# Sectoral interlinkages and the role of natural gas sector in India: An intertemporal economic impacts analysis

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## Abstract

This study aims to provide a comprehensive economic assessment of the natural gas sector and its impacts on sectoral output, employment, income, and price level. One of the significant contributions of this study is that it aims to capture the policy dynamics within natural gas and the rest of the economy by incorporating an intertemporal analysis of the effect. It employs the input-output (I-O) method to analyze the sectoral interlinkages and impact of exogenous change in the natural gas sector on the rest of the economy. The findings reveal stronger forward linkages compared to backward ones. The intertemporal dynamics of natural gas show consistent patterns in sectoral linkages, income, and employment impacts, with the strongly linked mining, manufacturing, construction, transportation, and services sectors. The findings suggest investment in natural gas upstream sectors to improve its backward linkages while investment in midstream infrastructure to boost the forward linkages. It also suggests formulating the gas allocation policies for India based on the sectoral interlinkages of the sector.

Keywords: Natural gas; Economic impacts; Input-output analysis; sectoral interlinkages; Energy

JEL Classification: C67, Q43

## Introduction

Natural gas plays a pivotal role in India's energy landscape, particularly as the country seeks to transition towards cleaner energy sources. The Indian government has set ambitious targets to increase the share of natural gas in the energy mix from approximately 6.5% to 15% by 2030, reflecting a strategic shift towards reducing carbon emissions and enhancing energy security (Sinha et al. 2022). Natural gas is recognized as the least emission-intensive fossil fuel, making it a preferable alternative to coal and oil for electricity generation, transportation, and industrial fuel (Shukla et al. 2007; Chugh 2021). India's endowment of total natural gas as of April 2022 was 1138 billion cubic meters (BCM), while the natural gas production stood at 34 BCM against the total consumption of 60 BCM. Hence, the strategic shift towards natural gas can improve the economy, environment and energy security, as India currently imports about 43% of its natural gas (Rawat and Garg 2023). The government of India implemented several regulatory and fiscal policy measures, notably the New Exploration and Licensing Policy (NELP) in 1999, the establishment of the Petroleum and Natural Gas Regulatory Board (PNGRB) in 2006 and the Hydrocarbon Exploration and Licensing Policy (HELP) in 2007 to improve competitiveness and reduce the import dependency on natural gas. These measures aim to improve upstream natural gas production and midstream and downstream infrastructure (Mason 2021; Ministry of Petroleum and Natural Gas (MoPNG) 2020). However, the gas allocation and skewed pricing policies, which largely affect the sectoral consumption of natural gas, hinder the economic potential of the sector (Nischal and Kumar 2008; Jain and Sen 2011). Though the sector has a small contribution to the economy, natural gas is considered the most suitable fossil fuel of the 21$^{st}$ century (Smil 2015).

Natural gas provides inputs to several energy and non-energy consumers, impacting the economy through its consumption channel. However, international studies on the causal relationship between natural gas consumption and economic growth provide mixed results. The early studies claim the absence of such evidence in Taiwan, Pakistan, Australia and New Zealand (Yang 2000; Aqeel and Butt 2001; Fatai, Oxley, and Scrimgeour 2004), while studies using the panel data found significant bidirectional causality between natural gas consumption and economic growth (Apergis and Payne 2010; Ozturk and Al-Mulali 2015; Solarin and Lean 2016). The Indian literature also provides sufficient evidence on the role of natural gas consumption in improving overall sustainable development (Srinivasan, Ravindra, and Prakasam 2015; Roy 2023; Adebayo et al. 2023), gross domestic product (GDP) growth (Solarin and Lean 2016; Ummalla and Samal 2019), and other economic indicators (Kumar, Shastri, and Hoadley 2020) in India. Other studies applying energy demand modelling reveal natural gas consumption will play a crucial role in energy independence and employment growth (IEA 2021; Malyan et al. 2021; Malyan 2020).

Economic impact through consumption channels mainly considers natural gas as input, so it is necessary to incorporate the impacts coming from its production channels. Prior studies have examined local, regional, and overall economic development due to natural gas upstream activities. The studies focusing on the economic impacts of natural gas production on local and

national economies provide several insights, such as transmitting effect from one region to another (Robison and Duffy-Deno 1996) and economic development through business-to-business spending and payments to landowners (Considine, Watson, and Blumsack 2010). These activities also boost income, employment, and government tax revenue. In the Indian context, a few case studies in Rajasthan and Assam provide mixed results on the localized economic impacts. These studies highlight that although natural gas production contributed to the state government's revenue and supplementary income for the local households, it failed to contribute significantly to the regional economic transformation due to mismanagement (Segal and Sen 2011; K. K. Sharma et al. 2011; D. Sharma et al. 2018).

The above studies, though, capture the economic impacts of natural gas through its consumption and production and lack evidence on the overall economic impacts. The overall economic impacts at the disaggregated level incorporating all the economic sectors can be captured through the input-output (I-O) and computational general equilibrium (CGE) framework. Using these assessment frameworks, studies on different countries such as Greece, Indonesia, and South Korea highlight that natural gas provides significant economic linkages to other sectors while boosting GDP, sectoral output, household income and employment, and investment in the economy (Caloghirou, Mourelatos, and Roboli 1996; Song, Lim, and Yoo 2014; Hutagalung et al. 2019; Lee, Kim, and Yoo 2023; Kim, Kim, and Yoo 2020). However, we have not found any studies on the economic role of the natural gas sector in India in terms of its economic linkages with the rest of the economy. Hence, against this backdrop, the present study aims to provide a comprehensive economic assessment of the natural gas sector through its impacts on sectoral output, employment, and income. It also attempts to complement the impact on economic indicators through supply shortages and changes in the price of natural gas. One of the significant contributions of this study is that it aims to capture the policy dynamics within natural gas and the rest of the economy by incorporating an intertemporal analysis of the effect. These policy dynamics capture the changes in natural gas allocation policy and sector-specific energy consumption policies, which significantly change the structure of the economic linkages and, in turn, the economic impacts of the sector. The study employs input-output (I-O) analysis, which is cost-effective and offers a robust framework for assessing how changes in final demand for one sector affect the rest of the economy. This method utilizes market transaction tables aligned with the national accounting system, providing frequent updates and high transparency and has the potential to account for multiple impacts at multiregional levels (Dimitriou, Mourmouris, and Sartzetaki 2015; Logar and Van Den Bergh 2013; Nansai et al. 2009).

