	...	...	...	...	...	23.03	-25.83	6.41
	(+)	7262.68	...	...	...	...	...	...	-173.37	...	...	...	...	...	31.22	-31.80	12.12
METREGAUGE ON ALLGAUGE [MG/AG]																	
OLS	(-)	...	...	-2.31	...	...	-3.39	-5.18	...	-6.26	...	...	...	...	...	-3.90	-9.40
	$\hat{b}_i$	...	...	2.31	...	...	-8.41	2.10	...	1.12	...	...	...	...	...	0.72	0.68
	(+)	...	...	6.94	...	...	-13.43	9.38	...	8.50	...	...	...	...	...	5.34	10.75
C-O	(-)	...	-5.13	-3.36	...	...	-4.65	-6.40	...	-7.71	...	...	...	...	...	...	-11.22
	$\hat{b}_i$	...	0.29	2.73	...	...	-12.73	2.51	...	1.16	...	...	...	...	...	...	0.66
	(+)	...	5.70	8.83	...	...	-20.81	11.41	...	10.03	...	...	...	...	...	...	12.55
METREGAUGE ON BROADGAUGE [MG/BG]																	
OLS	(-)	666.64	-4.17	1.82	...	...	-27.45	-1.98	...	0.40	...	...	...	...	...	...	-8.28
	$\hat{b}_i$	672.38	0.49	6.84	...	...	-34.54	3.60	...	4.81	...	...	...	...	...	...	1.20
	(+)	678.12	5.15	11.87	...	...	-41.64	9.18	...	9.22	...	...	...	...	...	...	10.69
C-O	(-)	642.59	-4.25	1.16	...	...	-35.68	-1.80	...	1.05	...	...	...	...	...	...	-10.30
	$\hat{b}_i$	648.40	0.46	6.27	...	...	-44.11	4.36	...	7.27	...	...	...	...	...	...	1.26
	(+)	654.21	5.17	11.39	...	...	-52.54	10.53	...	13.50	...	...	...	...	...	...	12.83

Note: Positive (+) and negative (-) probability limits are defined for freight coefficients at 95% confidence by $\{\hat{b}_i \pm s.e.(\hat{b}_i)t_{0.025}\}$

Table 6.3c: Intercommodity Relationships in IR Freight Operations
Significant Freight Coefficients and 99% Confidence Bands

		COMMODITY COEFFICIENTS															
		$\hat{b}_0$ Constant	$\hat{b}_1$ GPulses	$\hat{b}_2$ OSeed	$\hat{b}_3$ Tea	$\hat{b}_4$ RCott	$\hat{b}_5$ CottMf	$\hat{b}_6$ RJute	$\hat{b}_7$ JuteMf	$\hat{b}_8$ SCane	$\hat{b}_9$ Sugar	$\hat{b}_{10}$ CCoke	$\hat{b}_{11}$ MnOre	$\hat{b}_{12}$ OMOre	$\hat{b}_{13}$ IOre	$\hat{b}_{14}$ ISteel	$\hat{b}_{15}$ Cement
ALLGAUGE ON BROADGAUGE [AG/BG]																	
OLS	*(-)*	...	*-17.88*	...	...	...	*-24.13*	*-5.15*	...	...	...	*-20.33*	...	...	*-8.17*	*-7.83*	*-21.56*
	,	...	**1.49**	...	...	...	**-33.54**	**4.60**	...	...	...	**0.81**	...	...	**0.70**	**1.69**	**2.20**
	(+)	...	*20.86*	...	...	...	*-42.96*	*14.35*	...	...	...	*21.94*	...	...	*9.56*	*11.20*	*25.96*
C-O	*(-)*	...	*-18.98*	*-0.86*	...	...	*-31.83*	*-5.02*	...	*-1.43*	...	*-21.13*	...	...	*-8.11*	*-9.81*	*-26.15*
	,	...	**1.46**	**7.27**	...	...	**-43.11**	**5.36**	...	**8.27**	...	**0.83**	...	...	**0.61**	**1.76**	**2.26**
	(+)	...	*21.90*	*15.40*	...	...	*-54.39*	*15.74*	...	*17.98*	...	*22.80*	...	...	*9.33*	*13.32*	*30.67*
ALLGAUGE ON METREGAUGE [AG/MG]																	
OLS	*(-)*	*6946.50*	...	...	...	...	...	...	*-160.44*	...	...	...	...	...	...	...	...
	,	**6965.47**	...	...	...	...	...	...	**-169.08**	...	...	...	...	...	...	...	...
	(+)	*6984.44*	...	...	...	...	...	...	*-177.73*	...	...	...	...	...	...	...	...
C-O	*(-)*	*7220.81*	...	...	...	...	...	...	*-154.85*	...	...	...	...	...	*12.31*	...	*-1.64*
	,	**7244.25**	...	...	...	...	...	...	**-164.91**	...	...	...	...	...	**24.04**	...	**7.41**
	(+)	*7267.68*	...	...	...	...	...	...	*-174.98*	...	...	...	...	...	*35.77*	...	*16.45*
BROADGAUGE ON ALLGAUGE [BG/AG]																	
OLS	*(-)*	...	*-16.40*	...	...	...	...	...	...	...	...	*-44.39*	...	...	...	...	...
	,	...	**0.74**	...	...	...	...	...	...	...	...	**1.09**	...	...	...	...	...
	(+)	...	*17.88*	...	...	...	...	...	...	...	...	*46.57*	...	...	...	...	...
C-O	*(-)*	...	*-17.41*	...	...	...	*3.74*	...	...	...	...	*-49.57*	...	...	*-17.42*	...	...
	,	...	**0.70**	...	...	...	**14.94**	...	...	...	...	**1.08**	...	...	**1.17**	...	...
	(+)	...	*18.82*	...	...	...	*26.14*	...	...	...	...	*51.74*	...	...	*19.75*	...	...
BROADGAUGE ON METRE GAUGE [BG/MG]																	
OLS	*(-)*	*6946.50*	...	...	...	...	...	...	*-161.39*	...	...	...	...	...	...	*-23.30*	...
	,	**6965.47**	...	...	...	...	...	...	**-170.08**	...	...	...	...	...	...	**-32.01**	...
	(+)	*6984.44*	...	...	...	...	...	...	*-178.78*	...	...	...	...	...	...	*-40.72*	...
C-O	*(-)*	*7222.16*	...	...	...	...	...	...	*-155.86*	...	...	...	...	...	*11.80*	...	...
	,	**7245.58**	...	...	...	...	...	...	**-165.98**	...	...	...	...	...	**23.03**	...	...
	(+)	*7269.01*	...	...	...	...	...	...	*-176.11*	...	...	...	...	...	*34.26*	...	...
METREGAUGE ON ALLGAUGE [MG/AG]																	
OLS	*(-)*	...	...	...	...	...	...	*-7.84*	...	*-8.96*	...	...	...	...	...	...	*-13.10*
	,	...	...	...	...	...	...	**2.10**	...	**1.12**	...	...	...	...	...	..	**0.68**
	(+)	...	...	...	...	...	...	*12.04*	...	*11.20*	...	...	...	...	...	...	*14.45*
C-O	*(-)*	...	...	*-5.61*	...	...	*-1.66*	*-9.69*	...	*-10.99*	...	...	...	...	...	...	*-15.62*
	,	...	...	**2.73**	...	...	**-12.73**	**2.51**	...	**1.16**	...	...	...	...	...	...	**0.66**
	(+)	...	...	*11.08*	...	...	*-23.80*	*14.70*	...	*13.31*	...	...	...	...	...	...	*16.95*
METREGAUGE ON BROADGAUGE [MG/BG]																	
OLS	*(-)*	...	...	...	...	...	*-24.85*	...	...	...	...	...	...	...	...	...	*-11.76*
	,	...	...	...	...	...	**-34.54**	...	...	...	...	...	...	...	...	...	**1.20**
	(+)	...	...	...	...	...	*-44.24*	...	...	...	...	...	...	...	...	...	*14.17*
C-O	*(-)*	...	...	...	...	...	*-32.57*	*-4.08*	...	*-1.26*	...	...	...	...	...	...	*-14.58*
	,	...	...	...	...	...	**-44.11**	**4.36**	...	**7.27**	...	...	...	...	...	...	**1.26**
	(+)	...	...	...	...	...	*-55.65*	*12.81*	...	*15.80*	...	...	...	...	...	...	*17.11*

Note: Positive (+) and negative (-) probability limits are defined for freight coefficients at 99% confidence by $\{\hat{b}_i \pm s.e.(\hat{b}_i)t_{0.005}\}$

freight trend is provided by the transition of India from a purely agricultural economy to a growingly industrialised nation. It is here that the time-scale of the data begins to seem inappropriate. While for over 100 years, railway freight operations in India served the purpose of maintaining the economic *status quo*, the five planning decades have initiated a major break with the past. With the economy in transition following the establishment of heavy industry in the state sector during the early plans, downstream economic growth has accelerated in the later period. With this transition still far from complete, a more comprehensive evaluation of economic and infrastructural trends must await the future. The task of the present study is more limited, and concerns the evaluation of railway freight trends and their infrastructural role. This is attempted in the following sections through appropriate regression modelling methodologies.

6.3 IR Wagon-Loadings: Regression Analysis

Although the variations in IR freight-flows are seemingly interrelated, imputation of cause-and-effect across observed patterns of commodity freight is a complex task. While in the main, the declining loadings of certain commodities may be attributed to the rise in loadings of others, the intercommodity relation is in itself a combination of direct and oblique crossinfluences where displacement of one commodity by another may arise from direct competition within the same freight segment, as well as from the displacement of forward-linked or backward-linked commodities in other freight segments. Implicit factors also enter observed variances in the dataset. Holding particular importance among these are the technological determinants of freight capacity which also dictate the differences in relative availability of railway freight services to particular sectors and regions. Spatial factors such as the location of points of originating loadings and the magnitude and direction of commodity leads are also implicitly present within the dataset. Thus a proper investigation of commodity-freight trends must take recourse to specific mathematical tools of analysis which fit the dataset.

In the first approach, simple multiple regression analysis is undertaken to shed some light on intercommodity relationships between the wagon loadings of 15 commodities carried by IR for a period of 35 years commencing with 2FYP in 1955-56. Non-availability of similar data on other major freight categories like foodgrains, fertilisers and POL restricts multiple regression modelling to these 15 commodities and may consequently subject the analysis to modelling problems arising from the non-specification of major variables. After investigating the latter possibility, suitable modelling modifications can be resorted to.

Much more robustness can be added by the regression procedure to the simple working insights obtained from the earlier heuristic analysis. This becomes especially apparent when cross-gauge analysis is made of the statistical influence of IR wagon loadings in the BG network on resulting MG freight patterns. Secular transition in IR freight priorities over the planning period following the change in national transport policy, which can only be dimly perceived from visual examination of the dataset, is also captured much more vividly in the intercommodity regression relationships.

