

# Gauging Effects of Hypothetical Extraction Method on Transport Linkages in India

Simrit Kaur<sup>1,2</sup> and Vaibhav Puri<sup>3,4\*</sup>

<sup>1</sup>Professor, Economics and Public Policy, Faculty of Management Studies, University of Delhi, New Delhi – 110007, Delhi, India

<sup>2</sup>Principal, Shri Ram College of Commerce, University of Delhi, New Delhi – 110007, Delhi, India

<sup>3</sup>Assistant Professor, Department of Economics, Sri Guru Gobind Singh College of Commerce, New Delhi - 110034, Delhi, India

<sup>4</sup>Doctoral Research Scholar, Faculty of Management Studies, University of Delhi, New Delhi – 110007, Delhi, India; vaibhavpuri@sggsc.ac.in

Received: 28 February 2023

Accepted: 12 September 2023

Published: 08 December 2023

## Abstract

Transport infrastructure is imperative for sectoral growth and economic progress. To gauge the impact of reduced contributions by the Railway and Other Transport sectors on other sectors in India, we use the Hypothetical Extraction (HE) based methodology to analyse the impact of such changes on outcomes of different sectors. Five Input-Output Transaction Tables (IOTT), between the years 1993-2014, are aggregated into 22 sectors. Methodologically, sector pair-wise correlations and sectoral groupings are identified in the transport sector. Induced elimination of Railway and Other Transport sector contributions are used to capture sectoral dependencies. Changing patterns in 'Key' sector compositions are further identified. Manufacturing, Mining and Quarrying, Construction, Storage and Warehousing and Electricity appear significantly correlated with Transport. Extraction causes sizeable output loss (around 60 percent) for the Manufacturing sector. 'Self-extraction' results in declining loss of output for transport sectors, whereas, Electricity and Storage and Warehousing remain 'Key sectors' in the post-extraction economy. An important implication emerging from our analysis is that dynamic relational dependencies across other sectors must be considered for future investments in transport infrastructure.

**Keywords:** Dependence, Hypothetical Extraction, Input-Output, Linkages, Railways

**JEL Classification:** C67, D57, L91, O18, P00, R40

## 1. Introduction

Investments in core infrastructure present a strong case for economic development across emerging economies. Literature corroborates the influential role played by infrastructure in a nation's growth story<sup>1-3</sup>. Both public and private entities contribute towards investment in hard and soft infrastructure. Where public institutions at national and sub-national levels provide investments for the construction and establishment of networks (such as highways, railways and electricity), the private sector

has gained prominence in inter-state cargo, shipping, cab aggregation, electricity generation and distribution.

The significance of transport infrastructure in economic growth is irrefutable. Transport connectivity helps in mobilising the productive capacity of regions and firms through access to spatially segregated resources and markets<sup>4</sup>. It acts as a key link for determining trade flows, industrial location and urbanisation<sup>5</sup>. At an indirect level, transport infrastructure becomes instrumental in increasing the efficiency of other productive factors like capital and labour. Additionally, the causal relationship

\*Author for correspondence

described above is bidirectional, where growth accentuates the demand for critical infrastructure for socially optimal outcomes such as lowering congestion and carbon footprint alongside the provision of job opportunities across geographically separated communities<sup>6</sup>. Further, transport facilities can assist in overcoming the urban bias in access to health and education services<sup>1,6</sup>.

Transport density and economic well-being are interconnected. Where the absence of rail could strictly limit the growth<sup>7</sup>, better connectivity could enable people to access better job markets<sup>8,9</sup>, enhance trade flows<sup>10</sup>, reduce price variability in agriculture crop produce<sup>11,12</sup> and increase urban sprawl and urban built-up area<sup>13</sup>. For the population at risk, issues of poverty and inequality can be addressed through investments in transport networks. A study based in Latvia finds that there exists a negative and significant correlation between road connectivity and poverty in rural areas<sup>7</sup>. A similar study for Nepal<sup>14</sup> reports that an increased bridge and road density significantly reduces the variation in prices of agricultural produce.

Studies highlighting the positive impacts of Railways on the Indian economy are substantive<sup>1,5,15-17</sup>. A unidirectional causal link emerging from transport towards the direction of GDP exists in the Indian context<sup>2,3</sup>. Rail-based transit is instrumental in reshaping India's tourism activity encouraging medical and leisure-based travel<sup>18,19</sup>. Railways possess economic and environmental advantages over other modes of transport<sup>20</sup>, but their efficiency in India has neither been exceptional nor significant. Economic Survey, 2017, notes that there has been a considerable decline in freight movement primarily due to sticky tariffs. Further, being a Departmental undertaking of the Government of India, Railways incurred a cumulative loss of Rs. 330 billion in passenger transport business<sup>a</sup> for the year 2014-15. These trends raise a serious concern over the future path of investments in Railways and the role it would play in India's economic development.

To and seamless connectivity to remote regions, the government plans to contribute 12 perent of the Rs. 111 trillion National Infrastructure Pipeline (NIP)<sup>b</sup> fund towards Railway modernisation. This research provides a

method for evaluating the induced performance effects of the transport sector, especially railways, on other sectors in India through hypothetical extraction using Input-Output (I-O) models. We use a Hypothetical Extraction (HE) based methodology to measure the impact of reduced contributions by the Railway and Other Transport sectors on other sectors in India. To assess the role of the Railway sector, the study contributes to the existing literature using an extraction-based technique applied in the Indian context<sup>21,22</sup> for measuring changes in sectoral outcomes.

Following this brief introduction, the structure of this paper constitutes a discussion of recent literature pertaining about applications of I-O models in the Indian context along with applications specific to the transport sector in Section 3. In Section 4, a methodological approach to study the impact and linkages of railways and the transport sector using a hypothetical extraction model is presented along with a description of data and sources of I-O tables. Section 5 pertains to the results and discussions. Thereafter, Section 6 concludes with some broad policy perspectives.

## 2. Transport Sector in the Indian Context

The transport sub-sector occupies a noticeable share within the infrastructure investment in India, yet remains largely ignored from the economic debate. The contribution of Gross Value Added (GVA) by the transport sector in overall GVA is presented in Table 1.

The value added generated by sectors such as Manufacturing, Agriculture and Forestry, Real Estate and Trade as a proportion of total GVA is substantial. Contributions by these four sectors increased marginally from 61.9 perent to 62.3 perent over the period 2019-20 to 2021-22. Transport, storage, and communications-related sectors contributed not more than 6.5 perent over the years. But what draws more attention, is the contribution of Railways and Other Transport sectors to the value-added within the overall transport, storage, and communication-related activities. While the share of the Other Transport sector (comprising of air, road and water-based modes of transport) in GVA was around 61 perent, the share of the Railways sector in value added of

<sup>a</sup>As per NITI Aayog, Indian Railways spent Rs. 1.67 against every rupee earned in the year 2014-15. [http://niti.gov.in/writereaddata/files/document\\_publication/Social-Costs.pdf](http://niti.gov.in/writereaddata/files/document_publication/Social-Costs.pdf)

<sup>b</sup>National Infrastructure Pipeline fund worth Rs. 111 trillion over next five years is proposed towards development, operation and maintenance of infrastructure projects. <https://dea.gov.in/recentupdate/report-task-force-national-infrastructure-pipeline-nip-volume-i>

[recentupdate/report-task-force-national-infrastructure-pipeline-nip-volume-i](https://dea.gov.in/recentupdate/report-task-force-national-infrastructure-pipeline-nip-volume-i)

the overall Transport sector was limited in the range of 9-11 perent in the considered period. Such contributions by the Railways sector seem small when weighted at the scale of economy-wide value addition.

Contrary to the performance elaborated, the transport sector has received sizeable financial support through budgetary allocations. These allocations as a proportion of the total budget, as seen in Figure 1, grew by 3 percentage points for the period ranging from 2016-17 to 2021-22. Railways sector received

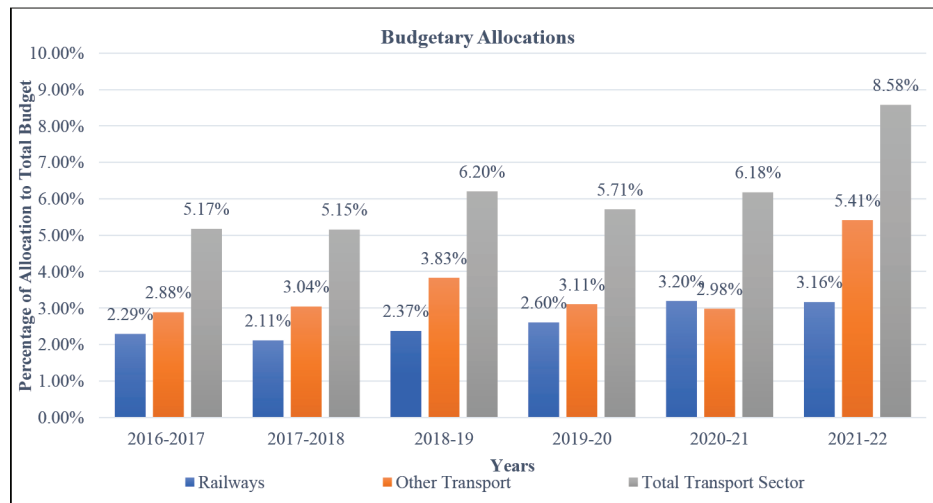
2.29 perent of the total budgetary allocations in the year 2016-17 which rose to 3.16 percent by the year 2021-22. The allocation was the least in the year 2017-18. Compared to Railways, the Other Transport sector received a higher proportion of allocation which almost doubled since 2016-17.