## Methodology

### Data Source

The study utilizes two secondary data sources: Supply and Use Tables (SUTs) by the Ministry of Statistics and Program Implementation (MoSPI) and the Employment Situation Report (Employment and Unemployment Survey) by the Ministry of Labour and Employment (MoLE), Government of India. The compilation of the input-output table in value terms for 2011-12, 2015-16, and 2019-20 was done using the supply and use table for the same years.

We constructed product-by-product I-O tables based on industry-technology assumptions (Miller and Blair 2022) following the guidelines of the compilation of the I-O table from SUT provided by the United Nations System of National Accounting (UN-SNA) (Beutel et al. 2018; Eurostat 2008). The resultant input-output table has dimensions of $140 \times 140$ structure, where 140 products are supplied to 140 sectors. The study aggregated the 140×140 structure into a 34×34 sectors input-output table to perform the numerical operations and demonstrate the analysis results. The aggregation of the original $140 \times 140$ table is based on the National Industrial Classification (NIC)-2008.

**General Framework of Input-output Analysis**

The general framework of the input-output system can be written from a demand and supply perspective. In general, the demand-side input-output system follows the following framework.

$$x = Zi + f \tag{1}$$

Where Z is the intermediary consumption matrix, and $f$ is the final demand matrix. The $x$ represents the total output, and the change in $x$ can be obtained as

$$\Delta x = (I - A)^{-1}\Delta f = L\Delta f \tag{2}$$

Where A is the input coefficient matrix $[a_{ij} = z_{ij}\hat{x}^{-1}]$, $(I - A)^{-1}$ or $L$ is the Leontief Inverse Matrix or total requirement matrix. Similarly, the supply-side input-output system can be written as

$$x' = i'Z + v' \tag{3}$$

Where Z is the intermediary consumption matrix, and $v'$ is the transpose of the value-added matrix. $x'$ represents the total supply and change in $x'$ can be obtained as

$$\Delta x' = \Delta v'(I - B)^{-1} = \Delta v'G \tag{4}$$

Where B is the output or allocation coefficient matrix, and $(I - B)^{-1}$ or $G$ is Output Inverse Matrix or Ghosh Inverse Matrix (Ghosh 1958).

**Estimating Inter-Industry Linkages Impacts of the Natural Gas Sector**

The economic linkages of the natural gas sector can be assessed through its backward and forward linkages to the rest of the economy. The backward linkage (BL) effect of the natural gas sector presents the power of dispersion, which is the sum of elements in the natural gas column of the total requirement matrix (Guitton and Rasmussen 1957).

$$BL_j = \sum_{i=1}^{n} l_{ij} \tag{5}$$

However, to compare the backward linkage scores of natural gas with other sectors, normalized backward linkage (NBL) scores are used (Guitton and Rasmussen 1957).

$$NBL_j = \frac{BL_j}{\frac{1}{n}\sum_{k=1}^{n} BL_k} \tag{6}$$

Similarly, the forward linkage (FL) effect of the natural gas sector presents the power of dispersion, which is the sum of elements in the natural gas sector row of the Ghosh inverse matrix (Guerra and Sancho 2011).

$$FL_i = \sum_{j=1}^{n} g_{ij} \tag{7}$$

The normalized forward linkages (NFL) score can be obtained to compare the sectoral score of forward linkage.

$$NFL_i = \frac{FL_i}{\frac{1}{n}\sum_{k=1}^{n} FL_k} \tag{8}$$

**Estimating Demand-Side Economic Impacts of the Natural Gas Sector**

Input-output analysis plays a crucial role in impact analysis by examining how exogenous change in a sector affects the rest of the economy. These impacts are assessed through different multipliers, which measure the excess of total effects over the initial effect of the exogenous change. The multiplier is called simple when total impacts capture direct and indirect impacts (open input-output model – the household sector is exogenous). It is called a total multiplier when it captures the former plus induce effects (closed input-output model – the household sector is endogenous).

This study utilizes four types of multipliers within a demand-driven input-output framework to assess the impact of changes in the natural gas sector. Precisely, output multipliers measure the effects on sectoral outputs, income multipliers evaluate the impact on household income within each sector, employment multipliers assess changes in employment levels, and value-added multipliers determine the effect on the value added by each industry. Additionally, the study estimates the effects of natural gas supply shortages on sectoral output using a supply-driven input-output system, providing a comprehensive view of both demand and supply-side impacts.

The simple output multiplier for the natural gas sector $(j)$ can be written as (Miller and Blair 2022)

$$m(o)_j = \sum_{i=1}^{n} l_{ij} \tag{9}$$

The income multiplier for the natural gas sector $(j)$ can be defined as the monetary income generated by a rupee increase in final demand for the natural gas sector's output. Let $h' = [z_{n+1,j}(j = 1 \dots n)]$ be the household column vector of the wage earned by a household in each sector in the monetary term, then the household input coefficient can be calculated as

$$h'_c = h'\hat{x}^{-1} = [a_{n+1,j}\ (j = 1 \dots n)] \tag{10}$$

Therefore, the simple income multiplier for the natural gas sector $(j)$ can be calculated as

$$m(h)_j = \sum_{i=1}^{n} a_{n+1,i}\, l_{ij} \tag{11}$$

The household input coefficient $[a_{n+1,j}]$ represents the initial income effect in terms of additional income payments to the household if the final demand for the natural gas sector $(j)$ output increases by one rupee. Following that, one can calculate the natural gas sector's Type I and Type II income multipliers by dividing the simple income multiplier by its initial income effect in the open and closed I-O tables (Emonts-Holley, Ross, and Swales 2021; Moore 1955; Miller and Blair 2009).