6.3.1 Multiple Regression Modelling

The standard model for the multiple regression analysis has been represented in matrix form below. The regression model comprises 16 freight variables with total gauge loadings for AG, BG and MG as regressands and with the gaugewise commodity loadings of wagons as regressors. One such regression for instance may regress total AG loadings by IR on individual wagon loadings of the 15 commodities carried on the BG or MG. The formal model may thus be stated as

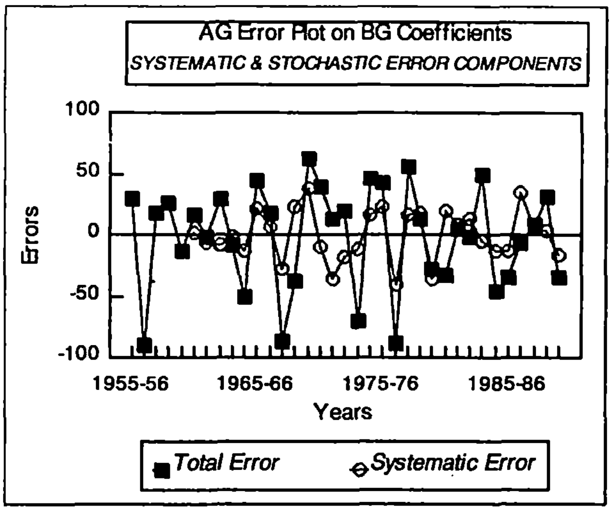
$$Y_i = b_0 + b_1W_{1i} + b_2W_{2i} + \dots\dots + b_{15}W_{15i} + U_i \qquad i = 1,2,\dots\dots,35 \qquad \dots\dots \quad (6.1)$$

or, $$\mathbf{Y} = \mathbf{Wb} + \mathbf{U} \qquad \dots\dots \quad (6.2)$$

with matix and vector equivalents as

Figure 6.2: Analysis of OLS Residuals

Fig 6.2a: Error Estimates on BG Wagon-loading Coefficients



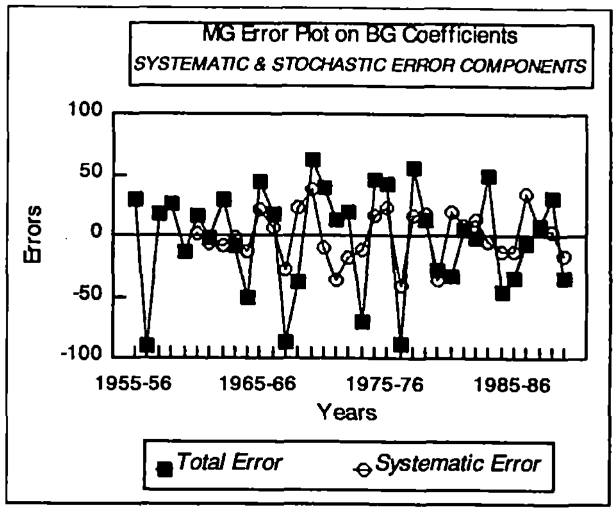
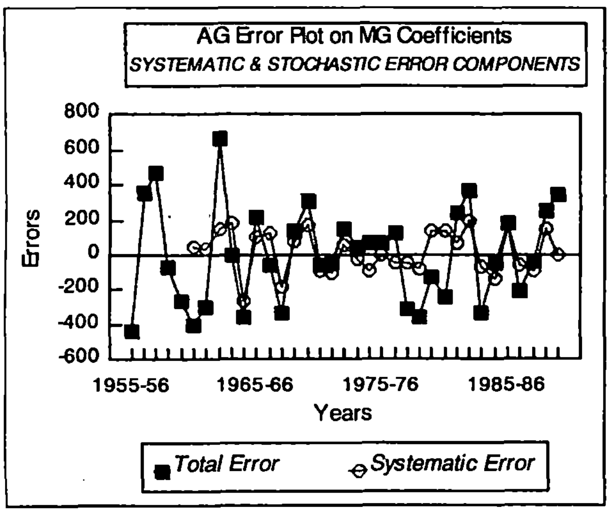


Fig 6.2b: Error Estimates on MG Wagon-loading Coefficients



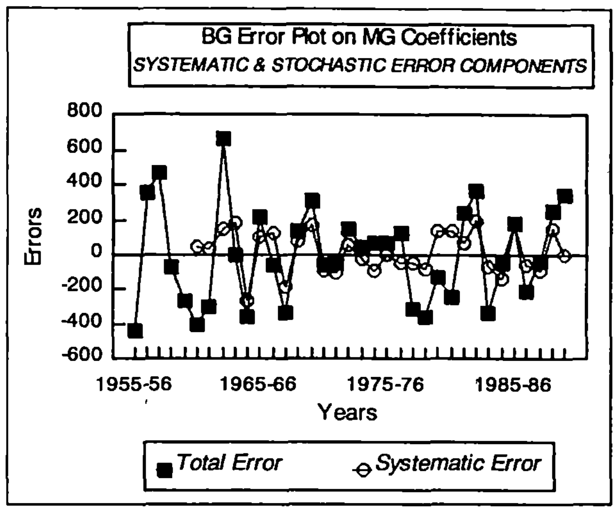
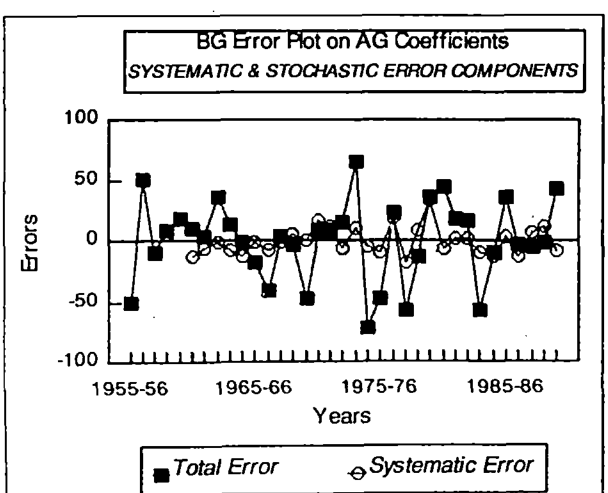
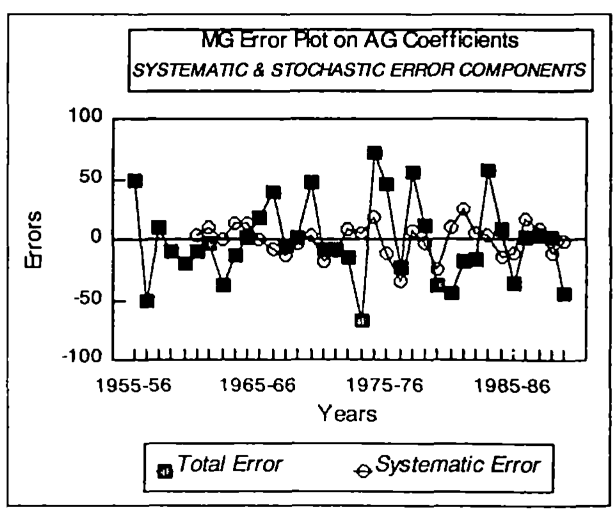


Fig 6.2c: Error Estimates on AG Wagon-loading Coefficients





$$
\begin{vmatrix} Y_1 \\ Y_2 \\ \cdots \\ \cdots \\ Y_{35} \end{vmatrix}_{[35 \times 1]} = \begin{vmatrix} 1\ w_{11}\, w_{21}\, w_{31} \ \cdots\cdots\cdots\ w_{15,1} \\ 1\ w_{12}\, w_{22}\, w_{32} \ \cdots\cdots\cdots\ w_{15,2} \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ 1\ w_{1,35}\, w_{2,35}\, w_{3,35} \cdots\cdots\ w_{15,35} \end{vmatrix}_{[35 \times 16]} \cdot \begin{vmatrix} b_0 \\ b_1 \\ \cdots \\ \cdots \\ b_{15} \end{vmatrix}_{[16 \times 1]} + \begin{vmatrix} u_1 \\ u_2 \\ \cdots \\ \cdots \\ u_{35} \end{vmatrix}_{[35 \times 1]} \quad \ldots\ (6.3)
$$

and where Y_i represent regressand values of aggregate IR wagon loadings for each year of the given 35-year dataframe, w_{ki} represent wagon loadings of the kth commodity in the given year, b_i represent the computed freight coefficients for each commodity and u_i represent the unexplained or stochastic variation within IR freight loadings, attributable to other commodities not within the wagon-loading dataset. The influence of freight historicity on subsequent IR wagon loading patterns are captured in b_0 or the intercept term. The matrix **W** is thus the expanded form of the wagon-loading dataset. A choice of regressor sets is provided by the gaugewise MG and BG commodity loadings of Tables 6.1 and 6.2 and AG commodity loadings over all gauges in Table 7.5 in the next chapter, each choice lending itself to different interpretations. The materialisation of freight demand and subsequent wagon allocation are assumed to be instantaneous processes, so that no explicit lags are introduced into the analysis.

Table 6.3d: Regression Analysis of Commodity-wise Wagon Loadings in IR Freight Operations
Tests of the Goodness of Fit of R^2 and $\bar{R}^2$ and Significance of the Regression

Regression Procedure	R^2	Adjusted $\bar{R}^2$	s.e.($\hat{y}$)	*df*	Theoretical $t_{0.05}$	$t_{0.01}$
ALLGAUGE ON BROADGAUGE [AG/BG]						
OLS	**0.999**	**0.999**	56.445	19	*2.0930*	*2.8609*
C-O	**1.000**	**0.999**	52,894	18	*2.1009*	*2.8784*
ALLGAUGE ON METREGAUGE [AG/MG]						
OLS	**0.976**	**0.957**	374.427	19	*2.0930*	*2.8609*
C-O	**0.982**	**0.967**	314.371	18	*2.1009*	*2.8784*
BROADGAUGE ON ALLGAUGE [BG/AG]						
OLS	**1.000**	**0.999**	44.690	19	*2.0930*	*2.8609*
C-O	**1.000**	**1.000**	40.078	18	*2.1009*	*2.8784*
BROAD GAUGE ON METREGAUGE [BG/MG]						
OLS	**0.980**	**0.964**	374.427	19	*2.0930*	*2.8609*
C-O	**0.985**	**0.973**	314.428	18	*2.1009*	*2.8784*
METREGAUGE ON ALLGAUGE [MG/AG]						
OLS	**0.980**	**0.965**	44.690	19	*2.0930*	*2.8609*
C-O	**0.991**	**0.983**	41.224	18	*2.1009*	*2.8784*
METREGAUGE ON BROADGAUGE [MG/BG]						
OLS	**0.969**	**0.944**	56.445	19	*2.0930*	*2.8609*
C-O	**0.983**	**0.969**	52.894	18	*2.1009*	*2.8784*

6.3.2 Cross-Commodity & Cross-Gauge Interrelationships in IR Freight

Regression results for OLS are presented jointly with results from the subsequent Cochrane-Orcutt adjustment in Tables 6.3*a* to 6.3d.An anticipatory word may be said about the development significance of the regression procedures. Specific cross-gauge regression of commodity freight loadings provides an estimate of regional interdependence in IR freight operations, bearing in mind that the MG network had traditionally served to consolidate freight flow from the hinterland to the mainline BG network. Since this regional specialisation of gauge still exists by default, the impact of IR's technological specialisation on hinterland freight flows to the railway network can thus be assessed from the regression. On the other hand, regressions of aggregate or crossgauge IR freight loadings on respective BG and MG loadings of commodity freight capture the relative influence that gaugewise commodity loadings exert on overall freight operations by IR. As such, commodities which have simultaneously either maintained or lost freight presence on both feeder and mainline IR networks exercise a deeper influence on AG wagon loadings than commodities which are freighted primarily over a single railway gauge. Converse regressions of aggregate BG and MG freight loadings on the loadings of commodity freight over all IR gauges capture the evolutionary influence on mainline and feeder railway freight operations exerted by freight policy in general and by its commodity and gauge specialisations.

The regression estimates of the commodity-freight coefficients are also important since they offer a direct measure of the continuing or declining importance of the respective commodity freight flows to aggregate mainline and hinterland freight operations by IR. While negative magnitudes for the commodity coefficient indicate inverse relationships between wagon loadings of the commodity and aggregate railway wagon loadings, the actual direction of influence may vary depending on whether the wagon-loading series have shown increasing or decreasing longterm trends over the 35-year time period. Thus interpretation of the commodity-freight coefficients in Table 6.3*a* has to be accompanied by visual examination of the associated wagon-loading dataset so that a correct interpretation can emerge.