The rate of growth of these allocations (Figure 2) saw a sharp decline for the Railways sector till the year 2017-18. The growth in budgetary expenditure peaked in 2020-21 but fell sharply in the year 2021-22. In

**Table 1. Gross Value Added (in Rs. Billion at 2011-12 prices) by Select Economic Activities**

| Sectors  | 2019-20          | 2020-21          | 2021-22          |
|--|------------------|------------------|------------------|
| Agriculture, forestry, and fishing                                     | <b>19943.26</b>  | <b>20763.27</b>  | <b>21491.22</b>  |
|  | (15.07)          | (16.37)          | (15.58)          |
| Mining and quarrying   | <b>3171.34</b>   | <b>2899.05</b>   | <b>3104.15</b>   |
|  | (2.40)           | (2.29)           | (2.25)           |
| Manufacturing  | <b>22597.06</b>  | <b>23254.38</b>  | <b>25824.73</b>  |
|  | (17.07)          | (18.34)          | (18.72)          |
| Electricity, gas, water supply and other utility services              | <b>3007.98</b>   | <b>2877.57</b>   | <b>3161.10</b>   |
|  | (2.27)           | (2.27)           | (2.29)           |
| Construction   | <b>10434.29</b>  | <b>9836.19</b>   | <b>11293.68</b>  |
|  | (7.88)           | (7.76)           | (8.18)           |
| Trade, repair, hotels and restaurants                                  | <b>18288.68</b>  | <b>14403.12</b>  | <b>15713.55</b>  |
|  | (13.82)          | (11.36)          | (11.39)          |
| Transport, storage, communication and services related to broadcasting | <b>8611.92</b>   | <b>7191.83</b>   | <b>8850.92</b>   |
|  | (6.51)           | (5.67)           | (6.41)           |
| Railways   | <b>823.03</b>    | <b>657.54</b>    | <b>831.07</b>    |
|  | (0.62)*          | (0.52)*          | (0.60)*          |
| Other Transport  | <b>5456.90</b>   | <b>4188.39</b>   | <b>5416.67</b>   |
|  | (4.12)*          | (3.30)*          | (3.93)*          |
| Financial services   | <b>7845.36</b>   | <b>8245.62</b>   | <b>8303.92</b>   |
|  | (5.93)           | (6.50)           | (6.02)           |
| Real estate, ownership of dwelling and professional services           | <b>21137.08</b>  | <b>21342.90</b>  | <b>22684.35</b>  |
|  | (15.97)          | (16.83)          | (16.44)          |
| Public administration and defence                                      | <b>7625.31</b>   | <b>7576.16</b>   | <b>7927.00</b>   |
|  | (5.76)           | (5.97)           | (5.75)           |
| Other Services   | <b>9698.73</b>   | <b>8424.74</b>   | <b>9625.62</b>   |
|  | (7.33)           | (6.64)           | (6.98)           |
| <b>TOTAL GVA at basic prices</b>                                       | <b>132361.00</b> | <b>126814.82</b> | <b>137980.25</b> |

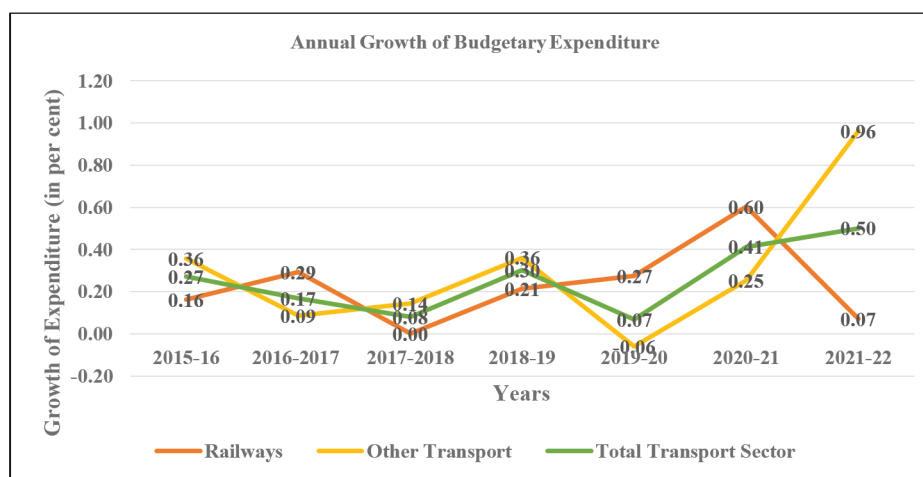
Source: Authors compilation from National Accounts Statistics 2018, Ministry of Statistics and Programme Implementation, Government of India. Note: Values in parenthesis are share of sectoral GVA as a perent of Total GVA. \*as a percentage of total GVA.



Source: Authors representation using Budget documents, Ministry of Finance, Government of India.

Note: Values are presented as a percentage of the total budget.

**Figure 1.** Allocations to Transport Sector (percent of Total Budgetary Allocations).



Source: Authors representation using Budget documents, Ministry of Finance, Government of India.

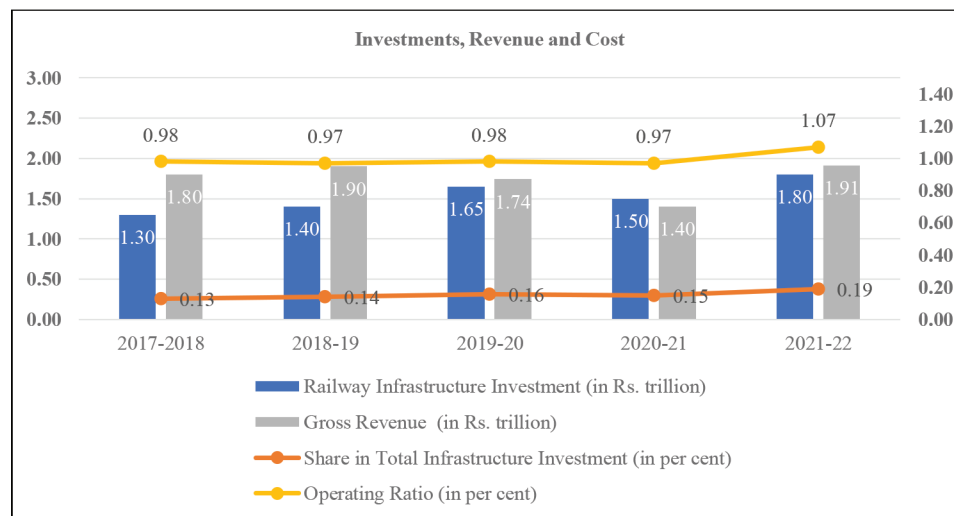
**Figure 2.** Growth in Transport Sector Budgetary Allocations 2015-16 to 2021-22 (in percent).

contrast, the Other Transport sector saw a sharp rise in expenditure growth.

Moving abreast with the Asian partners, the Indian Government chooses to provide sustainable and resilient infrastructure by making technological interventions and innovations within the transport sector. First, the Rs. 1100 billion ventures of the High-Speed Rail<sup>c</sup> (HSR) development project (in collaboration with the Government of Japan) would bring benefits of high-speed commutation, safe and cost-effective travel, employment opportunities along environmental protection.

<sup>c</sup>First Annual Report 2016-17, National High-Speed Rail Corporation Limited.

Although investments in railway infrastructure have increased over time, the share remains insignificant compared to overall investments (Figure 3). The rise in revenues over time has been shadowed by higher operating costs. Existing challenges for Indian Railways include rising investment gaps and subsequently increasing operating ratios, dwindling cargo movement, losses on passenger traffic and substitution by airlines, urgent station redevelopment and rising safety concerns. Ineffectiveness in implementing projects would further attract higher debt servicing costs for railways in future. Considering the investments made and value additions received, the cascading performance of railways in India needs attention.



Source: Authors compilation using NIP Report 2020 by Department of Economic Affairs, Ministry of Finance, Government of India.

**Figure 3.** Investment in Railway Infrastructure (Gross Revenue and Operating Ratio).

### 3. Literature Review

Extensive literature highlighting the relevance of economic sectors using I-O-based applications is available for several countries. However, the paucity of similar literature in the Indian context is discernible. Further, investigations pertaining to linkages of the transportation sector in India, especially for railways, are absent, making our study distinct and vital in this backdrop.

Lee and Yoo (2016) make an important contribution in this context to the Korean economy. Their research embodies the I-O-based linkages of four transport sectors in South Korea. Rail and road networks exhibit greater inter-industry linkage effects on sectors such as petroleum and coal. Higher absorption of products by the transport sector in aggregate provides the basis for long-term policy formulation<sup>23</sup>. A study by Dam and Kaur<sup>24</sup> provides a comparative picture of ideas and applications exploring transportation-economic linkages within existing studies. Justification of investment decisions and efficacy of strategy in transport development can be legitimised through hypothetically induced shocks. Measures of embeddedness of transport systems within the production and consumption of factors can be devised using demand and supply-driven I-O techniques<sup>25</sup>.

To evaluate the advancements made by the Indian economy on growth and productivity, several authors<sup>21,24,26,27</sup> have adopted Input-Output based models in specific contexts. Sectoral 'Keyness' and linkage are measured through multipliers. Irrespective of the type

of aggregation adopted, 'Infrastructure' (inclusive of transportation) remains a 'Key-sector' exerting large absorption and diffusion effects before and after economic reforms<sup>26</sup>.

The extraction technique provides insight to critically evaluate the importance of a sector and its activities for economic growth. The idea of hypothetical extraction by mathematically eliminating sectoral contributions reveals the plausible extent of linkages and sectoral importance. The methodology in its inceptive form<sup>28</sup> considers writing off the entire row and column of intermediate contributions pertaining to a particular sector along with the scalar of final demand. Extraction gained prominence<sup>29-31</sup> through application across different economies and scenarios. Though extraction methodology suffers from practical and intuitive constructs, some examples of its application in India also exist. Approaching this statistical exclusion with a methodologically enforced one, Sajid *et al.*,<sup>22</sup> use the recently developed Tourism Satellite Accounts (TSA) to endogenise the sector to evaluate its contributions. Focusing on the impacts of 'Tourism' through ex-ante and ex-post exclusion, the study finds strong interdependence of 'Tourism' with sectors such as 'Hotels' and 'Restaurants'. Here also, the four modes of transport emerge as key sectors using aggregated exercise across 25 sectors.

Through this study, we provide a comprehensive account of hypothetical extraction-based effects on outcomes of different sectors of the economy and measure their linkages with the Railway and Other Transport sectors. To understand how transport could support



**Table 2.** Aggregate Sectors used in Input-Output Model-Based Analysis

| Sectors |                           |    |                                |
|---------|---------------------------|----|--------------------------------|
| 1       | Agriculture (AG)          | 12 | Storage and Warehousing (SW)   |
| 2       | Animal Husbandry (AH)     | 13 | Communication (CM)             |
| 3       | Forestry and Logging (FL) | 14 | Trade (TR)                     |
| 4       | Fishing (FO)              | 15 | Hotels and Restaurants (HR)    |
| 5       | Mining and Quarrying (MQ) | 16 | Banking (BN)                   |
| 6       | Manufacturing (MF)        | 17 | Insurance (IS)                 |
| 7       | Construction (CO)         | 18 | Ownership of Dwellings (OD)    |
| 8       | Electricity (EL)          | 19 | Education and Research (ED)    |
| 9       | Water Supply (WS)         | 20 | Medical and Public Health (MH) |
| 10      | Railway (RL)              | 21 | Other Services (OS)            |
| 11      | Other Transport (OT)      | 22 | Public Administration (PA)     |

economic development, it is important to understand its 'Key' linkages with other sectors of the economy. This study gains its relevance from the fact, that we provide a numeric measure of impact across different sectors in India and show how induced reduction in contributions by the transport sector could affect the outcomes across the entire system. This would not only highlight the leading and lagging sectors but would enable policymakers to devise sector-specific policies in consonance with other sectors including transportation.

## 4. Methodological Approach

### 4.1 Non-Extractio-based Methodology

Input-Output Transaction Tables (IOTT) are tables detailing the process of production and use of goods and services. Consistent with National Accounts Statistics (NAS) these tables enumerate the inputs and outputs through sectoral classification. Since the structure of IOTT varies over the years, the tables have been aggregated to the level of 22 sectors<sup>d</sup> for capturing the effect of sub-industrial processes at a consolidated level<sup>32</sup>. To highlight the performance of the railway sector in comparison to other modes of transport, namely airways, waterways and land-based-transport networks, the latter have been aggregated as the 'Other Transport' sector<sup>e</sup>.

<sup>d</sup>Sector classification has been adopted using the methodology followed by Central Statistical Organization (CSO) which has been kept consistent over different tables.