The physical employment multipliers can be defined as the number of jobs generated due to one rupee increase in the final demand for the natural gas sector's output. The calculation of physical employment multipliers follows the same procedures as income multipliers by defining the $h'$ row vector in physical labour unit terms rather than monetary terms.

$$e'_c = e'\hat{x}^{-1} = [a_{n+1,j}\ (j = 1 \dots n)] \tag{12}$$

The simple employment multiplier for the natural gas sector $(j)$ can be calculated as

$$m(e)_j = \sum_{i=1}^{n} a_{n+1,i}\, l_{ij} \tag{13}$$

The calculation of value-added multipliers follows the same procedures as the calculation of income multipliers. However, at the place of $h'$ row vector, we provide value-added for each sector as $v'_c = [a_{n+1,j}\ \ (j = 1 \dots n)$. The sectoral value-added coefficient can be calculated using the same procedure as the technical coefficients.

$$m(v)_j = \sum_{i=1}^{n} a_{n+1,i}\, l_{ij} \tag{14}$$

It is often argued that since value-added captures the value of total output over the cost of total intermediate inputs used by the sector, the value-added multiplier measures the sector's contribution better than that measured through output multipliers (Miller and Blair 2022)

### Estimating Supply-Side Economic Impacts of the Natural Gas Sector

While the above multipliers are based on the demand-driven I-O model, the supply shortage effect of the natural gas sector on other sectors can be analyzed using the supply-driven I-O model. The supply-driven model analyses the effect of restrictions on the supply of the products or services of a sector directly and indirectly (Halvorson 1987; Davis and Salkin 1984). The simple supply-shortage multiplier for the natural gas sector $(j)$ can be written as

$$m(s)_i = \sum_{j=1}^{n} g_{ij} \tag{15}$$

### Estimating Price-Side Impacts of Natural Gas Sector

In input-output (I-O) analysis, the sectoral cost structure is intrinsic to the model, allowing for the assessment of price level impacts within an industry through changes in the cost structure within the value-added matrix. While the Leontief Price Model was originally designed for physical I-O tables, it can also be applied to monetary I-O tables by normalizing the price to ₹1 per unit of output for each sector. This adjustment facilitates the analysis of price impacts. In this model, changes in the value-added matrix reflect exogenous shocks resulting from increases in the price of intermediate inputs, which subsequently affect the output prices of the sector. Therefore, the exogenous change in value-added can be expressed as:

$$\Delta v_c = (\hat{x}^0)^{-1} \Delta v \tag{16}$$

While the endogenous change in price when quantity is fixed can be obtained as

$$\Delta \tilde{p} = (I - A^0)' \Delta v_c \tag{17}$$

The superscripts "0" and "1" refer to before and after the exogenous change. The change price refers to a change in relative price as the model does not explicitly include information on absolute price.

## Results and Discussion

### Linkages of Natural Gas with Other Economic Sectors

The Indian economic sectors show strong backward linkage (BL) and forward linkage (FL), scoring above one. Overall average BL scores for 2011-12, 2015-16, and 2019-20 were 1.81, 1.73, and 1.78, while average FL scores were 1.90, 1.83, and 1.89. Table 2 shows normalized backward linkages (NBL) for the natural gas sector below one, reflecting weaker sectoral BL, likely due to high import dependence and limited domestic reserves and production. Natural gas exhibits a lower score mainly due to narrow operational areas than other energy resources producing sectors such as coal and crude Petroleum. However, the normalized forward linkage (NFL) score, over one for natural gas, highlights its critical role in supporting production in other sectors. This suggests that while natural gas fuels many industries, its own economic stimulus is limited.

Energy sectors generally exhibit stronger forward than backward linkages as they are majorly used as energy inputs. The natural gas sector holds the position of the key economic sector with stronger forward linkages (Normalized Forward Linkage (NBL): 2011-12 – 1.80; 2015-16 – 1.79; 2019-20 – 1.71) than backward linkage (Normalized Backward Linkage (NBL): 2011-12 – 0.97; 2015-16 – 0.93; 2019-20 – 0.76). It supports mining, textiles, petrochemicals, and construction sectors while depending on inputs from sectors such as transportation and service. This emphasizes its interconnectedness and essential role in the Indian economy.

**Sector Output (Production Inducing Effect and Value-Added Effect)**

Table 2 summarizes the impact of the change in final demand for natural gas on sectoral output and value-added. The total production-induced effects of ₹1 worth of investment due to change in final demand in natural gas translated into ₹0.76, ₹0.62, and ₹0.35 worth of additional investment demand and ₹0.28, ₹0.25, and ₹0.17 in value addition to other sectors in 2011-12, 2015-16, and 2019-20, respectively. While we have also estimated the parameters for the closed input-output models, they have not been presented in the table due to the word limit and clear presentation of key data in the tables. After including households into the model, ₹1 invested in natural gas required ₹1.79, ₹1.81, and ₹1.62 worth of inputs from other sectors in 2011-12, 2015-16, and 2019-20, respectively. The reason for the decrease in the sector's pulling capacity can be attributed to the stagnancy in upstream activities, where only a few new natural gas wells were constructed in these periods. Hence, the sector mainly pulled the other sector through its operational activities, as observed by improving the ranking of services sectors by 2019.

Sectors such as Fertilizers, Crude Petroleum, Metals, Petroleum Products, and Construction ranked highly in providing input to the sector. However, by 2019-20, Crude Petroleum, Various Business and Financial Services, and Machinery Rental emerged as key sectors, providing backward linkages to the sector. The outperformance of these specific sectors in terms of providing backward linkages lies in the integrated nature of the natural gas sector with Crude Petroleum and capital-intensive operations, which increases its reliance on various services and rented equipment.

**Income and Employment of the Household**

Table 3 demonstrates that an additional rupee of final demand for natural gas generated ₹0.269, ₹0.270, and ₹0.345 in additional household income in 2011-12, 2015-16, and 2019-20, respectively. The increase in the total income effect was mainly due to the increase in the forward income multiplier, while the backward income effect declined in 2015-16 and remained constant thereafter. In 2011-12, the highest income through backward linkages was earned by households engaged in Chemical, Fertilizer & Pharmaceuticals (₹0.014), followed by Trade Activities (₹0.011), Construction (₹0.005), Mining & Quarrying (₹0.006), and Metal & Non-metal Products Manufacturing (₹0.006) which was outperformed by services sectors

by 2019-20. In terms of total income effect, the Construction, Chemical, Fertilizers & Pharmaceuticals, Transport, and Petroleum products industries remained dominant throughout the period. The natural gas sector itself contributed ₹0.136, ₹0.147, and ₹0.149 to household income in the respective years. The additional income generated per unit initial income in the natural gas sector was ₹1.397 through BL while ₹2.936 through FL in 2019-20. Considering the household as endogenous to the model, it was ₹2.373 and ₹5.065 through BL and FL, respectively.