The values for R^2 and $\bar{R}^2$ obtained for OLS regressions of aggregate gaugewise wagon lopadings on the specific loadings of different commodities are indicated in Table 6.3*d* above, which also indicates the theoretical values of the *t*-statistic at 95% and 99% confidence levels for testing the significance of the estimates of the respective commodity-freight coefficients. Table 6.3*b* indicates the intercommodity relationships found significant at 95% confidence levels for the OLS regressions of gaugewise freight loadings on the gaugewise loadings of individual commodities from the 15-commodity dataset. The upper and lower confidence limits for each commodity-freight coefficient form the (+/-) probability bands around each $\hat{b}_i$ coefficient estimate. As the table shows, overall BG freight loadings are significantly influenced by the BG loadings of most commodities, and also by the MG loadings of core industrials like iron ore, iron & steel and cement. These commodities have also been able to hold their own in MG freight operations. Among the other non-core commodities loaded on MG, only manufactured jute products continue to influence AG loading patterns. However, with the commodity-freight coefficient for jute manufactures being negative, around a relatively static MG loading trend, the overall impact of these on the AG/MG regression indicates that the MG commodity-freight in manufactured jute has displaced MG freight in several other commodities. Indication that a more specialised commodity-freight mix has evolved principally on IR's BG freight network is visible in the BG/AG and BG/MG regressions. These show that while aggregate BG freight loadings are influenced by fewer BG commodities, MG loadings of core industrials and jute manufactures continue to influence BG loading trends to almost the same degree as before. This also indicates that the principal MG commodity-freight flows on IR comprise feeder freight which either flows from or to the BG network. This is borne out again by the MG/AG and MG/BG regressions, which show principally that the cutback in IR's MG freight capacity has been absorbed by the longterm decline in BG loadings of cotton manufactures, which has allowed the partial preservation of MG freight volumes in grams & pulses, oilseeds, raw jute and manufactured sugar - all commodities with a feeder relation to the agricultural sector. The remainder of the slack has been taken up increased BG and MG loadings of cement. BG loadings of other core industrials now have scarecely any impact on IR's MG freight operations.

By contrast, the intercommodity freight relationships that remain significant at 99% confidence levels are generally sparse, with IR freight performance being influenced by the freight handling trends of only a few commodities. Overall AG freight loadings are mostly influenced by freight trends on the BG network. AG wagon loadings rise fairly strongly when BG handling of cement, iron & steel and grams & pulses increases and more moderately with expanded BG handling of coal & coke and iron ore. Overall BG freight handling trends on the other hand are less influenced by network-wide commodity loadings on IR, with the exception of coal & coke and grams & pulses. This apparently paradoxical result illustrates the effectiveness of the regression procedure in discriminating between interregional flows of commodities that are jointly handled by both BG and MG networks and involve transhipment, and freight flows involving commodities that are primarily handled within a single gauge. The strong influence of BG freight flows of cotton manufactures on overall IR freight handling deserves special attention, since obviously the freight downtrend in this historically important general-freight commodity frees substantial haulage capacity for other commodity flows. The juxtaposition of trends and coefficients would in fact suggest the displacement of cotton manufactures as a result of IR freight specialisation.

Although historic MG commodity handling patterns have fairly high influence on BG and overall freight handling by IR as revealed by the respective $\hat{b}_0$ coefficients, the converse is not true. This is in itself an interesting result since it indicates slackening of the MG network's feeder role, accompanying the strong departure that evolving BG freight patterns over the 35-year study period have made from the past historic modes of railway freight handling in India. It also appears likely that the major part of this historical influence of MG freight handling reflects MG-to-BG transhipment of bulk commodities rather than the opposite.

The simple correlation matrices obtained for the BG, MG and AG commodity-loading datasets are reproduced in Tables 6.1*b*, 6.2*b* and Table 7.5 in the next chapter. Since each simple correlation matrix is composed of zero-ordered correlation coefficients, where by definition, the degree of correlation between wagon-loadings for any pair of commodities is computed independently of any crossrelation that these wagon loadings show to any other commodity within the dataset. On first examination, the gaugewise simple correlation coefficients computed on the 15-commodity IR wagon loading series apparently show IR commodity freight trends to be highly correlated. It appears likely however that the data matrix is affected by a high degree of multicollinearity because of commodity-freight interdependence, although in the multiple regression analysis, the thumb-rule test of multicollinearity, *i.e.*, high R^2 and insignificant *t*-values for the b_i coefficients might suggest otherwise. It therefore becomes necessary to examine the residuals for the OLS regressions more closely.

6.4 Analysis of OLS Residuals

Assessment of the crossrelation in error residuals from the OLS regressions may begin from consideration of the time-sequence plots in Fig 6.2 of the OLS residuals associated with BG, MG and AG wagon loading coefficients for the 15-commodity dataset. No variation emerges between OLS residuals when BG loadings of commodities are alternately used as regressors for aggregate and MG wagon loadings [*Fig 6.2a*], and again when MG commodity loadings are used alternately as regressors for aggregate and BG wagon loadings [*Fig 6.2b*], indicating overall consistency in the respective OLS regression pairs. This arises from AG wagon loadings being tautologically defined in this case by the sum of commodity-wise wagon loadings on both IR gauges. The extent to which commodity-wise wagon loading trends on either gauge determine aggregate IR wagon loadings as well as loadings on the other IR gauge segment is internally consistent, since trends in the dataset show that while BG wagon loadings have increased substantially over the 35-year study period, MG wagon loadings on the other hand have declined. Differences become apparent however in the character of overall IR wagon-loading response to BG and MG commodity loading trends. Because strong increases in the BG wagon loadings of selected bulk commodities have tended to supplant the wider spectrum of other IR non-bulk freight, OLS regressions made on BG commodity coefficients [*see Fig 6.2a*]underestimate the potential trend of AG and MG freight loadings and overestimate the shortfall or error component e_i. Error-variances being similarly overestimated, the downward BG wagon loading trends in non-bulk commodities are then presumed to have carried over much more strongly than they actually do into the aggregate AG loadings - the displacement of non-bulk freight categories on the MG network being less severe than anticipated. The truth of the matter, verifiable from the wagon-loading dataset, is that while increased BG bulk-loadings by IR over the study period have displaced other commodities from the BG network and some from the IR railway system altogether - this traffic being gained by the other transportation modes - the shift to bulk freight is evident also on the MG network, where higher proportionate loadings of cement, coal & coke, and grams & pulses in the late period mitigate the loss of other IR traffic to a greater extent than would have been anticipated. Another point of observation is that the largest error ranges, i.e. the widest swings in OLS estimates of AG and MG wagon loadings congregate in the middle period of the study, earlier identified as representing an operational 'plateau'. Errors decline relatively in the late period when after the shift to bulk, OLS estimates of firm traffic become more reliable.

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The observation however changes when the OLS residual plot based on MG commodity coefficients is considered [*see Fig 6.2b*], because the middle period in this case is characterised by the lowest error-variances. The implication here would be that fluctuations in IR wagon loadings and commodity traffic in the oil crisis-affected period were more a characteristic of the BG networks and of the specific freight-mix carried on them, than of the entire IR system. MG traffic in that period was relatively stable because of the preponderance of agricultural and light industrial commodities in the traffic-mix, which imparted a core of stability to IR freight loadings during the severe recession in medium and heavy industries that hit the Indian economy over the 1970s, consequent upon the twin oil crises.[31] The error residuals estimated when AG and BG wagon loadings are regressed on MG commodity coefficients are therefore consequently small for the given period. The shift to bulk operations on both railway gauges over the 1980s, accompanied by downgrading of MG operations however greatly altered the commodity character of IR freight flows and expanded the associated OLS error-variances in the late period. Another point of observation with respect to the residuals on MG commodity coefficients is that over the 35-year study period, they tend in general to be positively autocorrelated because of their inherently rising trend. The late period of the study has actually been marked by sharp contraction in MG freight capacity because of nonreplacement of traction and rolling stock as a part of official IR policy. As a natural consequence the materialisations of freight traffic estimated on the basis of MG commodity coefficients are higher than the MG freight capacity retained by IR. The excess of this traffic obviously shifts to the roadways especially since it is composed of the very commodities that IR has been trying to exclude from its freight-mix.

While residuals for the paired OLS estimates of overall IR freight loadings on BG and MG commodity coefficients display the symmetry alluded to above, the residuals for aggregate BG and MG freight loadings from their regression on the AG commodity coefficients [*Fig 6.2c*]are markedly different, and in fact show antisymmetry, as evident in the residual plot. This antisymmetry would establish strong opposition between estimated BG and MG freight loading trends, so that MG loading estimates rise in the years when the estimated BG loading shows a shortfall, and vice versa. As a first approximation, residual behaviour of this nature would indicate that the BG and MG commodity freight flows on the IR network - both of which are subsumed in the AG commodity coefficients - are by and large consonant/dissonant in the sense that severe freight losses on one gauge are not entirely carried over to the other gauge, primarily because of the differences in MG and BG freight-loading patterns.

Another point of interest here is that the wagon-loading dataset includes both originating and transhipment loadings of freight, so that the locational pattern of freight operations enters as a determinant. It may be inferred in general from the residual plot that not all originating loadings of commodity freight tranship from one gauge-network to the other, for a high degree of transhipment would usually imply symmetry in BG and MG loadings of the commodity. Instead, what is seen in the wagon-loading dataset and is sufficiently captured in the associated error residuals is the nature of attenuation in IR freight operations in consequence of the rising bulk trend. Thus while wagon loadings of bulk commodities tend to be originating loads and moreover tend to be transported in most cases over a single railway gauge, giving rise to the increases in average freight lead noticed earlier, the same does not necessarily apply to other commodities for which originating loadings are not matched by equivalent transhipment. In a high rated commodity like cotton manufactures, for example, where the principal freight loading originates in the BG-dominated western region, increases in BG bulk freight have induced a shift of originating loads to the roadways. Transhipment loadings on IR do not accordingly materialise. On the other hand, for commodities governed by concessional tariffs, e.g. grams & pulses, originating loadings on one gauge carry over into transhipments on the other gauge. Since the commodity set being considered is a mixed bag of both low rated and high rated commodities, both tendencies exist in the data. But growing preeminence of BG and bulk operations on the IR freight system on the whole ensure the retention of originating loadings in most commodities without concomitant transhipment loadings, implying the delinking of BG and MG freight operations as also of IR and roadways transportation. Since the trend has only multiplied over the passage of time, transportation policy in India is far removed from the cogent utilisation of intermodal freight facilities, despite interventions such as the National Transport Policy formulated by the NTPC.

It is also noticed that the errors in the residual plot have generally tended to widen after the 1970s except for one brief interlude near the commencement of the 7FYP. As expected, the highest residual ranges occur in the mid-1970s, after which IR's shift towards bulk freight never let the subsequent wagon loading trends quieten down. This assessment of the OLS error residuals also allows an overall statement to be made in respect of IR freight policy and especially of its bulk-freight emphasis after the 1970s. In the foregoing analysis, erratic freight-flows in other commodity categories are generally seen to have been the consequence of the bulk-freight policy, with the retention of certain essential commodities of agricultural origin in the IR freight-mix being rendered possible by favourable tariffs. The other category of high-rated low-bulk traffic has generally switched to alternative transport modes despite the retention of some of it on the MG network. However, the downgrading of MG railway operations and nonreplacement of wornout MG railway inventories has jeopardised such retention, and the lack of freight integration between the two railway gauges eventually contributes to the ultimately losing character of the metre gauge.

6.4.1 Tests for Heteroscedasticity in the OLS Residuals

The wagon loading data on which the multiple regression analysis is being made span the rather long time-interval of 35 years, during which several structural changes in railway freight policy and IR wagon fleets had earlier been noted, consonant with the changes in plan emphases over the various FYPs. While aggregate freight tonnages and traffic have accordingly risen, shifts in commodity loadings towards bulk freight have lessened uncertainties regarding the firm availability of freight, which had characterised IR freight operations in the early planning period when a more assorted mix of commodity-freight had been carried. It would be interesting to examine whether such shifts in policy have indeed imparted greater stability over time to the wagon loading performance of IR.