<sup>e</sup>The IOTT for the years 1993-94 and 1998-99 comprise of 115 sectors. Transport sector is disaggregated into railways and other

Table 2 lists the aggregated sectors along with their abbreviated notations of which sector 10: Railway and sector 11: Other Transport are of interest for the study and further methodological purposes.

The analytical inspection in the consequent section begins with the presentation of correlations for Railway and Other Transport sectors with the rest of the economy over different time intervals. Sector pair-wise coefficients of correlation, quantified using Pearson's method, along with their levels of significance have been reported.

Technical richness for practical application of I-O models provided by deserves special mention<sup>33</sup>. For a squared  $n$ -sector matrix of intermediate transactions, represents the provision of inputs from sector to sector for producing goods. The matrix of direct unit input requirements, denoted with , comprises elements in the demand-driven system.

Total output as a function of intermediate and final demand is given in Eq. (1) as:

$$x = (I - A)^{-1} f = Lf \quad (1)$$

where,  $L = (I - A)^{-1}$  is called the *Leontief Inverse (of technology matrix) or multiplier matrix* and a column vector  $f$  of final demand.

transport (which include the land, air and water-based transport services). It was only since year 2003-04 that the other transport sector was further disaggregated to emphasise upon the economic contribution of each individual sector. The tables for later years comprised of 130 sectors and hence the aggregation was done to overcome the anomalies arising due to the statistical construct of the tables. In order to establish a parity and produce comparable results with railways of the years, the other modes of transport were aggregated into one sector, namely 'Other Transport'.

The surmounting dissent of using Leontief model for computing forward linkages drew out of the seminal works of Oosterhaven<sup>34</sup>. Adding an alternate perspective to the intermediate transactions, the Ghosh model considered such transactions to demarcate inter-sectoral supplies of inputs to support forward-sector outputs. Successive value additions to each of the output-oriented sectors resulted in changing the overall output of the economy. These assertions of production-induced output changes were subjectively challenged<sup>34-38</sup>. Guerra and Sancho<sup>35</sup> dispute the 'plausibility' of supply-driven Ghosh model to generate cyclical effects on value-added over time. By establishing equivalence between two models the studies by Dietzenbacher<sup>38</sup> and Guerra and Sancho<sup>35</sup> solve the problem of tenable acceptance by closing the model. Income and compensation to households result in consumption, thus treating value added as a transacting sector, which encourages public sector spending on infrastructure and utilities and completes the cyclical flow through endogenization of value added. Conclusive enough, a study by Dietzenbacher<sup>38</sup> affirmatively fields for impartial treatment of the two models and furthers the idea that interpretation and computation of forward linkage multipliers based on the Ghosh model holds merit.

Analogous derivation of the Ghosh model is given in Eq. (2)

$$x^t = v^t (1-B)^{-1} = v^t G \quad (2)$$

where,  $G = (1-B)^{-1}$  pertains to *Ghosh Inverse based multiplier matrix*,  $v$  represents the vector for *value added* and superscript  $t$  denotes transpose. Output matrix comprises of elements in the supply-driven framework.

Component in Eq. (1) and  $v$  in Eq. (2) inflict exogenous effects on respective models. The strategy of 'focused development'<sup>39</sup> entails an unbalanced or inequitable system in which leading sectors can influence the trailing and poorly performing sectors of the economy.

The sectoral Backward Linkages (BL) are calculated using the demand-driven Leontief model. Since the supply-driven Ghosh model holds utility for impact assessment in planned economies<sup>35,40</sup>, we calculate the sectoral Forward Linkages (FL) through the supply-driven Ghosh model. Key sectors<sup>f</sup> or sectors with both  $BL > 1$  and

$FL > 1$  are classified as important sectors with capabilities of generating stimulus across the economy<sup>35,41,42</sup>.

## 4.2 Extraction based Methodology

Considering policy evaluation and effectiveness, extraction-based methodology emerges as a useful tool for analysis. The technique enforces extraction or removal of sectoral intermediate contributions to quantify the resultant change in the total output of the economy. Benchmarking of such sectors which inflict larger changes in the total output could also become the focus of policy implementation. The analytical development of hypothetical extraction-based models began through strict reductions in contributions which lacked theoretical correctness and credibility. An industry or sector's contribution was outrightly eliminated by deleting a row and/or column of its interactions with other sectors along with its final demand<sup>28,30,31</sup>. The resultant Leontief inverse is then used to compute the outcome of these extractions in the form of a vector of final/total output. Change in the output ex-ante and ex-post methodological adjustments portray the strength of effect exerted by a sector or industry.

In all its simplicity, extraction of the  $k$ th sector within matrix does not hold theoretical ground<sup>43</sup>. Through row and column contribution along with subsequent final demand  $f_k$  set equal to zero (or which in case of deletion would reduce the exercise to sector), the new output is estimated by modifying Eq. (1) as  $\bar{x}$  with overhead bar denoting equation elements post extraction. The resulting difference in output would signify the magnitude loss inflicted by the extracted sector  $k$  thus denoting strong total linkages. Complete 'cessation' is contentious from an economic and policy perspective<sup>43,44</sup> and such nullifications at the scale of an entire sector or industry fail as a logical premise.

The argument of partial extraction<sup>43</sup> for dependence analysis is built upon the failures explained above and presents a more plausible case of capacity constraint. Sub-sectors or fragments within an industry may function sub-optimally. For measuring the backward dependencies of a sector and presenting strong dependence on inputs, the system-wide delivery of inputs to a particular sector ceases, keeping other things intact. This sector derives inputs for production exogenously through imports. Assuming a sector (such as railways in our study)

(FL) are computed using  $\bar{x}$  where  $\bar{x}$  is the Ghosh inverse matrix. Forward linkage is a measure of change in output of sector created due to a unit change in demand across all sectors.

<sup>f</sup>Under Rasmussen's method, Backward Linkages (BL) which measures the effect a unit change in demand of sector can create on the overall input productivity of rest of the sectors, is computed as  $BL = \frac{1}{x} \frac{dx}{df}$  where  $x$  is the Leontief inverse matrix. Similarly, Forward Linkages

purchases no inputs from across the system, the column vector is set equal to zero in matrix leading to . Final output through such extractions is computed by solving for old level of final demand. Corresponding difference in output is a causal outcome of reduced dependency of sector on production system and denotes '*absolute backward dependence*'. Similarly, the seller's reliance in the form of forward dependencies is measured by nullifying row elements of output matrix, which gives . The new output, using modified Eq. (2), is given by which is a row vector. Change in output denoting '*absolute forward dependence*' given by is due to sector extraction<sup>44,45</sup>.

Normalising the reduction in output<sup>44,45</sup> by the absolute value of hypothetically extracted sector's output results in *relative/normalised backwards and forward dependencies* given by and respectively.

### 4.3 Data Source

For our analysis, five Input-Output (I-O) tables (specifically for years 1993-94, 1998-99, 2003-04, 2007-08 and 2013-14) have been deployed. The sources and construct of the tables are described henceforth. IOTT in India were published quinquennially by the Central Statistical Organisation (CSO) with the last one being published officially for the year 2013-14<sup>g</sup>. With transactions valued at factor cost, in the year 2003-04, tables were reclassified to 130 sectors from 115 sectors in previous tables, which included a prominent change of interest for this study. The erstwhile sector of 'Other Transport' was disaggregated<sup>h</sup> into four new sectors due to their rising economic vitality<sup>46</sup> alongside the railways transport services sector. The IOTT for the year 2007-08 proved to be the definitive publication under the series by CSO. The table for the year 2013-14 has been compiled by Singh<sup>47</sup>. Some comparable features of these tables include homogeneity of sectors and schematic construction using *Use* and *Make* matrices. Recognition and focus on significant contributions by the Public Administration sector is a noted point of difference<sup>47,48</sup> which was absent in the previous versions of the table. Based on the assumption of non-marketability, Public Administration and Defence Services are non-generative activities on

account of intermediate flows and input use. Nonetheless, the sector acquired a spot within the IOTT due to its monetary contributions to employee compensation and salaries distributed across the central, state and local government bodies.

## 5. Findings and Discussions

The analytical framework of this section begins with the results derived from the methodological approach discussed. The important findings and discussions are as follows:

**Results based upon the level of correlations** existing across 22 sectors, aggregated using I-O Tables are reported in Table 3 in conjunction with the Railways and Other Transport sectors. Pertinent findings are hereby listed:

- Strong and significant correlations emerge within sectors coupled with Railways and Other transport sectors respectively based upon the inter-industry exchanges. Sectors such as Manufacturing, Electricity, Mining and Quarrying and Construction possess high level of correlations with railways whereas this relation strengthens over time for the other Transport sector. Since the nature of these activities entails heavy dependence of transportation networks for the movement of raw materials, the relations emerge significant.
- Another set of significant relationships emerge with sectors Storage and Warehousing and Communication which strengthen over time with the Railways sector and not as much with the Other Transport sector. Imperatively evident is the strong confluence between Railways and Other Transport sectors themselves. Interconnectivity for last mile transit along with intermodal competition and cooperation<sup>49</sup> thus cannot be ignored. The banking sector becomes significantly related, whereas, the Insurance sector lost significance with, the Railways sector in the year 2013-14. Medical and Public Health as a sector develops strong significant relationships with the Other Transport sector over time.
- Education, Research and Water Supply possess stronger relations with Other Transport sector than with the Railway sector in the year 2013-14. At the incentive level, these correlations illustrate an immediate structure of distribution of individual sectoral activities in consonance with economic contributions made by these sectors.

<sup>g</sup>Under the Ministry of Statistics and Program Implementation, Government of India.

<sup>h</sup>These were namely, Land Transport including via Pipeline, Water Transport, Air Transport and Supporting & Auxiliary transport services.