The employment multipliers in Table 4 indicate that a ₹1 crore increase in natural gas final demand created 73, 49, and 31 jobs economy-wide in 2011-12, 2015-16, and 2019-20. The highest jobs through BL were created in Agriculture and allied activities, Chemical, Fertilizer & Pharmaceuticals, Trade and Mental and Non-metal Products industries, while Through FL highest jobs were created in Agriculture and allied activities, Transportation, Petroleum products manufacturing, Construction, and Trade. While the highest impact on agriculture may be due to its labour-intensive nature and increased consumption, the role of natural gas in the manufacturing of petroleum products, chemicals, metal, construction sector, and transportation has increased significantly. The additional employment generated per unit initial job in the natural gas sector was 2 through BL while 9 through FL in 2019-20. However, after including households in the model, it was 10 and 16 through BL and FL, respectively.

**Supply Shortage Effect**

Table 5 illustrates the effects of a supply shortage in the natural gas sector. When natural gas supply was reduced by ₹1, it caused a supply shortage of ₹2.41, ₹2.25, and ₹2.23 in other sectors for 2011-12, 2015-16, and 2019-20, respectively. The sectors most affected by this supply shortage include Petroleum Products, Chemicals and Fertilizers, Transportation, Construction, Metal and Non-metal Products, Electricity, Gas & Water, Trade, Motor Vehicle Manufacturing, and Information and Communication Services. Unlike the production-induced effects, these sectors consistently experienced the highest impact intertemporally.

In 2011-12, the absence of natural gas would have led to production losses of ₹462 billion in Petroleum Products, ₹135 billion in Chemicals and Fertilizers, ₹82 billion in transportation, ₹74.5 billion in Construction, and ₹55 billion in Metal and Non-metal Products. This indicates that natural gas serves as a crucial energy source and feedstock input for these sectors. Overall, a total supply failure of natural gas in 2011-12, 2015-16, and 2019-20 would have resulted in an economic loss of ₹1.22 trillion, ₹1.14 trillion, and ₹1.22 trillion, respectively.

**Relative Price Effects (10% Increase in Compensation of Employees)**

The relative price effects of a 10% increase in the price of inputs, which translates into a change in the price of natural gas and, in turn, the price of other products, are presented in Table 5. The economy-wide effect of a 10% increase in compensation of employees in 2011-12 in the natural gas sector led to a 1.445% increase in natural gas prices. When this happens in 2015-16 and 2019-20, the natural gas price goes up by 1.561% and 1.962% respectively. Considering the price effect of natural gas on other sectors, Petroleum products, chemicals, fertilizers &

pharmaceuticals, transport, metal & non-metal products, and electricity, gas & water sectors are highly sensitive to changes in natural gas price. The weighted average impact of price change in the natural gas sector on the Indian economy stood at 0.063%, 0.056%, and 0.068% after changes in cost price in 2011-12, 2015-16, and 2019-20 respectively. Due to the lower share of natural gas in the Indian energy basket, it does not hold a significant share in the input structure of the other sectors and, hence, has a small price impact. However, an intertemporal comparison of the price impact shows that it increased in 2019-20 compared to previous time points.

## Policy Implications and Potential Use of the Study

The findings of this study on the intersectoral linkages and economic impacts of the natural gas sector in India have significant policy implications for the country's energy strategy, economic planning, and sustainable development goals. It also helps identify the key sectors of the economy and the sectors that provide support and get support from other economic sectors. The study reveals that the natural gas sector's backward linkages are weaker than forward linkages. It pulls the social overhead capitals, manufacturing of chemicals, metal, Construction, and various financial and non-financial Industries while providing forward linkages to petrochemicals, fertilizers, metals, and transportation. Hence, the strength of the natural gas sector lies in providing inputs rather than absorbing the products and services of the other sectors. The findings suggest policies that can enhance the investment in natural gas upstream activities and strengthen the natural gas infrastructure and distribution system. The findings highlight a few common sectors that provide higher backward and forward linkages to the sector. This suggests the expansion of natural gas supply to untapped regions and replacing coal and oil with natural gas in industries, which will further enhance the environmental benefits. The supply shortage effects indicate better fuel management in the industries relying heavily on natural gas.

While the natural gas sector has shown significant potential to contribute to household income and employment, the study finds a shift towards more capital-intensive technologies, which could reduce labour demand. Policymakers should consider these trends when designing policies to ensure that the transition to more efficient technologies does not adversely affect employment. This could involve retraining and upskilling programs for workers in the natural gas sector and related industries and promoting labour-intensive projects within the sector. The findings suggest that further penetration of natural gas into manufacturing could significantly boost its economic contribution, particularly in sectors like metals, Construction, and transportation.

The price effect of natural gas on the overall economy and most sectors is small. However, few sectors, such as manufacturing of petroleum products, fertilizer, transportation, and household consumers, are found to be sensitive to the change in natural gas prices. This advocates for a competitive pricing policy and regulation for those sectors where the penetration of cleaner energy is desirable. This also provides insights to formulate more informed policies regarding subsidies, pricing strategies, and taxation that can mitigate adverse effects on vulnerable sectors and consumers.

The study's intertemporal analysis of natural gas allocation policies suggests that changes in these policies significantly influence the sector's economic impacts. It recommends adopting a dynamic approach to policymaking, regularly reviewing and adjusting natural gas allocation policies in response to changing economic conditions, technological advancements, and market dynamics. This adaptive approach would ensure that the sector contributes effectively to India's economic growth while addressing emerging challenges and opportunities.