The conjecture to be examined, namely whether variability of freight has been reduced in more recent times, is approximated by positing the existence of heteroscedasticity in the wagon loading data, with the assumption of decreasing error variances over time. An appropriate test for the relevant hypotheses may therefore be applied to the OLS multiple regressions just computed.

In a k-variable linear regression model of the form

$$Y_i = \beta_1 + \beta_2 X_{2i} + \ldots\ldots + \beta_k X_{ki} + u_i \qquad \ldots. \quad (6.4)$$

the existence of heteroscedasticity can be postulated by linearly relating the error variance σ^2_i to non-stochastic variables Z_{mi}, which may include some or all of the OLS regressors X_{ni} ($n = 2, \ldots, k$). The relationship to be tested in order to validate the presence or absence of heteroscedasticity is therefore accordingly

$$\sigma^2_i = \alpha_1 + \alpha_2 Z_{2i} + \ldots\ldots + \alpha_m Z_{mi} \qquad \ldots. \quad (6.5)$$

for which homoscedasticity or the *constant-variance* property is established for $\alpha_2 = \alpha_3 = \ldots\ldots = \alpha_m = 0$, so that $\sigma^2_i = \alpha_1$, which is then a constant. Conversely, when $\alpha_2 \neq \alpha_3 \neq \ldots\ldots \neq \alpha_m \neq 0$, the error variance σ^2_i becomes unstable and varies either directly or inversely with values of Z_{mi}. Breusch and Pagan therefore propose an advanced test for homoscedasticity[32] based on whether the B-P test statistic defined by bifurcating the *explained sum of squares* [ESS] into two equal parts approximates the χ^2 distribution, when computed from the regression of p_i on the constructed variables Z_{mi},

$$i.e. \quad p_i = \alpha_1 + \alpha_2 Z_{2i} + \ldots\ldots + \alpha_m Z_{mi} + v_i \qquad \ldots. \quad (6.6)$$

where p_i relates the squared residual variances not captured within the OLS regression to the Maximum

Likelihood estimate of error variance σ^2 via the relationship $p_i = e_i^2 / \tilde{\sigma}^2$ (where $\tilde{\sigma}^2 = \Sigma e_i^2 / N$).

Table 6.4 : *Analysis of OLS Residuals:*
Breusch-Pagan Test for Heteroscedasticity in the OLS Dataset

Form of OLS Regression	Error Sum of Squares [ESS]	Maximum Likelihood [ML] Estimate of Variance	Value of B-P Statistic [Estimated χ^2]	*Nature of Residual Variances*
AG Freight on AG Wagon Loadings	0.00	0.00	7.08×10^{21}	**
AG Freight on BG Wagon Loadings	60534.99	1729.57	0.00	*homoscedastic*
AG Freight on MG Wagon Loadings	2663721.11	76106.32	0.00	*homoscedastic*
BG Freight on AG Wagon Loadings	37946.10	1084.17	0.00	*homoscedastic*
BG Freight on BG Wagon Loadings	0.00	0.00	1.78×10^{22}	**
BG Freight on MG Wagon Loadings	2663721.11	76106.32	0.00	*homoscedastic*
MG Freight on AG Wagon Loadings	37946.10	1084.17	0.00	*homoscedastic*
MG Freight on BG Wagon Loadings	60534.99	1729.57	0.00	*homoscedastic*
MG Freight on MG Wagon Loadings	0.00	0.00	1.75×10^{24}	**

Applying the test to the OLS regression of gaugewise wagon loadings on the individual wagon-loadings by commodity, the values of the B-P statistic computed on OLS residuals are tabulated in Table 6.4 above. Except in the trivial AG/AG, BG/BG and MG/MG regressions where computed χ^2 values are apparently significant, heteroscedasticity is not established in the other OLS regressions, indicating that freight policy changes and restructured IR wagonfleets have in fact neither imparted greater stability nor greater variability to IR wagon loading performance over the planning period. Although this inference is partially qualified because gauge-conversion from MG to BG has progressively reduced the levels of transhipment loadings on IR over the time horizon of the study, the changes in IR freight policy thus appear to have been geared towards stabilising the tonnages freighted by IR rather than the freight traffic carried. However, because of the shifting composition of the IR freight-mix towards bulk-freight, these rising tonnage volumes have not been adequately reflected in higher wagon loadings because of intervention from two interrelated factors, as a result of which identical freight tonnages are now transported on fewer wagons because of the growing proportion of bulk commodities, while increased specialisation in the IR wagonfleet and augmentation in the average carrying capacity of IR wagons serves to further reinforce this trend.

6.4.2 Serial Correlation in the OLS Residuals

While the analysis just concluded has shown that the OLS regressions are relatively free of heteroscedastic residuals, so that the stability of the OLS commodity-loading coefficients is not threatened by nonstochastic error, serial correlation between the time-series residuals can still vitiate the OLS regressions. Canonical OLS assumptions demand independence between error terms, in order to maintain the efficiency of coefficient estimates via the *minimum variance* property. However the phenomenon of nonindependent errors, which can often occur in the analysis of longitudinal datasets because of inertial tendencies, misspecification of regressed forms, or the existence of serial lags in relationships, can have serious consequences on the accuracy and significance properties of coefficients and consequently on overall surmises about the strength of the regressed relationship. Since the operational indicators for IR explored in the previous chapter had shown conformance to a distributed-lag structure induced by the planning process, strong apprehensions exist that OLS regressions of the wagon-loading timeseries would be affected by serial correlation because of non-lagged specifications, etc. The economic underpinning for the structural patterns of intercommodity and interperiod dependence observed in IR freight loadings lies in the evolutionary path which transportation planning and policy have followed in India over the planning era. Thus the various factors to which the existence of serial correlation in error residuals might be attributed, if established, would also add dramatic insights into the overall consequences of transport and railway policy. Testing of the OLS results for serial correlation is therefore undertaken next.

An exploration also has necessarily to be made of the autoregressive properties of residuals in the OLS regressions. In serially-dependent datasets - a case not uncommon to timeseries, OLS regression coefficients remain consistent and unbiased, but shed their *minimum-variance* property and are no longer considered efficient.[33] Recourse to model adjustments has therefore to be made in order to restore reliability to the coefficient estimates. The serially-dependent nature of the IR wagon loading dataset and the presence of serial correlation in the OLS residuals for the AG and MG regressions on BG commodity-loadings and the BG and MG regressions on AG commodity-loadings is established through the standard econometric test procedure of the D-W *d* test, and alternatively through the nonparametric or *distribution-free* Geary 'Runs' test.[34] The precise impact of serial correlation on the residuals, and consequent distortion in the numerical OLS estimates of different commodity coefficients had already become apparent during the earlier examination of OLS residuals for normality properties, which had allowed the segregation of systematic and stochastic error components in the associated residual plots.

In the context of the present dataset, serial correlation or autocorrelation would occur if current wagon loadings of any commodity were determined by the wagon loadings of the same and/or other commodities in past periods, in which case the classical OLS assumption of *error-independence* would be violated,

$$i.e. \quad E(u_i u_j) \neq 0 \qquad i \neq j \qquad \text{....} \quad (6.7)$$

which, for longitudinal data, would translate to

$$E(u_t u_{t-1}) \neq 0 \qquad \text{....} \quad (6.8)$$

where t and $t\text{-}1$ are time-subscripts, with *auto*correlation translating into *serial* correlation or *lag* correlation.[35]

As mentioned earlier, the point of interest in the tautological regressions concerns the possible presence of serial correlation in the longitudinal dataseries under consideration. Analyses of serial or autocorrelation can thus be utilised to explore the intersectoral relationships of IR wagon loadings for the particular reason that while railway commodity-freight loadings respond partially to production patterns in different sectors of the economy, they are circumscribed severely by the overall freight-capacity constraint imposed by wagonfleet and line-capacity utilisation and freight specialisation. It can therefore be logically expected that variation in the wagon loadings of the commodity inputs or outputs for any economic sector would affect the wagon loadings pertaining to other economic sectors either positively or negatively. Again, because of crossgauge flows of IR freight over spatially-delimited BG and MG networks, changes in any particular gaugewise series of commodity loadings would also carry over into the transhipment loadings of the same category of freight on the other gauge.

For all these reasons, presence of serial dependence in the BG and MG wagon loading datasets cannot and need not be wished away, since the serial correlation characteristics offer a measure of insight into intersectoral dependence in IR freight operations. Other potential sources also exist, to which serial correlation in IR wagon loading series may be attributed. Among these is the likelihood of presence of a large number of collinear series among the excluded commodity-loading categories, for which adequate and separate data was not available. The fact that important railway commodity-freight groups, *e.g.* POL, fertilisers and foodgrains occur among such excluded variables would mean that the included wagon-loading series are affected by freight interdependencies with the excluded series. Serial autocorrelation of the *specification-bias* variant[36] is also very likely to have been induced by the exclusion of major commodity-freight variables.

Inertial or *momentum-generated* autocorrelation,[37] which is also important within lagged and autoregressive model structures, could only be ruled out if IR was deemed to operate in an open market for commodity-freight services, with railfreight services being auctioned to the highest bidders. In such a case, neither inertia nor momentum would exist in the railway commodity-loading series since demand for freight services by each economic sector would depend purely on its production parameters. Such is not the case, if thought is also given to the fact that wagon specialisation over the 35-year period has imposed a freight policy stance on IR which through appropriate rate-setting is predisposed towards particular categories of commodity freight. Since such policy factors also operate via inter-PSU tieups between state enterprises and IR, this line of reasoning - which in effect posits *contestability* as being a characteristic of the Indian railfreight market - would succumb, lending support instead to the existence of some serial dependence in IR wagon loading series attributable to inertia or momentum in crossrelated commodity series. Canonical *autocorrelation,* or serial correlation resulting purely from neglect of lagged relationships within single series is intuitively less appealing, as no plausible reason would come to mind other than the workings of the railway freight manager's mind and his penchant to be guided by past experiences, if such characteristics can at all be attributed to his actions.

The results of the test computations for serial dependence in the OLS residuals are shown in Table 6.5 below. Detection procedures for serial autocorrelation in the OLS estimates for IR commodity freight loading using the Durbin-Watson [D-W] *d*-statistic are also crossverified through the nonparametric Geary 'runs' test.

Table 6.5: *Analysis of OLS Residuals:*
Tests for Serial Correlation in the OLS Dataset

Regression	AG/AG	AG/BG	AG/MG	BG/AG	BG/BG	BG/MG	MG/AG	MG/BG	MG/MG
Durbin-Watson Test									
Computed value of the *d*-statistic (n=35;k=15)	0.517	2.455	1.838	2.013	0.420	1.838	2.013	2.455	1.641
Geary "Runs" Test									
Positive residuals	*16*	*20*	*16*	*19*	*14*	*16*	*16*	*20*	*20*
Negative residuals	*19*	*15*	*19*	*16*	*20*	*19*	*19*	*15*	*15*
Total	35	35	35	35	34	35	35	35	35
Number of Runs	8	20	16	16	7	16	16	20	14
(Run)-mean	*18.371*	*18.143*	*18.371*	*18.371*	*17.471*	*18.371*	*18.371*	*18.143*	*18.143*
(Run)-var	*0.963*	*0.950*	*0.963*	*0.963*	*0.938*	*0.963*	*0.963*	*0.950*	*0.950*
(Run)-std	*0.981*	*0.974*	*0.981*	*0.981*	*0.968*	*0.981*	*0.981*	*0.974*	*0.974*
95%-lower confidence limit									
E(n)-1.96(std)	16.448	16.233	16.448	16.448	15.573	16.448	16.448	16.233	16.233
95%-upper confidence limit									
E(n)+1.96(std)	20.295	20.053	20.295	20.295	19.368	20.295	20.295	20.053	20.053

The tabular value of the *d*-statistic at 95% level of significance lies within lower and upper confidence limits set by $d_L = 0.546$ and $d_U = 2.716$. The *d*-statistic detects the presence of positive first-order serial correlation in the OLS residuals for the AG/AG and BG/BG regressions. Values of the computed *d*-statistic for all other OLS regressions in Table 6.5 lie in an inconclusive interval between the tabular values of d_L and d_U. Thus in no case is the presence of serial correlation ruled out, since the value of d_U always exceeds the magnitude of the computed *d*-statistic for all OLS regressions. The results of the D-W test are sharpened by additional results obtained from the 'runs' test. These show that the cumulative number of positive and negative runs in the AG/AG, BG/BG and MG/MG regressions, and also in the AG/MG, BG/AG and MG/AG regressions, lie outside the interval-range set by the respective lower and upper 95% confidence limits, leading to a similar inference that the corresponding OLS regression residuals are not autoregression-free. However, for the AG/BG, BG/MG and MG/BG regressions, the cumulative number or runs lie just within the appropriate 95% confidence limits, indicating that the corresponding pattern of runs in OLS residuals appears to be random in nature.