**Table 3. Correlation Coefficients of Railway and Other Transport Sectors with the Remaining Sectors**

|    | Sectors                        | Railway Sector Correlations |          |          |          |          | Other Transport Sector Correlations |          |          |          |          |
|----|--------------------------------|-----------------------------|----------|----------|----------|----------|-------------------------------------|----------|----------|----------|----------|
|    |                                | 1993-94                     | 1998-99  | 2003-04  | 2007-08  | 2013-14  | 1993-94                             | 1998-99  | 2003-04  | 2007-08  | 2013-14  |
| 1  | Agriculture (AG)               | 0.361                       | 0.367    | 0.287    | 0.236    | 0.520*   | 0.577**                             | 0.663*** | 0.381    | 0.316    | 0.854*** |
| 2  | Animal Husbandry (AH)          | -0.0286                     | -0.0569  | 0.00733  | 0.0163   | 0.110    | 0.164                               | 0.0469   | 0.175    | 0.172    | 0.349    |
| 3  | Forestry and Logging (FL)      | 0.778***                    | 0.383    | 0.538**  | 0.614**  | 0.648**  | 0.543**                             | 0.550**  | 0.657*** | 0.788*** | 0.895*** |
| 4  | Fishing (FO)                   | 0.760***                    | 0.504*   | 0.829*** | 0.801*** | 0.462*   | 0.914***                            | 0.904*** | 0.976*** | 0.917*** | 0.888*** |
| 5  | Mining and Quarrying (MQ)      | 0.858***                    | 0.779*** | 0.934*** | 0.925*** | 0.590**  | 0.970***                            | 0.943*** | 0.940*** | 0.921*** | 0.574**  |
| 6  | Manufacturing (MF)             | 0.783***                    | 0.548**  | 0.810*** | 0.801*** | 0.440*   | 0.940***                            | 0.872*** | 0.946*** | 0.905*** | 0.793*** |
| 7  | Construction (CO)              | 0.790***                    | 0.528*   | 0.847*** | 0.898*** | 0.536*   | 0.924***                            | 0.893*** | 0.971*** | 0.888*** | 0.946*** |
| 8  | Electricity (EL)               | 0.306                       | 0.777*** | 0.651**  | 0.756*** | 0.542**  | 0.259                               | 0.376    | 0.421    | 0.563**  | 0.919*** |
| 9  | Water Supply (WS)              | 0.442*                      | 0.355    | 0.212    | 0.260    | 0.514*   | 0.136                               | 0.116    | -0.00972 | 0.162    | 0.857*** |
| 10 | Railway (RL)                   | 1                           | 1        | 1        | 1        | 1        | 0.810***                            | 0.695*** | 0.831*** | 0.817*** | 0.649**  |
| 11 | Other Transport (OT)           | 0.810***                    | 0.695*** | 0.831*** | 0.817*** | 0.649**  | 1                                   | 1        | 1        | 1        | 1        |
| 12 | Storage and Warehousing (SW)   | 0.382                       | 0.895*** | 0.656*** | 0.886*** | 0.907*** | 0.501*                              | 0.673*** | 0.329    | 0.642**  | 0.418    |
| 13 | Communication (CM)             | 0.835***                    | 0.750*** | 0.889*** | 0.906*** | 0.968*** | 0.812***                            | 0.899*** | 0.951*** | 0.950*** | 0.598**  |
| 14 | Trade (TR)                     | 0.493*                      | 0.540**  | 0.468*   | 0.668*** | 0.770*** | 0.649**                             | 0.775*** | 0.585**  | 0.776*** | 0.927*** |
| 15 | Hotels and Restaurants (HR)    | 0.228                       | 0.216    | 0.438*   | 0.576**  | 0.366    | 0.437*                              | 0.447*   | 0.591**  | 0.740*** | 0.668*** |
| 16 | Banking (BN)                   | 0.178                       | 0.356    | 0.144    | 0.392    | 0.904*** | 0.282                               | 0.387    | 0.158    | 0.392    | 0.409    |
| 17 | Insurance (IS)                 | 0.356                       | 0.621**  | 0.626**  | 0.630**  | 0.282    | 0.576**                             | 0.762*** | 0.762*** | 0.790*** | 0.230    |
| 18 | Ownership of Dwellings (OD)    | 0.327                       | 0.150    | 0.266    | 0.258    | -0.0410  | -0.0541                             | -0.0547  | -0.0624  | -0.0718  | 0.163    |
| 19 | Education and Research (ED)    | 0.837***                    | 0.315    | 0.315    | 0.264    | 0.647**  | 0.644**                             | 0.570**  | 0.393    | 0.336    | 0.771*** |
| 20 | Medical and Public Health (MH) | 0.811***                    | 0.337    | 0.849*** | 0.806*** | 0.564**  | 0.923***                            | 0.762*** | 0.986*** | 0.983*** | 0.919*** |
| 21 | Other Services (OS)            | 0.812***                    | 0.599**  | 0.329    | 0.454*   | 0.725*** | 0.974***                            | 0.935*** | 0.459*   | 0.485*   | 0.716*** |
| 22 | Public Administration (PA)     | 0                           | 0        | 0        | 0        | 0.159    | 0                                   | 0        | 0        | 0        | 0.489*   |

Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Note: The asterisk in superscript denotes the level of significance at p-values colour-coded as \* p<0.05, \*\* p<0.01 and \*\*\* p<0.001.

An almost recognisable pattern of relationship exists across both segments of the transport system validating the sectoral contributions made by sectors to the overall gross value added (Table 1) over the years. The top contributors are the ones maintaining stronger ties with the transport sector.

Under *extraction-based results*, the elimination of column elements (for backward dependence) and row elements (for forward dependence) of Railway and Other Transport sectors results in effects varying in magnitude, yet exhibiting similar patterns. The demand-induced and supply-inflicted effects on the output of sectors through the extraction of Railway and Other Transport sectors are reported in Table 4a and Table 4b, respectively. Backward dependence portrays ‘buyers’ dependence on downstream suppliers’ and forward dependence symbolises ‘sellers’ dependence on upstream buyers’.

The results presented here are normalised to the output of the extracted sectors and not of the affected sectors.

## 5.1 Results Pertaining to Railway Extraction

- Hypothetical rollback of intermediate demand of inputs by the Railway sector affects the Manufacturing sector the most with its output declining in the range of 30-53 percent relative to Railway output. At the sectoral level, curtailment of intermediate supplies from the Railway sector inflicts a greater decline in the final output of the Manufacturing sector to the tune of 61.7-81 percent for the years in consideration. Saliency enough, this decline is coincidental with the changes in the level of correlation of these two sectors on the quinquennial basis, signifying

that higher impacts on output are linked with stronger correlation.

- Further in this sequence, sectors such as Electricity (between 4.6-27 perent) and Construction (between 2.5-17.3 perent) relatively lose substantial output through the extraction of the railways sector. The backward effects of extraction on Mining and Quarrying (between 5.4-7.8 perent) and Banking (between 3.5-9.9 perent) are more significant than their forward effects. The productive relationship between Railway and Electricity sectors is noteworthy. Compared to the total running track length of 89919 kilometres in the year 2013-14, the length of electrified tracks was around 39661 kilometres. In the same year around 15169.16 million kilowatt hours of electricity was consumed<sup>i</sup> as fuel consumption for locomotives. As a measure of energy dependence created between the Railway and Electricity sectors, this measure of consumption for diesel was capped at 2789.26 kilo-litres. Of the total 1052.44 million tonnes of Railway freight transported in the year 2017-18, Coal and Cement constituted 47.9 and 9.74 perent share respectively<sup>j</sup>, followed by Iron ore (12.06 perent), Iron and Steel (4.69 perent), Chemical Manure (4.19 perent) and Food grains (3.78 perent).
- No trend or pattern can be established from railway-based extraction over sectoral dependence. For sectors carrying greater dependence on Railways, namely - Manufacturing, Construction and Mining and Quarrying, the loss in output in 2013-14 is at lower levels than in 1993-94<sup>k</sup>.

## 5.2 Results Pertaining to the Other Transport Extraction

- On extraction, bi-directional loss-impact inflicted by Other Transport sector is the highest for Manufacturing sector which varies

in the range of 29.1-58.2 perent relative to the extracted sector's output, followed by Electricity (between 1.3 and 12.1 perent) and Construction (between 1.7 and 14.2 perent). Here too, Mining and Quarrying and Banking sectors receive considerable 'backward' shock. Witnessing a least significant impact of extraction, Water Supply, Ownership of Dwellings and Education and Research sectors score low even on 'relatedness' with both Railway and Other Transport sectors. Resulting proportional reduction in the output of sectors such as Trade (between 2.5 and 11.8 perent) and Hotel and Restaurants (between 0.7 and 8.6 perent) is sizeable, showing what matters for Other Transport sector.

- Analysing the trend in output decline generated through extraction of Other Transport sector, output losses for Mining and Quarrying and Construction sectors emerge higher in 2013-14 compared to 1993-94.

Interstate and cross-border trade of commodities is captured under Trade sector. Apart from the capital-intensive commodities (which rely more on Railway sector as a mode of long-distance transport), consumer durables and non-durables generally covering shorter distances rely upon other modes of transport. Freight movements by road<sup>l</sup>- based mode of transport was 1650.8 billion tonne kilometres in 2013-14. With a given capacity of 800.52 million tonnes, Indian ports were utilising only 69 perent<sup>m</sup> of this available capacity, by 2013-14. Annual air traffic movement of cargo<sup>n</sup> (both domestic and international) was around 2.27 million tonnes.

## 5.3 Self-effects of Extracted Sectors

Across 22 sectors and for years in consideration, the forward dependence effect on Railway sector, as an indicator of 'self-dependence', lies well below the average loss-impact, whereas that of Other Transport lies well above it irrespective of the source of extraction. A similar trend can be ascertained in terms of backward

<sup>i</sup>Indian Railways Year Book 2017-18, Ministry of Railways, Government of India.

<sup>j</sup>Indian Railways Year Book 2017-18, Ministry of Railways, Government of India.

<sup>k</sup>An exception being the Electricity sector for which the loss in output is higher in the year 2013-13 compared to 1993-94.

<sup>l</sup>Road Transport Year Book 2015-16, Ministry of Road Transport and Highways, Government of India.

<sup>m</sup>Annual Report 2018-19, Ministry of Shipping, Government of India.

<sup>n</sup>Annual Report 2015-16, Ministry of Civil Aviation, Government of India.

dependence with an exception for the year 2003-04 where Railway sector results outweigh the average.

Self-inflicted losses (defined as loss in output of a particular transport sector arising from its *extraction*) for both Railway and Other Transport sectors increase and are highest in 2003-04 and fall thereafter. Further, cross-sector inflicted losses (defined as a loss in output of a particular transport sector arising from the *extraction of opposite transport sector*) decline constantly over time

with the highest loss in the inception year 1993-94 and the lowest reduction in output for the year 2013-14.

To conclude, sectors namely, Manufacturing, Electricity and Construction are prominently related to Railway and Other Transport sectors. Role of Railways and Other Transport is crucial for Manufacturing by way of logistics and freight, while sectors such as Electricity and Construction are aligned through freight services rendered by transport sectors. Where profile of Railway