As India transitions towards a balanced and sustainable energy mix, natural gas can play a pivotal role as a cleaner alternative to coal and oil. Policymakers should, therefore, integrate natural gas into broader climate and energy policies aimed at reducing carbon emissions. This could involve setting clear targets for natural gas in the energy mix, offering incentives for switching to gas from more polluting fuels, and supporting research into cleaner technologies such as hydrogen production from natural gas with carbon capture and storage (CCS).

## Conclusion

This study analyzed intersectoral linkages between the natural gas sector and the rest of the Indian economy using an input-output framework. The findings reveal stronger forward linkages compared to backward ones. The moderate backward linkage, especially compared to coal and lignite, is due to high import dependence, yet the sector shows significant forward linkages, supplying inputs to various sectors.

This study significantly contributes to sectoral linkage analysis by incorporating both demand-driven and supply-driven input-output frameworks, allowing for a comprehensive exploration of natural gas sector interlinkages. It also examines the intertemporal impact of natural gas allocation on production, value addition, income, and employment, highlighting changes due to different allocation policies.

The intertemporal dynamics of natural gas show consistent patterns in sectoral linkages, income, and employment impacts, with the strongly linked mining, manufacturing, construction, transportation, and services sectors. In 2019-20, linkages shifted toward crude Petroleum and services like business, financial, and transport sectors, reflecting policy changes and increased investment in city gas distribution and technology. While income effects slightly increased, employment effects declined, indicating a shift from labour- to capital-intensive production. As India moves toward a balanced energy mix, natural gas will drive growth across sectors. Understanding these linkages is essential for effective policymaking and strategic planning in India's evolving economy.

Table 1. Backward and Forward Linkage Effects in India

| Sl. No. | Product * Industry | Backward Linkage Effects | | | | | | Forward Linkage Effects | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011-12 | | 2015-16 | | 2019-20 | | 2011-12 | | 2015-16 | | 2019-20 | |
| | | Value | Rank | Value | Rank | Value | Rank | Value | Rank | Value | Rank | Value | Rank |
| 1 | Agriculture & Allied Activities | 0.740 | 32 | 0.756 | 32 | 0.725 | 33 | 1.025 | 16 | 0.984 | 16 | 0.846 | 20 |
| 2 | Coal & Lignite | 0.991 | 19 | 0.895 | 24 | 0.878 | 22 | 1.700 | 3 | 1.787 | 1 | 1.808 | 1 |
| 3 | Natural Gas | 0.973 | 20 | 0.934 | 22 | 0.761 | 30 | 1.800 | 1 | 1.774 | 2 | 1.714 | 2 |
| 4 | Crude Petroleum | 0.965 | 21 | 0.934 | 23 | 0.779 | 28 | 1.800 | 2 | 1.774 | 3 | 1.703 | 3 |
| 5 | Mining and Querying (Metal & Non-metal) | 0.823 | 28 | 0.890 | 26 | 0.996 | 19 | 1.540 | 4 | 1.584 | 4 | 1.669 | 4 |
| 6 | Food Products | 1.237 | 2 | 1.263 | 1 | 1.317 | 1 | 0.680 | 24 | 0.626 | 29 | 0.742 | 27 |
| 7 | Beverages, Coffee & Tobacco | 1.045 | 17 | 1.054 | 14 | 1.194 | 7 | 0.649 | 27 | 0.636 | 28 | 0.642 | 30 |
| 8 | Cotton & Textile | 1.251 | 1 | 1.211 | 4 | 1.221 | 5 | 0.727 | 22 | 0.740 | 23 | 0.777 | 25 |
| 9 | Leather & Leather Products | 1.107 | 12 | 1.161 | 6 | 1.192 | 8 | 0.755 | 21 | 0.689 | 25 | 0.668 | 29 |
| 10 | Wood, Furniture & Products | 1.128 | 10 | 1.151 | 9 | 1.131 | 13 | 1.195 | 11 | 1.197 | 10 | 1.237 | 6 |
| 11 | Publishing, printing, and allied activities | 1.131 | 9 | 1.083 | 13 | 1.133 | 12 | 0.962 | 17 | 0.840 | 19 | 0.997 | 16 |
| 12 | Rubber & Plastic | 1.202 | 5 | 1.187 | 5 | 1.182 | 10 | 1.140 | 13 | 1.132 | 12 | 1.180 | 8 |
| 13 | Petroleum Products incl. Coal Tar | 0.889 | 24 | 0.983 | 19 | 0.814 | 27 | 1.266 | 8 | 1.199 | 9 | 1.123 | 12 |
| 14 | Chemical, Fertilizer & Pharmaceuticals | 1.092 | 14 | 1.125 | 10 | 1.072 | 15 | 1.320 | 7 | 1.403 | 6 | 1.147 | 10 |
| 15 | Metal and Non-Metal Products | 1.204 | 4 | 1.224 | 2 | 1.275 | 2 | 1.358 | 6 | 1.359 | 7 | 1.454 | 5 |
| 16 | Non-electrical Machinery & Equipment | 1.162 | 7 | 1.152 | 7 | 1.191 | 9 | 0.648 | 28 | 0.641 | 27 | 0.781 | 24 |
| 17 | Electrical Machinery & Equipment | 1.198 | 6 | 1.152 | 8 | 1.219 | 6 | 0.862 | 20 | 0.750 | 22 | 0.820 | 21 |
| 18 | Motor Vehicles and Transport Equipment | 1.217 | 3 | 1.217 | 3 | 1.246 | 3 | 0.635 | 30 | 0.619 | 30 | 0.810 | 23 |
| 19 | Other Manufacturing incl. Gems & Jewellery | 1.055 | 16 | 1.012 | 17 | 1.238 | 4 | 0.705 | 23 | 0.868 | 18 | 1.065 | 13 |
| 20 | Construction | 1.124 | 11 | 1.118 | 11 | 1.143 | 11 | 0.645 | 29 | 0.652 | 26 | 0.718 | 28 |
| 21 | Electricity, Gas & Water | 1.063 | 15 | 1.041 | 15 | 1.001 | 18 | 1.200 | 10 | 1.190 | 11 | 1.218 | 7 |
| 22 | Trade | 0.898 | 23 | 0.894 | 25 | 0.841 | 24 | 1.150 | 12 | 1.113 | 13 | 1.064 | 14 |
| 23 | Repair & Maintenance of Vehicle | 0.789 | 30 | 0.800 | 29 | 0.770 | 29 | 1.240 | 9 | 1.355 | 8 | 1.149 | 9 |
| 24 | Hotel & Restaurants | 1.144 | 8 | 1.102 | 12 | 1.085 | 14 | 0.941 | 18 | 0.879 | 17 | 0.774 | 26 |
| 25 | transport & Storage | 1.021 | 18 | 1.004 | 18 | 1.042 | 16 | 0.880 | 19 | 0.834 | 20 | 0.859 | 19 |
| 26 | Information & Communication Services | 1.100 | 13 | 1.024 | 16 | 1.037 | 17 | 1.057 | 15 | 1.029 | 15 | 1.008 | 15 |
| 27 | Financial and Insurance Services | 0.789 | 31 | 0.797 | 31 | 0.821 | 26 | 1.080 | 14 | 1.066 | 14 | 1.124 | 11 |
| 28 | Real Estate Activities | 0.687 | 34 | 0.692 | 34 | 0.646 | 34 | 0.666 | 26 | 0.700 | 24 | 0.588 | 33 |
| 29 | Renting of Machinery & Equipment | 0.866 | 25 | 0.957 | 20 | 0.932 | 21 | 1.522 | 5 | 1.494 | 5 | 0.867 | 18 |
| 30 | Business Services | 0.825 | 27 | 0.836 | 28 | 0.832 | 25 | 0.674 | 25 | 0.806 | 21 | 0.813 | 22 |
| 31 | Public Administration & Defense | 0.817 | 29 | 0.799 | 30 | 0.758 | 31 | 0.527 | 34 | 0.546 | 34 | 0.529 | 34 |
| 32 | Educational Services | 0.703 | 33 | 0.729 | 33 | 0.740 | 32 | 0.541 | 32 | 0.596 | 31 | 0.610 | 32 |
| 33 | Community, social, personal & health services | 0.920 | 22 | 0.937 | 21 | 0.853 | 23 | 0.530 | 33 | 0.551 | 33 | 0.620 | 31 |
| 34 | Entertainment, broadcasting, and other services | 0.843 | 26 | 0.884 | 27 | 0.935 | 20 | 0.580 | 31 | 0.587 | 32 | 0.880 | 17 |