6.4.3 Autoregressive Serial Dependence Schemes

While graphical evidence for the presence of serial correlation can be gleaned from examination of time-sequence plots for the OLS residuals, such as those presented earlier in Fig 6.2, more precise analysis of the intercorrelation of residuals in timeseries data requires that approximation be made of the structure of serial dependence through the choice of an appropriate *autoregressive* scheme of the general polynomial form

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \rho_3 u_{t-3} + \ldots\ldots + \varepsilon_t \qquad -1 < \rho_i < 1 \qquad \ldots. \qquad (6.9)$$

where ρ is known as the *coefficient of autocovariance.*[38] According to whether the general autoregressive structure of the scheme above can be subsumed within a first-differenced (ρ_2, ρ_3 = 0) / second-differenced (ρ_3 = 0) / etc. lag-function, the scheme is described as having an AR(1), AR(2), etc. type Markovian autoregressive structure. Thus the ρ_i coefficients would be described as *first-order* (ρ_1) / *second-order* (ρ_2) / *third-order* (ρ_3) *coefficients of autocovariance,* according to the structure of the autoregressive scheme that fully captures the serial dependence. In the polynomial form, the $\rho_i u_{t-i}$ terms refer to the component of present residuals systematically explained by error residuals of the past, while the ε_t term represents the stochastic component of present errors. Hence serial independence of errors would be assured only if all ρ_i = 0.

Since analysis is to be made in this instance of the residuals from the OLS regressions of IR wagon loadings, it would be appropriate to postulate an AR(5) scheme for estimating ρ_i coefficients, in view of the five-year structure of the Indian planning process - a factor which was also seen to have bearing in determining the polynomial order of the distributed lag scheme estimated in the previous chapter. Values of ρ_i coefficients estimated on the residuals of the OLS regressions of wagon loadings for autoregressive schemes of different orders are presented in **Table 6.6.** These coefficient values show no tendency to decay over the AR(5) scheme, thus indicating that current IR wagon loadings are influenced by the prior loading trends over a fairly long space of time. The AG/AG, BG/BG and MG/MG regressions being of trivial nature, the Markovian structures estimated for them do not hold much importance. For the other OLS regressions, coefficient magnitudes are generally smaller, as would be expected, but exercise a systematic and sustained influence on the nonstochastic component of error residuals. It is also interesting to note that ρ_i coefficients for AG/BG and MG/BG regressions, and again for AG/MG and BG/MG regressions are nearly or exactly equal, indicating similar proportions of nonstochastic *i.e.* autocorrelated error. With the proportion of BG wagon loadings in AG wagon loadings having grown substantially over the 35-year period of the study, the BG-based coefficients of the AG/BG for the former group of regressions are notably stronger.

6.4.4 Autocorrelation Analysis of OLS Residuals

Evidence of serial correlation in the wagon loading dataset from prior analysis of residuals points to a breakdown of canonical assumptions about randomness in OLS error. Since the density function F(u_i) of OLS residuals loses normality characteristics as a result, it ceases to be an efficient estiimator of the random component of error described mathematically by the probability density function F(e_i). In practical exercises, normality in OLS residuals may disappear either because of skewing in the error density function *i.e.* non-normality in the error mean E(u_i), or loss of minimum variance/covariance characteristics in the error dispersions E(u_i^2) and E($u_i u_j$), with the precise source of non-normality being defined by the conditions of the analysis. The first aberration is more tied up with problems of heteroscedasticity in datasets and has in fact been shown to present no serious obstacle to the application of OLS to the present analysis. If non-normality of F(u_i) is rooted however in occurrences of autoregressive error, the second aberration springs to life by destroying the credibility of model specifications and coefficient estimates. While prior analysis has signified the presence of serial correlation in the application of OLS to the IR commodity-loading trends, the AR(5) scheme adopted for estimation of autoregressive error was suggested by the five-year timeframe followed by the Indian plans and the cyclical boosts and slumps they have consequently been able to impart to economic activity through their autonomous regulation of investment flows, although it must also be stated that the pure periodicity of such economic impulses has been commuted by intrusion of plan-holidays in several periods. The oscillation noticed in the earlier residual plots is thus not entirely inconsistent with randomness. Nevertheless the ebbs and flows of plan investments in the Indian economy and in IR impart a periodic pulse to railway freight operations which is effectively captured in the ρ_i coefficients of autocovariance presented below.

Estimation of ρ_i coefficients reveals that because of serial correlation properties, the OLS residuals are a combination of *systematic* and *stochastic* error, with the former being responsible for covariance degeneracy in the canonical error assumption E($u_i u_j$) = 0 following from serial dependence in IR commodity loadings, because of the existence of an overall constraint on freight capacity. As such, it is established that IR freight trends are not independently determined by levels of production and freight demands in the country, but are also defined relative to each other by these constraints. Since meaningful interpretation can be made of these interdependent freight trends, it becomes instructive to study the non-normality of residuals in the IR dataset by apportioning OLS error between its systematic and stochastic components. The task is accomplished by evaluating the systematic component (u_t - e_t) in the error distributions on estimates of ρ_i derived from the AR(5) scheme, thus allowing isolation of e_t or the pure or stochastic element of error. A geometrical exposition is made here with reference to gaugewise plots of systematic errors for OLS applied on AG commodity loadings; however OLS regressions on the BG and MG loadings are excluded from the analysis because their error-means show non-normal characteristics [$E(u_i) \neq 0$] and imply a skewing in their error density functions.

Table 6.6: Analysis of OLS Residuals: Coefficients of Serial Correlation under alternative Autoregressive Schemes

Regression	AG/AG	AG/BG	AG/MG	BG/AG	BG/BG	BG/MG	MG/AG	MG/BG	MG/MG
Autocorrelation Coefficients									
1st-order: AR(1)	0.693	-0.248	0.023	-0.066	0.761	0.024	-0.327	-0.248	0.170
2nd-order: AR(2)	0.513	-0.400	-0.493	-0.195	0.546	-0.493	-0.195	-0.400	0.096
3rd-order: AR(3)	0.573	0.160	0.044	0.090	0.495	0.044	0.090	0.160	0.126
4th-order: AR(4)	0.637	-0.044	-0.121	-0.266	0.499	-0.121	-0.266	-0.044	-0.214
5th-order: AR(5)	0.579	0.112	-0.092	-0.096	0.469	-0.092	-0.096	0.112	-0.206
Estimates	AG/AG	AG/BG	AG/MG	BG/AG	BG/BG	BG/MG	MG/AG	MG/BG	MG/MG
D-W 1st-order p.	0.741	-0.228	0.081	-0.007	0.790	0.081	-0.007	-0.228	0.179

With the AR(5) scheme yielding coherent estimates of the extent to which extraneous correlation - *i.e.* that part of error-variance neither attributable to purely random phenomena or to direct physical interdependencies of commodity and gauge in IR freight flows - is present in the residuals, the influence of factors not directly incorporated into the regressor set, such as railway policy, plan allocations, etc. is caught in the systematic component of OLS errors. As such, the *systematic* error component becomes an important infrastructural variable which captures the indirect forward and backward linkages of railway operations which either govern or else are governed by factors such as downstream production and freighting demands, and the *partial adjustment* process[39] by which investments in railway infrastructure and the creation of freight capacity make deferred responses to these changes. It is worth mentioning that, theoretically, the adjustment of freight capacity by railways to changes in traffic demand is made in two parts, namely, *partial* or short-term adjustment of forward-linked freight operations (*e.g.* wagon-allocations), and *full or* medium-to-long-term adjustment of backward-linked freight infrastructure (*e.g.* wagon-acquisitions, traction and track modifications, route expansion). The association of such adjustments with the systematic error of the plots relates to the *investment-lag,*[40] which is the source of the serial dependence noticed earlier in IR wagon loadings. Thus while in the short-term, the response of IR to increases or decreases in plan investments and downstream production in the economy is a partial reallocation of its freight capacity to cope with the materialisation of new demands, full adjustment to the changes must await the sanction of required funds under the subsequent FYP. If the level of plan investment turns out to be inadequate, the adjustment of long-term freight capacity is further deferred and spills over into a succession of plans, leading to the phenomenon of serial dependence in railway operations. It might also be added that the adjustment of transport infrastructure to restructured fuel economics following the OPEC petroleum price-hike is a classic textbook example of partial adjustment[41] where the period of full adjustment is staggered over several years because of lumpiness of investments and durability of equipment inventories, as a consequence of which the associated lag coefficients may not in fact be subject to quick decays.

The actual estimation procedure for systematic error involves transformation of each direct OLS residual over ρ_i coefficients via the generic autoregressive form $(u_t - e_t) = \Sigma\rho_i\, u_{t-i}$; (i = 1, ...,4). The transformed residuals can then be arrayed into twin timeseries of (u_t - e_t) and e_t for the 35-year wagon loading dataset and yield a distinct density function for the systematic error for the period 1960-61 to 1989-90, with 5 degrees of freedom having been surrendered during the process of estimation. Systematic errors are high in the uniformly unstable $-363.7 \leq (u_t - e_t) \leq 375.8$ range when either BG gauge-totals or overall IR wagon loadings are estimated from the MG commodity-loading trends. The fact that regressions on BG commodity loadings on the other hand yield insignificant systematic error for estimates of overall IR freight trends and a fairly low systematic error range of $-32.1 \leq (u_t - e_t) \leq 30.8$ for estimated MG freight trends thus confirms the greater predictability of BG versus MG freight trends on IR because of the order of causality earlier established between freight operations on the two IR gauges. Higher systematic error ranges are however invariably found for overall MG and BG freight loading estimates when these are estimated gaugewise on the AG commodity regressors. While the systematic error range for the MG/AG regression is still the larger of the two at $-45.9 \le (u_t - e_t) \le 53.2$, it narrows down credibly for the BG/AG regression to $-30.2 \le (u_t - e_t) \le 39.2$, serving to illustrate that the nature of crossgauge displacement in IR freight operations is largely determined by their bulk-oriented BG freight trend.

The time-sequence plots of systematic error $(u_t - e_t)$ on the direct OLS residuals for MG/AG and BG/AG regressions presented in Fig 6.2*c* prove useful in making an assessment of the relative proportion of autoregressed error in the two regressions. As implied above, the error distributions for $(u_t - e_t)$ are small in either case, since the AG regressors which include wagon loadings on both IR gauges subsume internal displacements of commodity freight on the IR system within the OLS estimate. However the fact that they exist at all and are moreover periodic in nature is evidence of the external pulse affecting IR freight operations, which enters the transportation scenario mainly through the mechanism of fund-flows during the FYPs.