**Table 4a. Resultant Change in Output of 22 Remaining Sectors through Extraction of Railway and Other Transport Sectors (Column-based) denoting 'Relative Backward Dependence' (in percent)**

|    | Sectors                      | Railway based HE |         |         |         |         | Other Transport based HE |         |         |         |         |
|----|------------------------------|------------------|---------|---------|---------|---------|--------------------------|---------|---------|---------|---------|
|    |                              | 1993-94          | 1998-99 | 2003-04 | 2007-08 | 2013-14 | 1993-94                  | 1998-99 | 2003-04 | 2007-08 | 2013-14 |
| 1  | Agriculture (AG)             | -3.21            | -3.40   | -4.49   | -2.90   | -3.47   | -6.99                    | -5.57   | -6.94   | -7.33   | -5.91   |
| 2  | Animal Husbandry (AH)        | -0.71            | -0.75   | -0.82   | -0.59   | -0.76   | -1.11                    | -1.05   | -1.16   | -1.90   | -1.07   |
| 3  | Forestry and Logging (FL)    | -0.30            | -0.25   | -0.24   | -0.51   | -0.50   | -0.33                    | -0.33   | -0.22   | -0.49   | -1.04   |
| 4  | Fishing (FO)                 | -0.07            | -0.06   | -0.13   | -0.09   | -0.10   | -0.08                    | -0.09   | -0.14   | -0.15   | -0.17   |
| 5  | Mining and Quarrying (MQ)    | -7.53            | -5.42   | -7.79   | -6.28   | -6.60   | -4.77                    | -4.10   | -6.07   | -7.15   | -11.15  |
| 6  | Manufacturing (MF)           | -33.80           | -30.86  | -53.30  | -40.27  | -30.29  | -39.15                   | -40.45  | -57.74  | -56.01  | -58.22  |
| 7  | Construction (CO)            | -7.98            | -6.15   | -10.82  | -8.60   | -2.57   | -1.99                    | -1.80   | -1.79   | -2.19   | -8.80   |
| 8  | Electricity (EL)             | -8.51            | -27.19  | -17.60  | -10.73  | -18.28  | -10.87                   | -12.12  | -4.65   | -2.68   | -10.12  |
| 9  | Water Supply (WS)            | -0.11            | -0.08   | -0.07   | -0.04   | -1.74   | -0.52                    | -0.18   | -0.11   | -0.07   | -1.41   |
| 10 | Railway (RL)                 | -2.46            | -1.91   | -6.29   | -0.67   | -0.30   | -1.85                    | -1.65   | -1.21   | -0.76   | -0.46   |
| 11 | Other Transport (OT)         | -4.33            | -3.36   | -4.94   | -4.04   | -1.33   | -6.10                    | -5.93   | -7.61   | -7.19   | -2.75   |
| 12 | Storage and Warehousing (SW) | -0.04            | -0.04   | -0.05   | -0.03   | -0.04   | -0.05                    | -0.06   | -0.09   | -0.08   | -0.06   |
| 13 | Communication (CM)           | -0.98            | -1.17   | -1.10   | -0.66   | -4.37   | -1.77                    | -2.03   | -3.32   | -1.93   | -3.57   |
| 14 | Trade (TR)                   | -6.61            | -5.27   | -7.48   | -6.01   | -3.90   | -8.31                    | -8.04   | -10.90  | -11.82  | -6.85   |
| 15 | Hotels and Restaurants (HR)  | -0.29            | -0.46   | -0.51   | -0.91   | -3.00   | -1.75                    | -2.29   | -2.72   | -8.64   | -2.26   |
| 16 | Banking (BN)                 | -4.96            | -9.95   | -4.73   | -3.51   | -4.60   | -7.19                    | -4.56   | -4.07   | -2.89   | -6.59   |
| 17 | Insurance (IS)               | -0.45            | -1.39   | -0.83   | -0.44   | -0.25   | -1.77                    | -1.25   | -2.06   | -1.26   | -0.39   |
| 18 | Ownership of Dwellings (OD)  | 0.00             | 0.00    | 0.00    | 0.00    | 0.00    | 0.00                     | 0.00    | 0.00    | 0.00    | 0.00    |
| 19 | Education and Research (ED)  | -0.36            | -0.21   | -0.23   | -0.22   | -0.26   | -0.01                    | 0.00    | -0.02   | -0.21   | -0.24   |
| 20 | Medical & Public Health (MH) | -6.27            | -1.02   | -1.11   | -1.36   | 0.00    | -0.13                    | -0.02   | -0.04   | -0.06   | 0.00    |
| 21 | Other Services (OS)          | -2.29            | -6.58   | -1.58   | -2.55   | -6.23   | -4.61                    | -10.95  | -4.98   | -4.47   | -8.58   |
| 22 | Public Administration (PA)   | 0.00             | 0.00    | 0.00    | 0.00    | 0.00    | 0.00                     | 0.00    | 0.00    | 0.00    | 0.00    |

Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Note: The heat map shows the extent of output lost due to column-based extraction of the transport sectors.

**Table 4b. Resultant Change in Output of 22 Remaining Sectors through Extraction of Railway and Other Transport Sectors (Row-based) denoting 'Relative Forward Dependence' (in percent)**

|    | Sectors                      | Railway based HE |         |         |         |         | Other Transport based HE |         |         |         |         |
|----|------------------------------|------------------|---------|---------|---------|---------|--------------------------|---------|---------|---------|---------|
|    |                              | 1993-94          | 1998-99 | 2003-04 | 2007-08 | 2013-14 | 1993-94                  | 1998-99 | 2003-04 | 2007-08 | 2013-14 |
| 1  | Agriculture (AG)             | -9.98            | -7.34   | -7.88   | -5.03   | -2.29   | -9.07                    | -5.45   | -5.23   | -3.66   | -1.39   |
| 2  | Animal Husbandry (AH)        | -1.59            | -1.05   | -1.30   | -1.09   | -0.96   | -2.36                    | -1.36   | -2.03   | -1.64   | -1.27   |
| 3  | Forestry and Logging (FL)    | -0.45            | -0.40   | -0.17   | -0.37   | -0.13   | -0.22                    | -0.21   | -0.23   | -0.66   | -0.41   |
| 4  | Fishing (FO)                 | -0.24            | -0.21   | -0.18   | -0.12   | -0.17   | -0.27                    | -0.17   | -0.21   | -0.14   | -0.10   |
| 5  | Mining and Quarrying (MQ)    | -2.05            | -1.51   | -1.52   | -2.34   | -1.59   | -0.94                    | -0.76   | -0.87   | -0.89   | -1.21   |
| 6  | Manufacturing (MF)           | -64.88           | -67.12  | -67.62  | -81.02  | -61.76  | -43.30                   | -33.76  | -38.14  | -47.41  | -29.18  |
| 7  | Construction (CO)            | -15.95           | -15.70  | -12.91  | -17.35  | -13.53  | -10.43                   | -8.41   | -10.10  | -14.29  | -11.35  |
| 8  | Electricity (EL)             | -19.69           | -23.62  | -13.05  | -4.67   | -6.93   | -3.33                    | -3.77   | -2.84   | -1.38   | -2.80   |
| 9  | Water Supply (WS)            | -0.16            | -0.28   | -0.12   | -0.12   | -0.22   | -0.06                    | -0.10   | -0.05   | -0.37   | -0.18   |
| 10 | Railway (RL)                 | -2.46            | -1.91   | -6.29   | -0.67   | -0.30   | -0.75                    | -0.53   | -0.74   | -0.40   | -0.17   |
| 11 | Other Transport (OT)         | -10.65           | -10.52  | -8.10   | -7.67   | -3.67   | -6.10                    | -5.93   | -7.61   | -7.19   | -2.75   |
| 12 | Storage and Warehousing (SW) | -0.05            | -0.12   | -0.10   | -0.06   | -0.05   | -0.02                    | -0.04   | -0.04   | -0.03   | -0.03   |
| 13 | Communication (CM)           | -0.54            | -0.64   | -0.67   | -0.59   | -1.71   | -0.15                    | -0.19   | -0.38   | -0.38   | -0.77   |
| 14 | Trade (TR)                   | -6.49            | -4.97   | -2.58   | -3.04   | -2.98   | -4.79                    | -5.82   | -6.02   | -6.66   | -4.80   |
| 15 | Hotels and Restaurants (HR)  | -1.39            | -1.57   | -1.91   | -2.15   | -0.71   | -1.36                    | -1.41   | -1.94   | -2.51   | -0.81   |
| 16 | Banking (BN)                 | -0.70            | -1.58   | -1.42   | -1.70   | -1.29   | -0.31                    | -0.78   | -0.89   | -0.82   | -0.74   |
| 17 | Insurance (IS)               | -0.19            | -0.44   | -1.20   | -0.79   | -0.31   | -0.09                    | -0.22   | -0.61   | -0.38   | -0.40   |
| 18 | Ownership of Dwellings (OD)  | -0.38            | -0.36   | -0.20   | -0.16   | -0.17   | -0.25                    | -0.19   | -0.16   | -0.13   | -0.14   |
| 19 | Education and Research (ED)  | -0.95            | -1.12   | -0.25   | -0.23   | -0.63   | -0.42                    | -0.99   | -0.85   | -0.94   | -0.52   |
| 20 | Medical & Public Health (MH) | -1.15            | -2.71   | -0.99   | -0.88   | -0.55   | -1.57                    | -1.90   | -1.00   | -0.83   | -0.53   |
| 21 | Other Services (OS)          | -3.89            | -6.72   | -1.82   | -2.05   | -5.20   | -3.22                    | -3.55   | -1.33   | -1.49   | -4.11   |
| 22 | Public Administration (PA)   | 0.00             | 0.00    | 0.00    | 0.00    | -1.28   | 0.00                     | 0.00    | 0.00    | 0.00    | -2.19   |

Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Note: The heat map shows the extent of output lost due to row-based extraction of the transport sectors.

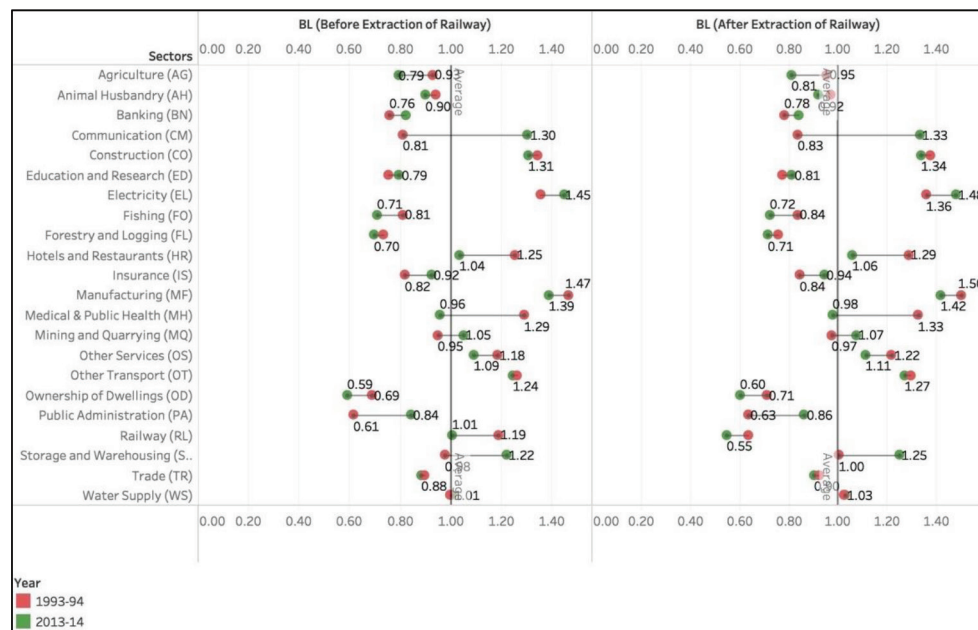
activity favours Electricity, inter-state trade relies heavily upon road networks. State revenues<sup>o</sup> collected through tax on passengers and goods collectively amounted to Rs. 194.45 billion in 2013-14, which rose significantly to Rs. 235.36 billion by 2015-16. For a country such as India, witnessing a boom in e-commerce activity, the role of transport is inseparable from production, supply chain management, trade, business and even migration.

Subsidiary tables (in Appendix A and Appendix B respectively) provide an alternate analysis of backward and forward dependence from a rank-based perspective.

<sup>o</sup>Road Transport Year Book 2015-16, Ministry of Road Transport and Highways, Government of India.