Source: Author's computation

Table 2. Production-induced effects and value-added creation effects of natural gas on other sectors.

| Sl. No. | Product * Industry | Production Induced Effect | | | | | | Value-Added Effect | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011-12 | | 2015-16 | | 2019-20 | | 2011-12 | | 2015-16 | | 2019-20 | |
| | | Value | Rank | Value | Rank | Value | Rank | Value | Rank | Value | Rank | Value | Rank |
| 1 | Agriculture & Allied Activities | 0.027 | 8 | 0.024 | 7 | 0.005 | 15 | 0.021 | 5 | 0.019 | 4 | 0.004 | 11 |
| 2 | Coal & Lignite | 0.007 | 14 | 0.004 | 16 | 0.004 | 16 | 0.004 | 14 | 0.003 | 14 | 0.002 | 14 |
| 3 | Natural Gas | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4 | Crude Petroleum | 0.014 | 11 | 0.013 | 9 | 0.049 | 1 | 0.007 | 10 | 0.008 | 10 | 0.024 | 2 |
| 5 | Mining and Querying (Metal & Non-metal) | 0.034 | 6 | 0.043 | 5 | 0.004 | 17 | 0.023 | 4 | 0.026 | 3 | 0.002 | 16 |
| 6 | Food Products | 0.002 | 22 | 0.002 | 22 | 0.001 | 28 | 0.000 | 25 | 0.000 | 27 | 0.000 | 29 |
| 7 | Beverages, Coffee & Tobacco | 0.000 | 28 | 0.000 | 31 | 0.000 | 31 | 0.000 | 29 | 0.000 | 32 | 0.000 | 31 |
| 8 | Cotton & Textile | 0.004 | 20 | 0.004 | 17 | 0.001 | 26 | 0.001 | 22 | 0.001 | 18 | 0.000 | 27 |
| 9 | Leather & Leather Products | 0.000 | 29 | 0.000 | 29 | 0.000 | 32 | 0.000 | 31 | 0.000 | 30 | 0.000 | 32 |
| 10 | Wood, Furniture & Products | 0.004 | 18 | 0.004 | 18 | 0.003 | 18 | 0.001 | 18 | 0.001 | 19 | 0.001 | 21 |
| 11 | Publishing, printing and allied activities | 0.001 | 26 | 0.000 | 28 | 0.000 | 30 | 0.000 | 27 | 0.000 | 28 | 0.000 | 30 |
| 12 | Rubber & Plastic | 0.005 | 15 | 0.006 | 14 | 0.003 | 19 | 0.001 | 19 | 0.002 | 16 | 0.001 | 24 |
| 13 | Petroleum Products incl. Coal Tar | 0.061 | 4 | 0.080 | 3 | 0.008 | 12 | 0.004 | 13 | 0.012 | 5 | 0.001 | 22 |
| 14 | Chemical, Fertilizer & Pharmaceuticals | 0.249 | 1 | 0.193 | 1 | 0.007 | 13 | 0.061 | 2 | 0.056 | 2 | 0.002 | 15 |
| 15 | Metal and Non-Metal Products | 0.098 | 3 | 0.047 | 4 | 0.016 | 9 | 0.024 | 3 | 0.011 | 7 | 0.004 | 12 |
| 16 | Non-electrical Machinery & Equipment | 0.015 | 10 | 0.002 | 21 | 0.001 | 29 | 0.004 | 12 | 0.001 | 21 | 0.000 | 28 |
| 17 | Electrical Machinery & Equipment | 0.004 | 17 | 0.002 | 23 | 0.002 | 22 | 0.001 | 20 | 0.001 | 22 | 0.000 | 26 |
| 18 | Motor Vehicles and Transport Equipment | 0.003 | 21 | 0.001 | 25 | 0.002 | 24 | 0.001 | 23 | 0.000 | 26 | 0.000 | 25 |
| 19 | Other Manufacturing incl. Gems & Jewellery | 0.001 | 25 | 0.001 | 24 | 0.029 | 5 | 0.000 | 26 | 0.000 | 25 | 0.006 | 9 |
| 20 | Construction | 0.028 | 7 | 0.007 | 12 | 0.022 | 8 | 0.010 | 8 | 0.003 | 15 | 0.008 | 7 |
| 21 | Electricity, Gas & Water | 0.036 | 5 | 0.025 | 6 | 0.014 | 10 | 0.014 | 6 | 0.010 | 8 | 0.006 | 8 |
| 22 | Trade | 0.110 | 2 | 0.102 | 2 | 0.028 | 6 | 0.067 | 1 | 0.064 | 1 | 0.018 | 4 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Repair & Maintenance of Vehicle | 0.000 | 27 | 0.005 | 15 | 0.002 | 23 | 0.000 | 24 | 0.004 | 13 | 0.001 | 17 |
| 24 | Hotel & Restaurants | 0.004 | 19 | 0.002 | 20 | 0.002 | 20 | 0.001 | 17 | 0.001 | 20 | 0.001 | 23 |
| 25 | transport & Storage | 0.013 | 12 | 0.011 | 10 | 0.023 | 7 | 0.006 | 11 | 0.005 | 11 | 0.010 | 6 |
| 26 | Information & Communication Services | 0.005 | 16 | 0.003 | 19 | 0.006 | 14 | 0.002 | 15 | 0.001 | 17 | 0.002 | 13 |
| 27 | Financial and Insurance Services | 0.017 | 9 | 0.015 | 8 | 0.030 | 4 | 0.012 | 7 | 0.011 | 6 | 0.021 | 3 |
| 28 | Real Estate Activities | 0.010 | 13 | 0.009 | 11 | 0.001 | 27 | 0.009 | 9 | 0.008 | 9 | 0.001 | 19 |
| 29 | Renting of Machinery & Equipment | 0.001 | 24 | 0.001 | 26 | 0.032 | 3 | 0.001 | 21 | 0.000 | 24 | 0.018 | 5 |
| 30 | Business Services | 0.002 | 23 | 0.007 | 13 | 0.040 | 2 | 0.001 | 16 | 0.004 | 12 | 0.028 | 1 |
| 31 | Public Administration & Defense | 0.000 | 33 | 0.000 | 33 | 0.000 | 33 | 0.000 | 33 | 0.000 | 33 | 0.000 | 33 |
| 32 | Educational Services | 0.000 | 31 | 0.000 | 27 | 0.002 | 25 | 0.000 | 30 | 0.000 | 23 | 0.001 | 20 |
| 33 | Community, social, personal & health services | 0.000 | 32 | 0.000 | 30 | 0.002 | 21 | 0.000 | 32 | 0.000 | 29 | 0.001 | 18 |
| 34 | Entertainment, broadcasting, and other services | 0.000 | 30 | 0.000 | 32 | 0.010 | 11 | 0.000 | 28 | 0.000 | 31 | 0.005 | 10 |
| | Total indirect | 0.756 | | 0.613 | | 0.347 | | 0.278 | | 0.252 | | 0.172 | |
| | Direct | 0.005 | | 0.004 | | 0.006 | | 0.546 | | 0.600 | | 0.550 | |
| | Total (Direct + Indirect) | 0.761 | | 0.617 | | 0.353 | | 0.824 | | 0.852 | | 0.722 | |