The first comment that the timeplots elicit concerns the relative proximity of systematic error to OLS residuals apparent in the BG/AG error plot for most years till the early 1970s, a few truly random dips and peaks indicated by the series outliers notwithstanding. This would associate the generally low error-variances during the years of the early plans with the mixed character of IR commodity-freight loadings for the corresponding period within the dataset. Although BG freight trends appear to have been more stable compared to MG over the early period, as evident also in the lower range in both error-categories, this position is radically altered after the first oil shock. Resulting traffic instability appears to have affected BG wagon loadings more than MG wagon loadings over the rest of the 1970s as seen in the widening of differentials between OLS residuals and systematic error for the former. However the consequences of freight policy shifts thereafter is evident in higher fluctuations of both OLS residuals as well as systematic errors apparent in general ever since then, except for a brief duration during the starting years of the 6FYP, when the MG segment of IR freight operations was stabilised by the shift to bulk and gradual phase-out of MG railways.

An important point to note in respect of MG operations is the fact that the systematic errors here are laterally out of phase with the residuals ever since the 3FYP indicating the operation of a lag, and moreover are in a higher range than systematic errors for BG loading estimates. Since MG loadings rise when BG loadings have been low, the evidence of the lateral lag suggests that the partial adjustment hypothesis is borne out in case of MG loadings which so closely mimic the apparent ranges of the OLS residuals so as to reduce the influence of purely stochastic elements. The adjustment in such cases is first-differenced and has thus generally taken place during the year immediately subsequent to major rises and falls in BG loadings. Since till the new emphasis on bulk traffic appeared, the MG commodity-mix was more representative of downstream economic activity in the economy, inference can also be drawn about the infrastructural influence of BG freight activity on the economy, with periods of low activity in the core sector which contribute the greater part of IR bulk-freight leading downstream to listlessness of forward-linked economic sectors in the subsequent year.

The second and more incisive inference drawn from the two error plots pertains to the evolutionary role that Indian plan investments are seen to have played in shaping the error distributions as well as the order of infrastructural support available to freight flows within the Indian economy at different points of the 35-year dataspan. This inference is drawn from coincidence of pulse patterns in the timeplots with the phases and turning-points of Indian planning. The boosting effect of the buildup in freight capacity ahead of demand over the 2FYP period which is captured in the associated timeplots is seen to have been felt through improvement in the BG freight offtake over the period immediately after, accounting also for the gradual fall in residual errors over the 3FYP. Reluctance to add sufficiently to freight capacity after the 3FYP which forced an industrial slowdown after the mid-1960s appears as freight shortfalls and the rise of residual errors following the mid-1960s. The crises in IR freight operations during the 1970s then break into the regularity of systematic error distributions after 1973-74 and any semblance of order in the evolution of commodity freight flows has been lost over the period since because of policy factors already enumerated elsewhere, such as wagon and freight specialisation, loss of high rated traffic and inroads made by roadways. It is then noticed that over a very short period at the commencement of the 7FYP - by which time IR planning priorities were strongly in favour of technology upgradation and the discouragement of traffic smalls - the IR freight-flows appear to stabilise around steadier bulk BG trends. But since stable bulk freight loadings flow first and foremost to and from the core industrial sector which is linked to the first periodic phase of IR freight operations , the duration of the lag over which increased movement of bulk intermediates and raw materials translates into wider development of downstream industrials can only have become longer. It has already been seen elsewhere in the present study that the promising freight trends in the 7FYP were associated partly with tariff revision and block-rake loadings that further displaced non-bulk freight. These have eventually lost momentum over the 1990s due to the overpricing freight services to levels higher than what the IR bulk-traffic would.bear.

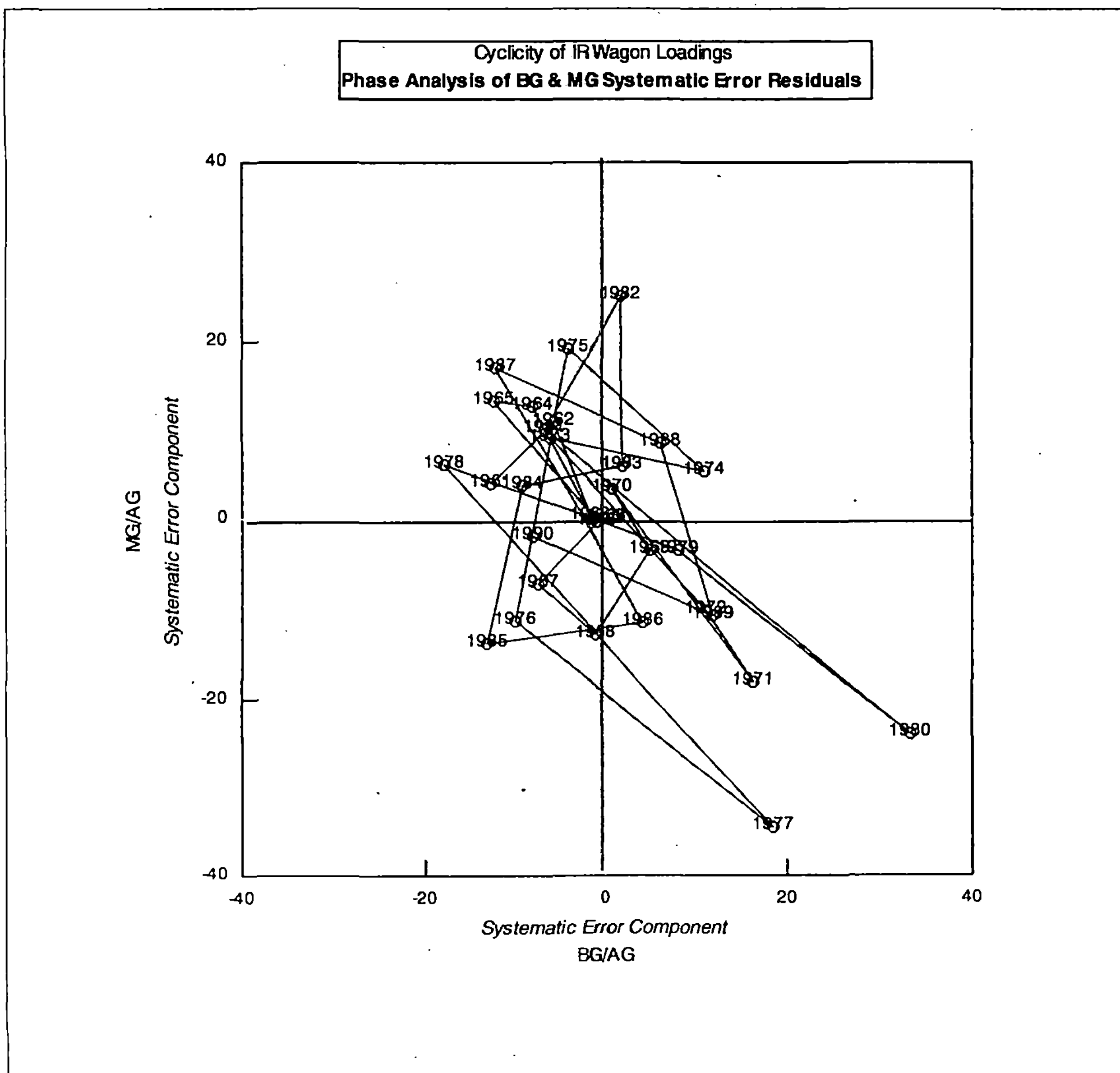
It would seem therefore that the structural character of the relationship between railway freight infrastructure and economic changes was altered substantially in the upheavals brought about by the twin oil crises because of total reorganisation of costs in both the economy and in the transportation sector, in line with similar upheavals witnessed in all major railway systems across the world. A response of this kind is in keeping with the upheavals witnessed by all major railway systems across the world, although the mode of subsequent readjustment is markedly different in the Indian case, as compared especially to the railways in Japan or France, for instance. JNR [later JR] first underwent frenzied tariff revisions in an effort to maintain profit bottomlines over the 1970s and early 1980s before succumbing to privatisation, and has since become increasingly passenger-oriented in its operations. SNCF countered the traffic and industrial relocations induced by rising oil prices through a bold policy of carrying the competition to the roadways, competing on the inherent cost-efficiency of railways in the changed world energy scenario. Two elements essential to the maintenance of cost-efficiency were maintenance of efficient traffic leads and the gradual switch to full trainload traffic, using freight consolidation where necessary in order to trim the network. One freedom that SNCF was bestowed with was the move towards managerial independence in rate-setting which enabled railway competition to take enter even those traffic segments which the roadlines had monopolised. The principal difference in the manner in which IR has adapted to the changed transportation economics of the situation lies in the increasing centralisation of its traffic decisions, in contrast to trends towards decentralisation elsewhere. Thus although features of the JNR strategy are evident in the repeated revisions of freight tariffs in recent years, and somewhat unwittingly in the overwhelming passenger orientation that IR operations have now acquired, the lack of independence and of any overt move towards denationalisation makes sufficient departure. IR's emphasis in the 1980s on technology upgradation, bulk freight specialisation and full trainload operations is in keeping with the direction, if not the scale, of the adaptations made by SNCF. However no effort has been made in the other vital direction of loosening ministerial control to permit the evolution of separate zonal railway strategies that more closely address the regional character of freight flows in India. Emphasis on bulk, when translated into action by railways all over the country, results in neglect of available traffic in quest of commodity flows not found in every region, in the rising leads and absence of return traffic, and in overuse of track and traction without adequate provision for their timely replenishment.

6.4.5 Phase Analysis of Residuals

A characteristic that has been noticeably present in all residual and error plots examined earlier is the phenomenon of freight cyclicity, which from the analysis of systematic errors just concluded, appears to originate structurally in flow-patterns of plan investments on the railways and on industrial sectors that are forward and backward-linked to railway freight operations under the FYPs - rather than merely in short-term endogenous adjustment of IR commodity loadings to the commodity-freight demands emerging from the industrial economy of the country. This position emanates from the overall role assigned to the plans as instruments for channeling investment into desired economic sectors for the achievement of development and industrialisation goals. Since much of the investment over the course of the planning period has been public in character and has enabled India's PSUs to occupy the 'commanding heights' of the economy, economic performance within the country is strongly influenced by the periodicity of the simultaneous capital injections that enter the economy through the process of public investment. No real reason exists why the operational performance of the state-sector IR - which has core mining and industrial PSUs as its principal clients - can remain immune to periodic ebbs and flows, especially with the increasing specialisation of its freight operations around a few bulk commodities. It is also clear that with IR wagon loadings as indicators of operational railway performance, the part of total variance in the wagon loading dataseries that is neither stochastic in character nor fully explained by internal adjustments between commodity- and gaugewise loadings, captures this exogenous pulse in the cyclic character of systematic errors seen in the preceding error plots.

To further dissect the phenomenon of cyclic freight performance and periodic freight capacity adjustments on the two principal IR gauges, phase-analysis of the gaugewise traffic movements implied within the autoregressed or systematic component of the OLS error residuals is now undertaken. This is accomplished by means of the phaseplot above, which pits BG systematic errors against those on MG. Distribution of these error components by positive and negative magnitude creates the 4-orthant space over which systematic errors have been arrayed. Before phasewise interpretation of the error distributions can be undertaken, it is useful to develop an understanding of the nature of each orthant. In the phaseplot, the NE and SE orthants reflect phases when systematic error in the BG wagon loadings estimated against AG commodity coefficients is *positive*, *i.e.*a period when actual BG wagon loadings have exceeded regressed values. Conversely, the NW and SW orthants reflect periods when systematic errors in BG loadings are *negative* and have fallen below levels expected from the regression. When the orthants are viewed from the perspective of MG loadings, the NE and NW orthants both reflect higher MG loadings than regressed values, while the SE and SW orthants indicate the converse. Sufficient insight into the appearance of gaugewise slacks in wagon loadings and into the subsequent modes of adjustment in IR freight handling can thus be gleaned by studying the timepath of the systematic error-traverses made by BG and MG wagon loadings across the orthants, with the years under consideration being identified by their respective end-points.