The results presented in these tables corroborate the findings presented in the preceding section. Looking at the rank effects, the *backward dependence* of the Railways and Other Transport sectors on the Manufacturing sector is evidential from the correlations. Disruption in transportation services would reverberate in production and industrial activity through stronger *forward dependence*. Over-reliance of power and energy sector on non-renewable sources for electricity generation<sup>p</sup> would turn pandemic spread through logistical suspensions.

<sup>p</sup>As reported by Central Electricity Authority of India, Coal-based power plants in India possess 197171.5 megawatts of the total installed capacity of 344002.39 megawatts for the year 2017-18.



Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

**Figure 4.** Backward Linkage Effects of Railway-based Extraction.

**Linkage based outcomes** generated over the period of 1993-94 to 2013-14 through extraction are presented graphically in Figures 4 and 5. The ex-ante and ex-post effects of Railway-based extraction in Figures 6 and 7 present the same for Other Transport-based extraction outcomes. Pertinent findings are listed hereby:

- Juxtaposing effects generated through Railway based extraction show static position of sectoral performances for both backward (Figure 4) and forward (Figure 5) linkages. Sectors, namely Electricity and Storage and Warehousing, possessing 'Key-sector' status are impervious to the changes in output forced by Railway sector over time and retain their position. This analysis provides an insight from policy perspective to promote the 'dots' connecting to Storage and Warehousing and Electricity sectors. Special attention must be directed towards Electricity sector. Though it appears as a leading Key sector, its contributions to total GVA is low (around 2.3 perent).
- *Role reversal* across various sectors, as a phenomenon over time, remains pervasive irrespective of the extraction. Sectors such as Construction, Hotel and Restaurants and Other Services witness a dip in backward linkages, while Banking, Communication and Storage and

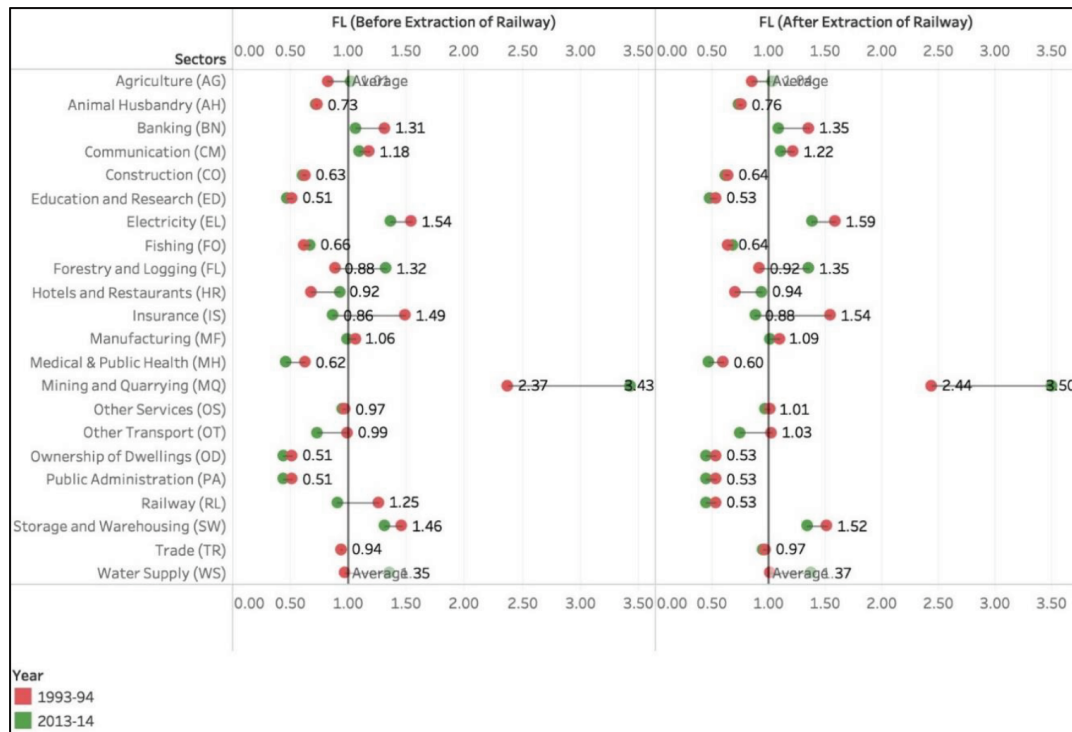
Warehousing witness a drop in their forward linkages as we move forward in time.

- Largest deviations are seen across Communication, Medical and Public Health, Hotel and Restaurants and Storage and Warehousing sectors (for their backward linkages) along with Mining and Quarrying, Insurance and Forestry and Logging (for their forward linkages). Of all such deviations, *deterioration* of Insurance, Medical and Public Health, Agriculture and Railway sector linkages is strikingly important since it erodes their status of sectors with linkages greater than 1.

Reflecting upon the magnitude change occurring because of extraction, these small yet significant changes are an ipso-facto outcome of relative dependencies with Railway sector.

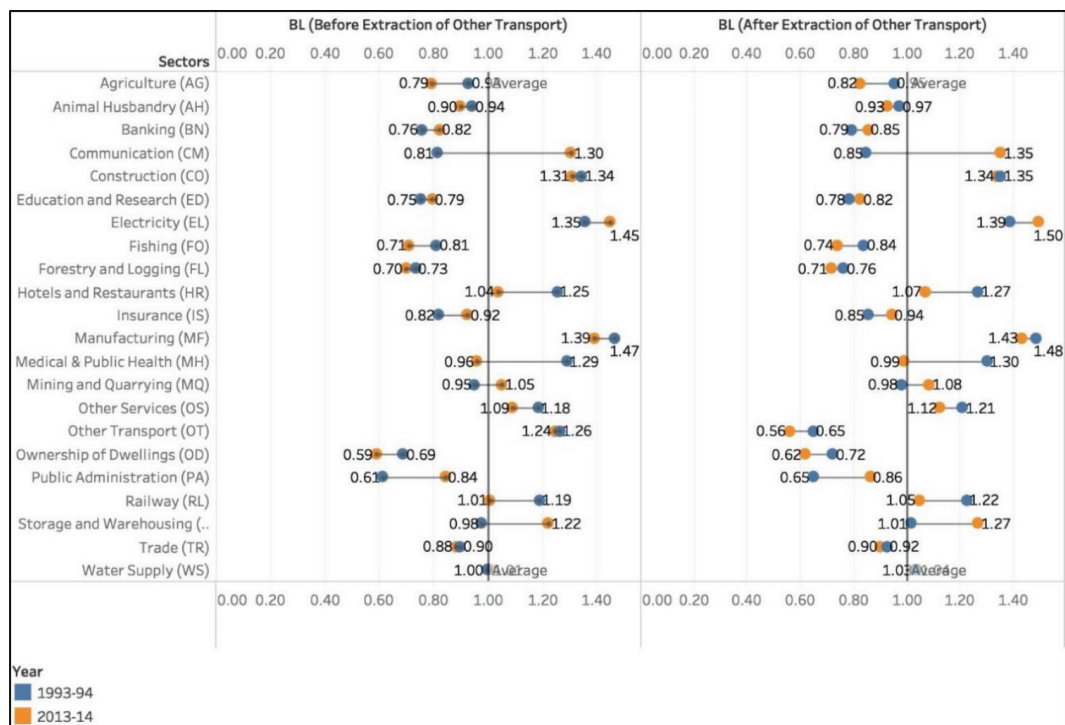
Placing the Other Transport based effects together, we again trace a similar static trend in Figure 6 and Figure 7. Sectors retain their status before and after extraction of Other Transport services. Even the deviations follow the observed pattern from Railway based analysis, whereby Electricity sector possesses 'Key-sector' status. Storage and Warehousing and Manufacturing survive by the brink of missing their 'prized' status. Here too, some of the largest deviations in upstream linkages are witnessed across Mining and





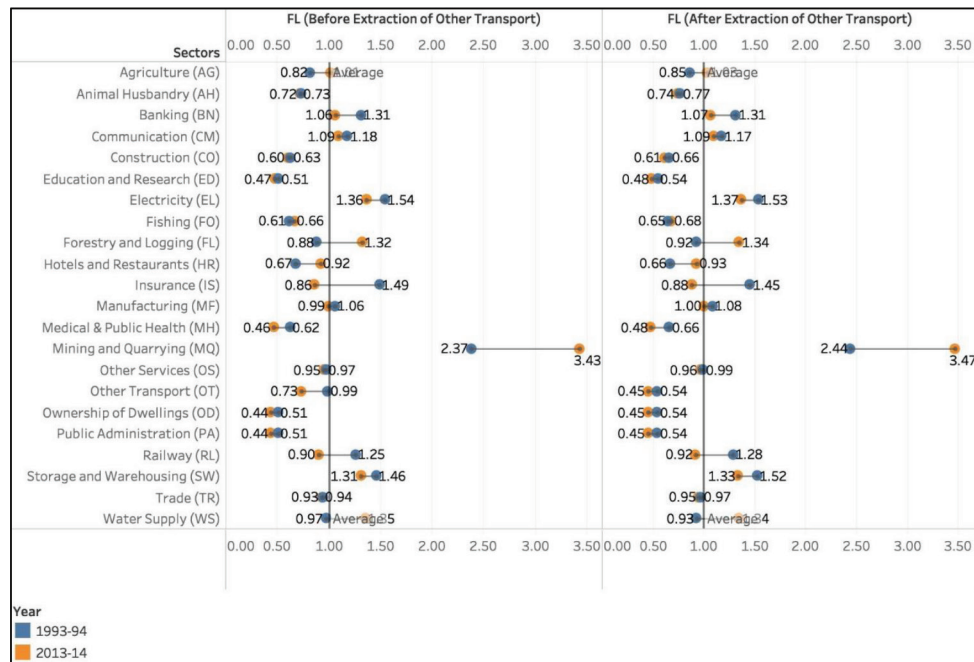
Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Figure 5. Forward Linkage Effects of Railway-based Extraction.



Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Figure 6. Backward Linkage Effects of Other Transport-based Extraction.



Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

**Figure 7.** Forward Linkage Effects of Other Transport-based Extraction.

Quarrying, Insurance and Forestry and Logging vis-à-vis downstream linkage deviations in Communication, Medical and Public Health, Hotel and Restaurants and Storage and Warehousing sectors.

The findings establish the idea of cyclicity of relations across sectors reliant upon the embedded nature of activities. Implications derived through diversity in methodological perspectives, and further confined within the premise of well-defined objectives, strengthens the credence of the findings established in this study.

## 6. Conclusion and Policy Implications

In this study, we analysed the effects of Railway and Other Transport sectors on the economy along with level of embeddedness using the I-O based models and hypothetical extraction-based methods. Through this paper, we provide a method of evaluating the impact of economic downsizing. We measure the variations in outcomes across different sectors of the economy generated through sustained reduction in a crucial sector, such as transport infrastructure. Given our objective to explore this impact specifically for Railway sector, we

gauge how this impact extends across different sectors. Based upon the backward and forward dependence exerted by the transport sectors, specific sectors scored above the rest in terms of output and linkages-based effects. The findings are in consonance with the literature reviewed in establishing the linkages of railways with other sectors activities<sup>21,24,26,47,50</sup>.