Source: Authors Compilation

Table 3. Income-induced effects of the natural gas sector on other sectors

| **Sl. No.** | **Product * Industry** | **Income Effect** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011-12 | | | | 2015-16 | | | | 2019-20 | | | |
| | | BL | FL | Total | Rank | BL | FL | Total | Rank | BL | FL | Total | Rank |
| 1 | Agriculture & Allied Activities | 0.003 | 0.006 | 0.009 | 11 | 0.003 | 0.006 | 0.009 | 10 | 0.001 | 0.006 | 0.007 | 14 |
| 2 | Coal & Lignite | 0.001 | 0.001 | 0.002 | 20 | 0.001 | 0.001 | 0.002 | 22 | 0.001 | 0.001 | 0.002 | 24 |
| 3 | Natural Gas | 0.000 | 0.000 | 0.000 | 34 | 0.000 | 0.000 | 0.000 | 34 | 0.000 | 0.000 | 0.000 | 34 |
| 4 | Crude Petroleum | 0.002 | 0.002 | 0.003 | 18 | 0.002 | 0.001 | 0.003 | 17 | 0.006 | 0.003 | 0.010 | 9 |
| 5 | Mining and Querying (Metal & Non-metal) | 0.006 | 0.002 | 0.008 | 12 | 0.006 | 0.002 | 0.008 | 12 | 0.001 | 0.003 | 0.003 | 21 |
| 6 | Food Products | 0.000 | 0.001 | 0.001 | 26 | 0.000 | 0.001 | 0.001 | 27 | 0.000 | 0.002 | 0.002 | 27 |
| 7 | Beverages, Coffee & Tobacco | 0.000 | 0.000 | 0.000 | 30 | 0.000 | 0.000 | 0.000 | 31 | 0.000 | 0.001 | 0.001 | 30 |
| 8 | Cotton & Textile | 0.000 | 0.002 | 0.002 | 21 | 0.000 | 0.003 | 0.003 | 16 | 0.000 | 0.004 | 0.004 | 18 |
| 9 | Leather & Leather Products | 0.000 | 0.000 | 0.000 | 33 | 0.000 | 0.000 | 0.000 | 32 | 0.000 | 0.000 | 0.000 | 32 |
| 10 | Wood, Furniture & Products | 0.000 | 0.001 | 0.001 | 25 | 0.000 | 0.001 | 0.001 | 24 | 0.000 | 0.001 | 0.002 | 26 |
| 11 | Publishing, printing and allied activities | 0.000 | 0.000 | 0.000 | 31 | 0.000 | 0.000 | 0.000 | 33 | 0.000 | 0.000 | 0.000 | 33 |
| 12 | Rubber & Plastic | 0.000 | 0.001 | 0.001 | 24 | 0.000 | 0.002 | 0.002 | 20 | 0.000 | 0.002 | 0.002 | 22 |
| 13 | Petroleum Products incl. Coal Tar | 0.001 | 0.013 | 0.014 | 7 | 0.003 | 0.034 | 0.037 | 1 | 0.000 | 0.008 | 0.008 | 12 |
| 14 | Chemical, Fertilizer & Pharmaceuticals | 0.014 | 0.015 | 0.029 | 2 | 0.013 | 0.016 | 0.029 | 3 | 0.001 | 0.018 | 0.018 | 5 |
| 15 | Metal and Non-Metal Products | 0.006 | 0.006 | 0.012 | 8 | 0.003 | 0.005 | 0.008 | 13 | 0.001 | 0.008 | 0.009 | 10 |
| 16 | Non-electrical Machinery & Equipment | 0.001 | 0.002 | 0.003 | 19 | 0.000 | 0.002 | 0.002 | 21 | 0.000 | 0.001 | 0.001 | 29 |
| 17 | Electrical Machinery & Equipment | 0.000 | 0.001 | 0.002 | 23 | 0.000 | 0.001 | 0.001 | 23 | 0.000 | 0.002 | 0.002 | 25 |
| 18 | Motor Vehicles and Transport Equipment | 0.000 | 0.006 | 0.006 | 15 | 0.000 | 0.002 | 0.002 | 18 | 0.000 | 0.002 | 0.002 | 23 |
| 19 | Other Manufacturing incl. Gems & Jewellery | 0.000 | 0.001 | 0.001 | 28 | 0.000 | 0.000 | 0.001 | 30 | 0.002 | 0.002 | 0.004 | 17 |
| 20 | Construction | 0.007 | 0.035 | 0.042 | 1 | 0.002 | 0.029 | 0.031 | 2 | 0.005 | 0.054 | 0.059 | 2 |