***Figure* 6.3: Freight Cycles in IR Freight Operations: 3FYP to 7FYP**



Tracing the time-trajectory which commences just above the SW orthant, it is seen that BG freight loadings stood well below par levels at the commencement of the 3FYP in 1961-62. The traffic slack was gradually taken up, first by augmentation of MG loadings and then by increased BG loadings so that in 1962-63, wagon loadings on both IR gauges had risen to near-par levels. The fall in IR freight handling that recurred immediately thereafter resulted from sharp subsequent shortfalls in BG loadings, although the slack was partially relieved by increased MG freight loadings. Freight recovery in 1965-66, the terminal year of the plan, brought IR freight levels close to par again. Thus although the freight handling setbacks encountered by IR over the 3FYP were principally on account of anomalies in BG freight operations, MG freight handling remained relatively high, so that IR freight cycles remained ensconced in the NW orthant where MG loadings proved partially complementary to BG loadings, confining overall IR freight fluctuation within low amplitudes. Nevertheless, since the magnitude of fluctuations in BG freight loadings over the 3FYP was relatively high, the principal impact occurred within the bulk-commodity segment of the railway freight market. Considerable traffic slack consequently prevailed over the 3FYP period.

The subsequent period of Annual Plans was marked by the growth of BG freight loadings at the cost of MG freight handling. However, as noted earlier, the period coincided with mass foodgrains imports to forestall famine-like conditions induced by consecutive failures of the monsoon. While a slippage consequently took place in the BG handling of bulk industrials, MG feeder-freight operations suffered continuously over the period. Only in 1968-69, the year just preceding the 4FYP, did IR freight handling recover substantially, bringing both BG and MG loadings close to par.

The 4FYP commenced with sharp increases in BG freight handling which however induced a shortfall in MG freight realisation by IR. This was quickly followed by a BG freight setback during the mid-years of the 4FYP, as a partial consequence of which MG freight handling was gradually raised in order to take up the traffic slack. While recovery in the bulk-freight segment carried IR's BG and MG freight operations to above-par levels in 1973-74, the terminal year of the 4FYP, this improved railway performance was not unrelated to the dislocations in road freight operations induced by the Oil Shock. Shortfalls in freight loading began to set in with the commencement of the 5FYP, with the fall in MG freight operations proving sharper than that in BG freight. The notable recovery made by BG bulk-freight handing in 1976-77, the mid-year of the 5FYP, drove MG freight loadings to unprecedentedly low levels. However, BG freight realisation shrunk sharply in the very next year and had to be partially compensated by an expansion in MG freight handling. Between 1978-80, the terminal year of the 5FYP and the subsequent rolling-plan year, recovery in the BG freight segments took IR freight handling marginally above par-levels

As the 6FYP commenced, BG freight handling took a sharp downturn, before recovering through the two subsequent plan-years. MG freight loadings remained at above-par levels over this period, but declined from 1982-83 onwards till the end of the 5FYP. This decline was also accompanied by falling BG freight handling in the last two years of the plan to below-par levels, so that IR freight loadings were at their lowest ebb in 1984-85. Over the first two years of the 7FYP, BG freight handling initially declined but the resulting traffic slack was partially offset by increased MG freight handling. Buoyancy was restored to IR freight loadings by recovery in the BG bulk-freight segment in 1987-88 and 1988-89, which however gradually drove MG freight handling to below-par levels. By the terminal year of the 7FYP, decline had set in also within the BG freight segment, with marginal recovery of MG freight loadings.

Several important features of IR freight loading patterns emerge from the phase analysis of autoregressive error residuals. While IR freight loading performance has traditionally been driven by BG loadings of bulk-freight, the existence of adequate MG freighting capacity provided a degree of insulation to overall IR freight performance prior to the 4FYP. The cyclic structure of IR freight operations is clearly evident in the phaseplot. Thus while shortfalls in BG freight loadings occur with distressing frequency on IR, these have been offset on many occasions in the past by compensating increases in MG freight loadings which have served to even out freight fluctuations. Consequently, the amplitude of freight fluctuations during the 1960s was relatively limited, and was characterised usually either by above-par MG freight handling during the 3FYP, or by above-par BG handling during the subsequent Annual Plans. The amplitude of freight fluctuations began to increase during the 4FYP period and reached a maximum over the 5FYP, when wild swings in the time-trajectory are noticed between the different orthants of the phaseplot. The magnitude of these fluctuations also indicates the extent to which IR freight handling was affected by the succession of Oil Shocks during the 1970s, through much of which bulk-freight handling remained at unanticipatedly low levels. The converse case, where high BG loadings have compensated for shortfalls in MG freight loadings, has been less frequent, and occasions when very high freight loading has been achieved on both BG and MG gauge networks are extremely rare.

The resetting of IR freight priorities during the 6FYP and 7FYP also involved a restructuring of the IR freight-base, along with substantial modification in wagonfleet composition, directed towards improving bulk-freight handling capacity. Nevertheless, while the amplitude of freight fluctuation has remained relatively high over the 1980s, the counterbalancing role of MG freight loadings has begun to decline, partially because of the de-emphasis on MG freight operations. Since the dataset had shown earlier that the commodity composition of IR freight differs radically between the BG and MG networks, with general freight being more important to the MG freight segment, this would indicate that the increasing emphasis on bulk-freight over the period under review has narrowed the IR freight-base to a greater degree than had been anticipated by the plans, and has fuelled the exodus of general freight to other modes of transportation. The principal cause of this appears to have been IR's neglect of the MG freight network, and the shrinkage of its freight emphasis to the high-density BG corridors.

6.5 Model Adjustment for Serial Correlation

Although the initial OLS regressions on IR freight loadings were vitiated by the extensive presence of serial dependence within the wagon loading dataset, analysis of the error residuals has allowed substantial insight to be gleaned about the nature of commodity and gauge interdependence on IR freight operations, which showed up through the phenomenon of freight cyclicity. Estimation of the autocovariance coefficients ρ_i on the postulate of an AR(5) autoregressive model has thus captured the adaptive structure of India's 5-year planning horizon, relating IR freight-capacity planning decisions to the cyclicity of crossgauge commodity-freight trends. Resolution is still required, however, of the difficulties imposed by the loss of efficiency in OLS regression coefficients because of the presence of serial dependence - a feature also evident within the simple r_{ij} coefficients for gaugewise commodity loadings arrayed in the correlation matrices. Corrected coefficients estimated on the more elementary postulate of an AR(1) autoregressive structure for the serially-correlated residuals, would allow truer understanding of the magnitude of the aggregate IR freight response to the rising or falling loading trends of given commodities. This is attempted by adjusting the regression coefficients for the presence of serial dependence.

6.5.1 The Cochrane-Orcutt Modelling Procedure

The popular Cochrane-Orcutt [C-O] method,[42] which will now be employed to smoothen coefficient estimates in the presence of serial correlation, is an iterative procedure designed to estimate ρ - the coefficient of autocovariance - in the absence of *a priori* information about its structural nature. The two-step modification of the procedure however restricts the iteration to the simpler first-order *i.e.* AR(1) autoregressive scheme where the estimate of ρ is obtained from the first-order lagged regression of observed OLS residuals, and in analysis, it is found that the original OLS coefficients can then be adjusted for the loss of minimum-variance properties that occurs when running OLS on serially-correlated datasets, thus sharpening the conclusions regarding the original sources of serial dependence, namely the interdependence autonomously induced into commodity-loadings on IR by shortages of freight capacity during the plans.

The C-O two-step procedure is briefly outlined below to explain the modelling adjustment. Under the governing assumption of the procedure, the residual term u_t in the k-variable linear regression model

$$Y_t = \beta_1 + \beta_2 X_{2t} + \ldots + \beta_k X_{kt} + u_t, \qquad \ldots \quad (6.10)$$

is assumed to have been generated by the AR(1) scheme $u_t = \rho u_{t-1} + \varepsilon_t$. Estimation of the regression coefficients of k-variable model is first made by OLS in order to obtain observed residual estimates of u_t, denoted as e_t. For each period, these are then regressed on the observed residual of the immediately prior period to obtain a coefficient estimate of autocovariance or $\hat{\rho}$ from the first-differenced expression

$$e_t = \hat{\rho}\, e_{t-1} + v_t \,. \qquad \text{.... (6.11)}$$

where v_t is an estimate of the uncorrelated component of error. The computed $\hat{\rho}$ which is a consistent although still biased[43] estimator of ρ may then be used to transform the variables in the dataset to form the *generalised* difference equation of GLS [Generalised Least Squares]

$$(Y_t - \hat{\rho}\, Y_{t-1}) = \beta_1(1 - \hat{\rho}) + \beta_2(X_{2t} - \hat{\rho}\, X_{2t-1}) + ... + \beta_k(X_{kt} - \hat{\rho}\, X_{kt-1}) + e(u_t - \hat{\rho}\, u_{t-1}) \quad .... \quad (6.12)$$

or equivalently

$$Y_t^* = \beta_1^* + \beta_2^* X_{2t}^* + ... + \beta_k^* X_{kt}^* + e_t^* \qquad .... \quad (6.13)$$

with new β_i^* coefficients that are now autocorrelation-adjusted. Since the C-O procedure employs the estimated $\hat{\rho}$ instead of the true ρ estimated from a generalised AR scheme, the estimation of regression coefficients is equivalent to employing GLS methods for coefficient estimation. The estimate $\hat{\rho}$ which is readily obtained from the OLS residuals already computed during the autocorrelation check can then be utilised to obtain the C-O adjusted β_i^* coefficient estimates for the wagon loading dataset.

6.5.2 Analysis of Adjusted Commodity Coefficients

The wagon-loading dataset that is presently being subjected to regression analysis combines commodities which have magnified their freight presence considerably over the 35-year review period, as well as commodities which have lost freight presence as a result. Comparative estimates of OLS and C-O adjusted commodity-coefficients for the gauge-to-gauge regressions of the IR wagon-loading dataset had been presented earlier in Tables 6.3*a*, 6.3*b* and 6.3*c*. After application of the C-O adjustment procedure, notable improvements are noticed in the respective computed *t*-coefficients, indicating therefore that the significance levels of the commodity coefficients improve considerably after the autocorrelation adjustment. The associated R^2 and adjusted $\bar{R}^2$ multiple regression coefficients after the C-O adjustment in Table 6.3*d* also indicate that much closer fit is obtained in the regression after application of the C-O procedure, accompanied by substantial reduction in the standard errors of commodity-coefficient estimates Prior to further analysis of the modified β_i^* coefficient estimates obtained from the C-O adjustment, it is important to note that recourse to the simpler AR(1) scheme for estimation of the autocovariance coefficient ρ under the two-step C-O adjustment for serial correlation is justified because the estimated $\hat{\rho}$ converges to true ρ in large samples on account of consistency between $\hat{\rho}$ and ρ.

Comparing the estimates of commodity-coefficients, their standard error and t-statistics under the C-O adjustment with the respective results obtained before the autocorrelation adjustments, the coefficient estimates for commodities like coal & coke, grams pulses, sugar, cement, iron & steel and tea (for the AG/BG regression) are found to improve sharply. With consequent reduction in standard errors, the t-statistics for these coefficients accordingly improve, widening the confidence limits for the coefficient estimates. The values of R^2 and $\bar{R}^2$ increase for all regressions, sharpening the utility of the related inferences.

The commodity-coefficients estimated by the C-O procedure provide indication of the freight elasticities of increased or decreased wagon loadings of the concerned commodity, namely the degree to which changes in the handling of freight in these commodities affect aggregate IR wagon loadings over all gauges. Considering the intercommodity freight relationships found to be significant at 95% confidence level [*see Table 6.b*], it is seen that a fairly large group of commodities with both increasing and decreasing wagon-loading trends show significant freight elasticity withiin IR's BG freight operations. Most commodities handled on IR's MG network show relative freight inelasticity, with the exception of jute manufactures, iron ore, iron & steel and cement. It is also noted that declining wagon loadings of cotton manufactures, which were a prominent constituent of general freight over most of IR's operational history, have been the most important casualty of changes in the IR freight-base over the period under review, displaying the highest freight elasticities.