Our analysis shows transport sectoral relationships (measured through correlations) develop around the cluster of core activity sectors yielding higher gross value addition. Ironically, the extent of relationship with Agriculture and allied activities emerges insignificant, given the over-reliance of Indian economy in terms of employment and food subsistence is relatively higher than other sectors. Examining the strength and direction of relationship across different sectors, statistical evidence substantiates the influential role played by railways in creating downstream impacts through induced shocks. Results presented support the bi-directional dependence amongst Manufacturing, Electricity and Construction with Railway and Other Transport providing evidence that 'buyers' dependence on 'sellers' alternatively also means 'sellers' dependence on those very sectors called 'buyers'. Innate dependencies, further, emerge ineffective in diluting the existing linkage structure across the

economy. Our longitudinal study of linkages suggests 'Keyness' of sectors (such as Electricity and Storage and Warehousing) is unconditionally protected but the strength gets affected due to dependencies extending across sectors.

When taken together, results and findings permit varied conclusions and policy discussions. First, the role and importance of transport, especially railways, in advancing support and fostering greater value additions by industrial activities cannot be ignored. Economic Survey (2021) notes that higher investments in railways carry positive and durable effects on manufacturing and aggregate output by strengthening of the national supply chain. Dependence on transport sector for re-allocation of resources like migrant farm labour and distribution of agrarian output to non-producing states presents a case in favour of railways on ground. However, the weak statistical linkages, as our findings show, could be an outcome of prolonged ignorance of primary sector from the transport policies over time. Railway system guarantees greater 'socio-economic' return on investment by reducing carbon emissions and freight cost<sup>51</sup>. On the supply side, integrated through system networks, spill-over effects of investments in transport expand labour market access and employment opportunities.

Though the performance of transport (roads, railways, airways and waterways), electricity and water supply parameters, which constitute the definition of Infrastructure, emerged insignificant, importance of infrastructure for economic growth cannot be ignored. Developing economies lack quality and quantity of infrastructure including transport base<sup>3</sup>. Literature recognises that increasing transport infrastructure would result in higher gross fixed capital formation making growth more pervasive<sup>5</sup>. Physical stock of infrastructure (including electricity consumption, energy usage, rail density, air transport and road length) also leads to positive and significant long-run impact on India's growth<sup>52</sup>. Since transport infrastructure carries positive elasticity with economic outcomes, enhancing social overhead capital would enrich the efforts to curb poverty and facilitate human development. At policy level, a sustained addition of physical stock of capital thus becomes not only a necessary condition for economic development, but also a sufficient condition for addressing the social outcomes in the long run. Railway possesses greater forward dependence and lesser backward dependence with the economy compared to Other Transport, implying that

dependence of Railway as a sector on other sectors is less than the dependence of other sectors on Railway itself. A measured reduction in output of Railway and Other Transport sector could simultaneously discharge retributive effects on output of important productive and manufacturing sectors.

The performance-based analysis in a goal-driven environment provides crucial insights for policy making. Investment and budgetary support to the transport sector is necessary to generate the macroeconomic 'churn', but discussion in Section 2 shows the decoupling of investment and revenue generated by Railways since 2018. Emerging market and low-income economies like India have a dire need for additional infrastructure to support economic development. Literature shows that operational and location factors result in improving the performance of rail passenger business for Japan and freight business for US<sup>20</sup>. Rail container business in India is managed by CONCOR which is a public sector monopoly<sup>20</sup>. Railways remain a public sector entity and the participatory role of private stakeholders must be enhanced to match the outcomes with related sectors<sup>4</sup>. There is a need to track the progress made in this direction over time and across sectors more deeply. Lack of comprehensive long-term data on sectoral interactions creates a hinderance. In future, a move towards sustainable energy production and development of resilient infrastructure cannot exist in isolation. Intertwined through 'relational dependency', planning for mobility should be envisioned in consonance with existing productive structures and industrial orientation defined within the broad economic framework. Equally important, transport superstructures should be adaptive enough to incorporate productive advancements and technological progress which redefines commercial and non-commercial flows within economic ecosystem. This requires a dynamic impact-based evaluation which can be made possible through non-linear models.

## 7. References

1. Maparu TS, Mazumder TN. Transport infrastructure, economic development and urbanization in India (1990-2011): Is there a causal relationship? Transportation

<sup>4</sup>Niti Aayog's report titled 'Improving Rail Efficiency & Share in India's Freight Transport (2018) lays the road map for future reforms in railways. The report acknowledges the call for involving private partnerships in operations, infrastructure and marketing of railway business.

- Research Part A: Policy and Practice. 2017; 100:319-36. <https://doi.org/10.1016/j.tra.2017.04.033>
2. Pradhan RP, Gupta V. Transport infrastructure, energy consumption and economic growth triangle in India: Cointegration and causality analysis. *Journal of Sustainable Development*. 2010; 3. <https://doi.org/10.5539/jsd.v3n2p167>
3. Pradhan RP, Bagchi TP. Effect of transportation infrastructure on economic growth in India: The VECM approach. *Research in Transportation Economics*. 2013; 38(1):139-48. <https://doi.org/10.1016/j.retrec.2012.05.008>
4. Amairia R, Amaira B. Transport infrastructure and economic growth: New evidence from Tunisia an ARDL bounds testing approach. *Journal of Infrastructure Development*. 2017; 9(2):98-112. <https://doi.org/10.1177/0974930617732246>
5. Pradhan RP, Bagchi TP. Effect of transportation infrastructure on economic growth in India: The VECM approach. *Research in Transportation Economics*. 2013; 38(1):139-48. <https://doi.org/10.1016/j.retrec.2012.05.008>
6. United Nations. A pilot study on the alleviation of poverty in remote island communities in Indonesia. 1999.
7. Knowles RD, Ferbrache F. Evaluation of wider economic impacts of light rail investment on cities. *Journal of Transport Geography*. 2016; 54:430-9. <https://doi.org/10.1016/j.jtrangeo.2015.09.002>
8. Talebian A, Zou B, Hansen M. Assessing the impacts of state-supported rail services on local population and employment: A California case study. *Transport Policy*. 2018; 63:108-21. <https://doi.org/10.1016/j.tranpol.2017.12.013>
9. Chakrabarti S. Can highway development promote employment growth in India? *Transport Policy*. 2018; 69:1-9. <https://doi.org/10.1016/j.tranpol.2018.05.009>
10. Berger T, Enflo K. Locomotives of local growth: The short- and long-term impact of railroads in Sweden. *Journal of Urban Economics*. 2017; 98:124-38. <https://doi.org/10.1016/j.jue.2015.09.001>
11. Donaldson D. Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review*. 2018; 108(4-5):899-934. <https://doi.org/10.1257/aer.20101199>
12. Andrabi T, Kuehlwein M. Railways and price convergence in British India. *The Journal of Economic History*. 2010; 70(2):351-77. <https://doi.org/10.1017/S0022050710000318>
13. Kasraian D, Maat K, Van Wee B. Development of rail infrastructure and its impact on urbanization in the Randstad, the Netherlands. *Journal of Transport and Land Use*. 2015; 9(1). <https://doi.org/10.5198/jtlu.2015.665>
14. Shively G, Thapa G. Markets, Transportation infrastructure, and food prices in Nepal. *American Journal of Agricultural Economics*. 2017; 99(3):660-82. <https://doi.org/10.1093/ajae/aaw086>
15. George SA, Rangaraj N. A performance benchmarking study of Indian Railway zones. *Benchmarking*. 2008; 15(5):599-617. <https://doi.org/10.1108/14635770810903178>
16. Lall SV. Infrastructure and regional growth, growth dynamics and policy relevance for India. *The Annals of Regional Science*. 2007; 41:581-99. <https://doi.org/10.1007/s00168-006-0112-4>
17. Singhal S, Newell G, Nguyen TK. The significance and performance of infrastructure in India. *Journal of Property Research*. 2011; 28(1):15-34. <https://doi.org/10.1080/09599916.2011.544147>
18. Biswas T, Rai A. Analysis of spatial patterns and driving factors of domestic medical tourism demand in North East India. *GeoJournal*. 2023; 88(3):3163-81. <https://doi.org/10.1007/s10708-022-10798-y>
19. Bardhan R, Varghese V, Jana A. Analyzing regional travel patterns in India: Disaggregated analysis of social, health and pilgrimage trips. *Journal of the Eastern Asia Society for Transportation Studies*. 2015; 11:362-78.
20. Marchetti D, Wanke PF. Efficiency in rail transport: Evaluation of the Main drivers through meta-analysis with resampling. *Transp Res Part A Policy Pract*. 2019; 120:83-100. <https://doi.org/10.1016/j.tra.2018.12.005>
21. Munjal P. The impact of presence and hypothetical absence of tourism in Indian Economy: An input - output analysis. Springer Singapore. 2018. [https://doi.org/10.1007/978-981-13-1507-7\\_5](https://doi.org/10.1007/978-981-13-1507-7_5)
22. Sajid MJ, Cao Q, Cao M, Li S. Sectoral carbon linkages of Indian economy based on hypothetical extraction model. *International Journal of Climate Change Strategies and Management*. 2020; 12(3):323-47. <https://doi.org/10.1108/IJCCSM-11-2018-0075>
23. Lee MK, Yoo SH. The role of transportation sectors in the Korean National Economy: An input-output analysis. *Transportation Research Part A: Policy and Practice*. 2016; 93:13-22. <https://doi.org/10.1016/j.tra.2016.08.016>
24. Dam SK, Kaur S. Sectoral linkages of energy in Indian Economy: An empirical evidence. *International Journals Research Journal of Economics and Business Studies*. 2012; 01(05):35-45.
25. Yu H. A review of input-output models on multisectoral modelling of transportation-economic linkages. *Transp Rev*. 2018; 38(5):654-77. <https://doi.org/10.1080/01441647.2017.1406557>
26. Munjal P. Structural changes in Indian Economy: An input-output analysis. *Indian Economic Review*. 2007; 42(1):77-95.
27. Simrit K. Privatization and public regulation: The Indian experience. Macmillan; 2003.
28. Paelinck J, Caemel J De, Degueldre J. Analyse quantitative de certains phénomènes du développement régional polarisé. Essai de simulation statique d'itinéraires de propagation, Collection de l'Institut de Science Economique de l'Université de Liège. 1965; 8.