Consequent to the IR emphasis on increased bulk-freight handling, the displacement of cotton manufactures has been most severe on the MG freight segment. Freight elasticity is also relatively high for raw jute, which has similarly lost considerable ground within the IR freight-mix. Nevertheless, although wagon loadings of bulk mining materials like coal & coke and iron ore have shown strongly increasing trends in terms of their aggregate freight-handling on both IR gauges, their estimated commodity-coefficients under the C-O adjustment indicate relatively low freight elasticity. Commodity-coefficients for bulk industrials like iron & steel and cement are notably stronger, indicating higher freight elasticity for wagon loadings in this segment. BG freight-handling trends in other mineral ores and sugar, which had displayed insignificant freight elasticity under OLS, are also found to have become significant under the C-O procedure. Only grams & pulses with strongly increasing freight-loading trends and oilseeds and sugarcane with declining freight-loading trends show relatively high freight elasticity within the agricultural output segment of the freight market. Increased wagon loadings of grams & pulses appear to have led to strong displacement of the other two commodities, indicating the mutuality of IR freight gains and losses in this commodity segment. The principal reason for such mutuality would appear to be the common requirement of these commodities for covered wagons, the proportion of which has substantially declined within the IR wagonfleet.

Considering the crossgauge relationships within the IR wagon-loading dataset, the dependence of overall BG freight loadings on MG freight handling is seen to be much lower than the dependence of MG freight loadings on BG freight handling. Little difference is consequently noticed in the BG/MG freight elasticities computed under OLS and C-O procedures for jute manufactures, iron ore, iron & steel and cement. In the MG/BG regression, freight elasticities increase under C-O estimation for commodities like raw cotton, jute and cotton manufactures and to a lesser degree for cement, while the freight elasticities of oilseeds and grams & pulses decline marginally. Since jute manufactures and grams & pulses have retained some presence in both BG and MG segments, this would signify that retention of these commodities by IR has a strong displacing effect on the wagon loadings of other agricultural commodities and light industrials. In the case of cement, which is carried with the longest traffic leads over the entire IR network, the freight elasticity of MG loadings is much stronger than the freight elasticity of BG loadings of this commodity, implying that growing demands for cement in isolated regions of the country which are only served by IR's MG network are an important cause of the escalation in freight dlows of this commodity on the BG trunk network. Rather surprisingly, coal & coke which is the main freight commodity moved by IR shows relatively low freight elasticity for AG and BG loadings and is freight-inelastic in the MG segment. The principal reasons for this would be the specialised wagon and handling needs of this commodity which have been a major source for wagonfleet specialisation on the IR network, as well as the location of most originating points of coal & coke freight within a specific region to the east of the country, thus accounting for the relative paucity of reversed-lead freight and of consequent increases in the wagon loadings of other commodity-freight.

At 99% confidence limits, the number of commodities with significant freight elasticities becomes relative sparse [*see Table 3.2c*] Nevertheless, several commodity-coefficients which are found insignificant under the OLS estimation become significant after the C-O adjustment. Notable among these are sugarcane and oilseeds in the AG/BG regression, cotton manufactures and iron ore in the BG/AG regression, cotton manufactures and oilseeds in the MG/AG regression, and jute manufactures and sugarcane in the MG/BG regression. Conversely, while the freight elasticity of iron & steel in the BG/MG regression declines into insignificance under the C-O adjustment, the freight elasticity of iron ore becomes significant and high. The respective coefficient values of course remain unaltered between the two tables. Thus at 99% confidence, increased BG bulk-freight loadings of cement, iron & steel, grams & pulses, coal & coke and cement continue to have a strong displacing impact on the handling of other freight like cotton manufactures, sugarcane, oilseeds and raw jute on the IR network. A large proportion of this displacement occurs in general freight and light industrial commodities traditionally handled by both MG and BG freight networks, including long-lead freight in cotton and jute manufactures, as well as freight in raw jute and sugarcane with shorter traffic leads. Since the MG and BG networks cover different spatial regions within India, this has a profound impact on the quality of infrastructural services provided by IR to different economic sectors and regions in the country.

Another notable result of the C-O adjustment is noticed in the change in coefficient magnitudes, leading to sign reversals in several cases [*see Table 6.3a*]. Since the C-O procedure theoretically recombines the partial correlations between the wagon-loadings of different commodity-pairs denoted in the correlation matrices reproduced below each gaugewise wagon-loading table, the C-O adjusted commodity coefficients represent corrected freight elasticity estimates that subsume the direct and indirect impact of intercommodity freight relationships within the changing IR freight-mix. While a detailed examination of the magnitude of coefficient changes would exceed the purpose of the present investigation, a few general remarks may be made. It is noticed from Table 6.3*a* that the magnitude of shifts in freight elasticity are notably higher for commodity loadings on IR's MG network. The secular decline in MG freight operations can thus largely be attributed to the downstream displacement of commodity freight as a consequence of IR's bulk-freight specialisation and the narrowing of the freight-focus within the BG network. Thus the apparent withering away of IR's MG freight operations ties in very closely to the dominant railway planning decisions taken over the FYPs. Considering freight trends in cotton manufactures, where IR has lost the greatest amount of ground, the associated commodity-freight coefficients for cotton manufactures in the AG/MG and BG/MG regressions show very strong sign-reversal under the C-O adjustment. Thus while a decline in the wagon loadings of cotton manufactures has been manifest on both BG and MG networks, the change of coefficient sign from a negative to a positive magnitude indicates that the displacement of this commodity from IR freight operations has been magnified manifold by related displacements of several other commodities. Once more attention is drawn to the shortage of covered wagons in the IR wagonfleet which once carried a variety of other general freight on reversed leads after initially delivering consignments of cotton manufactures to different corners of the country. Even this single instance adequately draws attention to the unforeseen consequences of bulk-freight and wagonfleet specialisation, which have seriously undermined the ability of IR to retain a credible share of the highly-rated low-bulk market segment in general freight. At the other end of the freight spectrum, reversals of coefficient signs are also noticed in the AG/MG and BG/MG freight elasticities for coal & coke. Although the coefficient magnitudes are low, freight dominance of this commodity in the IR freight-base ensure that each successive increase in coal & coke loadings has a strong displacing impact on other general categories of freight. The mechanism for such displacement works through wagon specialisation, under which coal wagons are unsuitable for the carriage of other freight and must run empty on reversed leads. Thus increased handling of coal & coke by IR increases the need for traction and associated transhipment loadings, in the long run strengthening the displacement of high-valued general freight to the roadways.

6.6 Longterm Freight Implications for IR

IR is often described in the literature as being the second largest railway system under a single management. Yet at the time of the commencement of the 8FYP, only around 23 percent of the IR route network consisted of dual or multiple tracks and nearly 44 percent of the IR network was served by MG and NG routes. Thus the BG network carried almost 91 percent of total freight and 83 percent of passenger volumes in traffic terms. The MG network which spanned 38 percent of the route network carried only 9.43 percent of total IR freight traffic.[44] The conceptual spread of IR freight services is thus far more limited than the size of the IR route network might suggest. Although the BG wagonfleet at the end of the 8FYP comprised around 88 percent of the IR wagonfleet in FWU terms, the aggregate freighting capacity of the BG wagonfleet at around 9.89MT amounted to more than 92 percent of total IR freighting capacity, reflecting the higher average carrying capacities of BG wagons. [*see ch4, Table 4.2*] The MG wagonfleet, by contrast, had declined by then to only 33 thousand FWUs with an average wagon capacity of 25.8T and an aggregate freighting capacity of 0.85MT. Because of the higher average train running speeds on the BG network, the traffic potential of BG freight operations in net tonne-km terms was even higher. But with most of this traffic flows now being concentrated on the HDCs, IR appeared to have withdrawn from most of its MG and BG single-line network.

Nevertheless, existence of the dual gauge system resulted in relatively high freight transhipment needs, with most transhipments occurring over 14 major transhipment points on IR route network. At the close of the 6FYP in 1984-85, around 3.15 percent of BG originating freight and over 32 percent of MG originating freight was estimated to have required transhipment, with approximately 6.45 percent of total originating tonnages on the IR network actually comprising transhipment loadings. Because of increased gauge conversion and the streamlining of BG freight operations during the 7FYP, transhipment loadings were estimated to have declined proportionately by 1991-92 to 5.6 percent of total originating revenue-earning tonnages of 337.9MT. However, since 6.6MT was transhipped from BG to MG and NG that year, against transhipments of 12.5MT from MG and 0.1MT from NG to other gauges, the feeder character that MG freight operations still retain within the IR system becomes readily apparent.[45] The major commodities requiring transhipment included major IR bulk-freight constituents like coal & coke, iron & steel, cement, foodgrains and POL, as well as limestone and gypsum.

While restructuring of the IR freight-mix through increasing bulk-freight emphasis and wagonfleet specialisation has improved the throughput of BG freight operations by reducing handling and transhipment costs and wagon TAT, its implication on the profitability of IR's freight operations has not been as definitive. As part of this new freight stance, IR now insists on point-to-point movement of bulk-freight in full rakeloads and has accordingly restricted the booking of parcel and break-bulk traffic. Consequently, the seven major freight commodities which include coal & coke, POL, iron & steel, foodgrains, chemical fertilisers and iron ore contributed 87.2 percent of IR freight revenues and 85.2 percent of IR freight traffic in net tonne-km terms in 1991-92 on the threshold of the 8FYP. In pointed contrast, the next seven commodities including limestone & dolomite, salt, sugar, oilcake fodder, other quarried stones, wrought timber and gypsum contributed only 6.1 percent of IR's freight revenues and only 8 percent of revenue earning freight traffic.[46] The principal causes of slow growth in railway freight operations in India may thus be jointly identified as the shrinkage of the IR freight-base to only a few bulk commodities regardless of the traffic offer from the economy, and consequent underutilisation of the IR route infrastructure and assets elsewhere. While no slack appears visible in IR freighting capacity because of the slow pace of wagon replacement and acquisition, the real slacks of the IR system exist in the form of low intensity of operations outside the golden quadrilateral and repressed transportation demands in the economy.

The analysis in the present chapter has served to bring out the longterm implications of such slacks. IR asset renewal under the FYPs has involved substantial inductions of upgraded railway technology into track, traction as well as rolling stock. These have in turn reduced IR's freight focus to a few commodities and a few high-density routes, for which specialised wagonfleet upgradations have had to be made. Because of the production lags which operate between producer goods and consumption goods sectors in the economy, the freight streams from these do not coincide over time. The increasing inability of IR to meet the transportation demands of low-bulk freight segment which raises transportation costs and lowers transportation efficiency throughout the economy ultimately causes periodic interruptions in the bulk-freight flows. The phenomenon of freight cyclicity experienced by IR is thus observed to tie in very closely with the shrinkage of IR feeder freight operations on the MG network and to the consequent surrender of the general freight segment to the roadways. The wagon-loading dataset used in the regression analysis in the present chapter has certain limitations. Multicollinearity in the dataset is the inevitable consequence of the peculiarities of the railway freight scenario to which the regression analysis has been applied, in which the loadings of commodity freight by IR are constrained by available freighting capacity on the IR wagonfleet, and also by the degree of technological specialisation within the wagonfleet. Thus achievement of higher freight loadings in chosen commodity-freight categories tends to crowd out other freight, reducing the loading of low-bulk general freight and also of short- and medium-lead traffic which is accorded lower priority in IR freight policy. However since freight flows on the IR network are unevenly balanced between the BG and MG segments, these changes in freight priorities have specific spatial impact on the regional freight patterns in the country, and also on the backward and forward linkages between railway infrastructure and other sectors of the economy. Detailed examination of such features is made in the next chapter.

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