29. Meller P, Marfán M. Small and large industry: Employment generation, Linkages, and Key Sectors. *Economic Development and Cultural Change*. 2018; 29:263-74. <https://doi.org/10.1086/451246>
30. Schultz S. Approaches to identifying key sectors empirically by means of input-output analysis. *The Journal of Development Studies*. 1977; 14(1):77-96. <https://doi.org/10.1080/00220387708421663>
31. Strassert G. Zur Bestimmung strategischer Sektoren mit Hilfe von Input-Output Modellen. *Jahrb Natl Okon Stat*. 1968; 182:211-15. <https://doi.org/10.1515/jbnst-1968-0114>
32. Miller RE, Blair PD. Input-output analysis. *Physiological Research*. 2009; 64:897-905. <https://doi.org/10.1017/CBO9780511626982>
33. Temurshoev U. Key sectors in the Kyrgystan Economy. *Cerge-Ei Discussion Paper Series*. 2004; (135).
34. Oosterhaven J. On the plausibility of the supply-driven model. *Journal of Regional Science*. 1988; 28(2):203-17. <https://doi.org/10.1111/j.1467-9787.1988.tb01208.x>
35. Guerra AI, Sancho F. Revisiting the original ghosh model: Can it be made more plausible? *Economic Systems Research*. 2011; 23(3):319-28. <https://doi.org/10.1080/09535314.2011.566261>
36. Oosterhaven J. Leontief versus Ghoshian price and quantity models. *Southern Economic Journal*. 2006; 62(3):750. <https://doi.org/10.2307/1060892>
37. Dietzenbacher E. On the relationship between the supply-driven and the demand-driven input - output model. *Environment and Planning A: Economy and Space*. 2006; 21(11):1533-9. <https://doi.org/10.1068/a211533>
38. Dietzenbacher E. In vindication of the ghosh model: A reinterpretation as a price model. *Journal of Regional Science*. 1997; 37(4):629-51. <https://doi.org/10.1111/0022-4146.00073>
39. Hirschman A. *The strategy of economic development*. Yale Univ. Press; 1958.
40. Jones LP. The measurement of Hirschmanian Linkages. *The Quarterly Journal of Economics*. 1976; 90(2):323-33. <https://doi.org/10.2307/1884635>
41. Rasmussen PN. *Studies in Inter-sectoral Relations*. Einar Harcks Forlag; 1957.
42. Sonis M, Hewings GJD, Guo J. A new image of classical key sector analysis: Minimum information decomposition of the Leontief Inverse. *Economic Systems Research*. 2000; 12(3):401-23. <https://doi.org/10.1080/09535310050120952>
43. Dietzenbacher E, Lahr ML. Expanding extractions. *Economic Systems Research*. 2013; 25(3):341-60. <https://doi.org/10.1080/09535314.2013.774266>
44. Dietzenbacher E, van der Linden JA. Sectoral and spatial linkages in the EC production structure. *Journal of Regional Science*. 1997; 37(2):235-57. <https://doi.org/10.1111/0022-4146.00053>
45. Temurshoev U, Oosterhaven J. Analytical and empirical comparison of policy-relevant key sector measures. *Spatial Economic Analysis*. 2014; 9(3):284-308. <https://doi.org/10.1080/17421772.2014.930168>
46. Kuwamori H, Sato H. Features of input-output tables of India. 17th International Input-Output Conference. 2009.
47. Singh, S. Input output table for India: 2013-14. 2016; Available from: [http://www.ncaer.org/publication\\_details.php?PID=274](http://www.ncaer.org/publication_details.php?PID=274)
48. Singh K, Saluja MR. Input-output table for India 2013-2014: Based on the new series of national accounts statistics and supply and the use table. *Margin*. 2018; 12(2):197-223. <https://doi.org/10.1177/0973801017753258>
49. Givoni M, Banister D. Role of the railways in the future of air transport. *Transportation Planning and Technology*. 2007; 30(1):95-112. <https://doi.org/10.1080/03081060701208100>
50. Hazari BR. Empirical identification of key sectors in the Indian economy. *The Review of Economics and Statistics*. 2017; 52(3):301-5. <https://doi.org/10.2307/1926298>
51. Asian Development Bank. *Reducing carbon emissions from transport projects*. 2010.
52. Dasha RK, Sahoo P. Economic growth in India: The role of physical and social infrastructure. *Journal of Economic Policy Reform*. 2010; 13(4):373-85. <https://doi.org/10.1080/17487870.2010.523980>



## Appendices

### Appendix A. Ranks based upon change in output of 22 sectors through column-based extraction of Railway and Other Transport sectors.

|    | Sectors                        | Railway based HE |         |         |         |         | Other Transport based HE |         |         |         |         |
|----|--------------------------------|------------------|---------|---------|---------|---------|--------------------------|---------|---------|---------|---------|
|    |                                | 1993-94          | 1998-99 | 2003-04 | 2007-08 | 2013-14 | 1993-94                  | 1998-99 | 2003-04 | 2007-08 | 2013-14 |
| 1  | Agriculture (AG)               | 9                | 8       | 9       | 8       | 8       | 5                        | 6       | 4       | 4       | 8       |
| 2  | Animal Husbandry (AH)          | 13               | 14      | 14      | 14      | 13      | 14                       | 14      | 14      | 12      | 13      |
| 3  | Forestry and Logging (FL)      | 16               | 16      | 16      | 15      | 14      | 16                       | 15      | 15      | 15      | 14      |
| 4  | Fishing (FO)                   | 19               | 19      | 18      | 18      | 18      | 18                       | 17      | 16      | 17      | 18      |
| 5  | Mining and Quarrying (MQ)      | 4                | 6       | 4       | 4       | 3       | 7                        | 8       | 5       | 6       | 2       |
| 6  | Manufacturing (MF)             | 1                | 1       | 1       | 1       | 1       | 1                        | 1       | 1       | 1       | 1       |
| 7  | Construction (CO)              | 3                | 5       | 3       | 3       | 10      | 9                        | 11      | 12      | 10      | 4       |
| 8  | Electricity (EL)               | 2                | 2       | 2       | 2       | 2       | 2                        | 2       | 7       | 9       | 3       |
| 9  | Water Supply (WS)              | 18               | 18      | 19      | 19      | 11      | 15                       | 16      | 17      | 19      | 12      |
| 10 | Railway (RL)                   | 10               | 10      | 6       | 12      | 15      | 10                       | 12      | 13      | 14      | 15      |
| 11 | Other Transport (OT)           | 8                | 9       | 7       | 6       | 12      | 6                        | 5       | 3       | 5       | 10      |
| 12 | Storage and Warehousing (SW)   | 20               | 20      | 20      | 20      | 19      | 19                       | 18      | 18      | 18      | 19      |
| 13 | Communication (CM)             | 12               | 12      | 12      | 13      | 6       | 11                       | 10      | 9       | 11      | 9       |
| 14 | Trade (TR)                     | 5                | 7       | 5       | 5       | 7       | 3                        | 4       | 2       | 2       | 6       |
| 15 | Hotels and Restaurants (HR)    | 17               | 15      | 15      | 11      | 9       | 13                       | 9       | 10      | 3       | 11      |
| 16 | Banking (BN)                   | 7                | 3       | 8       | 7       | 5       | 4                        | 7       | 8       | 8       | 7       |
| 17 | Insurance (IS)                 | 14               | 11      | 13      | 16      | 17      | 12                       | 13      | 11      | 13      | 16      |
| 18 | Ownership of Dwellings (OD)    | 21               | 21      | 21      | 21      | 21      | 21                       | 21      | 21      | 21      | 21      |
| 19 | Education and Research (ED)    | 15               | 17      | 17      | 17      | 16      | 20                       | 20      | 20      | 16      | 17      |
| 20 | Medical and Public Health (MH) | 6                | 13      | 11      | 10      | 20      | 17                       | 19      | 19      | 20      | 20      |
| 21 | Other Services (OS)            | 11               | 4       | 10      | 9       | 4       | 8                        | 3       | 6       | 7       | 5       |
| 22 | Public Administration (PA)     | 22               | 21      | 21      | 21      | 21      | 22                       | 21      | 21      | 21      | 21      |

Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Note: Top three sectors affected are highlighted.

### Appendix B. Ranks based upon change in output of 22 sectors through row-based extraction of Railway and Other Transport sectors.

|    | Sectors                        | Railway based HE |         |         |         |         | Other Transport based HE |         |         |         |         |
|----|--------------------------------|------------------|---------|---------|---------|---------|--------------------------|---------|---------|---------|---------|
|    |                                | 1993-94          | 1998-99 | 2003-04 | 2007-08 | 2013-14 | 1993-94                  | 1998-99 | 2003-04 | 2007-08 | 2013-14 |
| 1  | Agriculture (AG)               | 5                | 5       | 5       | 4       | 7       | 3                        | 5       | 5       | 5       | 8       |
| 2  | Animal Husbandry (AH)          | 10               | 14      | 12      | 11      | 12      | 8                        | 10      | 7       | 7       | 9       |
| 3  | Forestry and Logging (FL)      | 16               | 17      | 19      | 16      | 21      | 17                       | 16      | 17      | 14      | 16      |
| 4  | Fishing (FO)                   | 18               | 20      | 18      | 19      | 20      | 15                       | 19      | 18      | 19      | 21      |
| 5  | Mining and Quarrying (MQ)      | 9                | 12      | 10      | 7       | 9       | 11                       | 13      | 12      | 11      | 10      |
| 6  | Manufacturing (MF)             | 1                | 1       | 1       | 1       | 1       | 1                        | 1       | 1       | 1       | 1       |
| 7  | Construction (CO)              | 3                | 3       | 3       | 2       | 2       | 2                        | 2       | 2       | 2       | 2       |
| 8  | Electricity (EL)               | 2                | 2       | 2       | 5       | 3       | 6                        | 6       | 6       | 9       | 5       |
| 9  | Water Supply (WS)              | 20               | 19      | 20      | 20      | 18      | 20                       | 20      | 20      | 18      | 18      |
| 10 | Railway (RL)                   | 8                | 9       | 6       | 14      | 17      | 12                       | 14      | 14      | 15      | 19      |
| 11 | Other Transport (OT)           | 4                | 4       | 4       | 3       | 5       | 4                        | 3       | 3       | 3       | 6       |
| 12 | Storage and Warehousing (SW)   | 21               | 21      | 21      | 21      | 22      | 21                       | 21      | 21      | 21      | 22      |
| 13 | Communication (CM)             | 15               | 15      | 15      | 15      | 8       | 18                       | 18      | 16      | 16      | 12      |
| 14 | Trade (TR)                     | 6                | 7       | 7       | 6       | 6       | 5                        | 4       | 4       | 4       | 3       |
| 15 | Hotels and Restaurants (HR)    | 11               | 11      | 8       | 8       | 13      | 10                       | 9       | 8       | 6       | 11      |
| 16 | Banking (BN)                   | 14               | 10      | 11      | 10      | 10      | 14                       | 12      | 11      | 13      | 13      |
| 17 | Insurance (IS)                 | 19               | 16      | 13      | 13      | 16      | 19                       | 15      | 15      | 17      | 17      |
| 18 | Ownership of Dwellings (OD)    | 17               | 18      | 17      | 18      | 19      | 16                       | 17      | 19      | 20      | 20      |
| 19 | Education and Research (ED)    | 13               | 13      | 16      | 17      | 14      | 13                       | 11      | 13      | 10      | 15      |
| 20 | Medical and Public Health (MH) | 12               | 8       | 14      | 12      | 15      | 9                        | 8       | 10      | 12      | 14      |
| 21 | Other Services (OS)            | 7                | 6       | 9       | 9       | 4       | 7                        | 7       | 9       | 8       | 4       |
| 22 | Public Administration (PA)     | 22               | 22      | 22      | 22      | 11      | 22                       | 22      | 22      | 22      | 7       |

Source: Authors compilation using multiple I-O tables published by Central Statistical Organisation (CSO), India.

Note: Top three sectors affected are highlighted.