| 21 | Electricity, Gas & Water | 0.005 | 0.014 | 0.019 | 5 | 0.003 | 0.014 | 0.017 | 6 | 0.002 | 0.083 | 0.085 | 1 |
| 22 | Trade | 0.011 | 0.011 | 0.022 | 4 | 0.010 | 0.009 | 0.019 | 5 | 0.003 | 0.010 | 0.013 | 8 |
| 23 | Repair & Maintenance of Vehicle | 0.000 | 0.000 | 0.000 | 32 | 0.001 | 0.001 | 0.001 | 25 | 0.000 | 0.000 | 0.001 | 31 |
| 24 | Hotel & Restaurants | 0.000 | 0.001 | 0.001 | 27 | 0.000 | 0.001 | 0.001 | 26 | 0.000 | 0.001 | 0.001 | 28 |
| 25 | transport & Storage | 0.002 | 0.025 | 0.027 | 3 | 0.002 | 0.023 | 0.025 | 4 | 0.003 | 0.015 | 0.019 | 4 |
| 26 | Information & Communication Services | 0.001 | 0.006 | 0.007 | 14 | 0.000 | 0.007 | 0.007 | 14 | 0.001 | 0.003 | 0.004 | 19 |
| 27 | Financial and Insurance Services | 0.003 | 0.007 | 0.011 | 9 | 0.004 | 0.005 | 0.009 | 11 | 0.007 | 0.011 | 0.018 | 6 |
| 28 | Real Estate Activities | 0.002 | 0.005 | 0.007 | 13 | 0.003 | 0.009 | 0.012 | 9 | 0.001 | 0.005 | 0.006 | 16 |
| 29 | Renting of Machinery & Equipment | 0.000 | 0.000 | 0.001 | 29 | 0.000 | 0.000 | 0.001 | 28 | 0.008 | 0.001 | 0.008 | 11 |
| 30 | Business Services | 0.000 | 0.005 | 0.006 | 16 | 0.002 | 0.014 | 0.016 | 7 | 0.012 | 0.010 | 0.022 | 3 |
| 31 | Public Administration & Defense | 0.000 | 0.010 | 0.010 | 10 | 0.000 | 0.007 | 0.007 | 15 | 0.000 | 0.015 | 0.015 | 7 |
| 32 | Educational Services | 0.000 | 0.004 | 0.004 | 17 | 0.000 | 0.002 | 0.002 | 19 | 0.001 | 0.006 | 0.007 | 15 |
| 33 | Community, social, personal & health services | 0.000 | 0.017 | 0.017 | 6 | 0.000 | 0.012 | 0.012 | 8 | 0.001 | 0.007 | 0.008 | 13 |
| 34 | Entertainment, broadcasting, and other services | 0.000 | 0.002 | 0.002 | 22 | 0.000 | 0.001 | 0.001 | 29 | 0.002 | 0.001 | 0.003 | 20 |
| | Total Indirect | 0.066 | 0.203 | 0.269 | | 0.058 | 0.212 | 0.270 | | 0.058 | 0.287 | 0.345 | |
| | Self-inducing effect | 0.136 | 0.136 | | | 0.147 | 0.147 | | | 0.149 | 0.149 | | |
| | Total (Direct + Indirect) | 0.202 | 0.339 | | | 0.205 | 0.359 | | | 0.208 | 0.436 | | |
| | Initial | 0.135 | 0.135 | | | 0.147 | 0.147 | | | 0.149 | 0.149 | | |
| | Type I Income Multiplier | 1.495 | 2.510 | | | 1.401 | 2.450 | | | 1.397 | 2.936 | | |
| | Type II Income Multiplier | 2.220 | 3.985 | | | 2.234 | 4.145 | | | 2.373 | 5.065 | | |

Source: Author's computation

Table 4. Employment-induced effects of the natural gas sector on other sectors

| Sl. No. | Product * Industry | Employment Effect | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011-12 | | | | 2015-16 | | | | 2019-20 | | | |
| | | BL | FL | Total | Rank | BL | FL | Total | Rank | BL | FL | Total | Rank |
| 1 | Agriculture & Allied Activities | 4.981 | 8.482 | 13.463 | 1 | 2.617 | 5.902 | 8.518 | 1 | 0.391 | 3.871 | 4.262 | 2 |
| 2 | Coal & Lignite | 0.064 | 0.103 | 0.167 | 25 | 0.023 | 0.031 | 0.055 | 28 | 0.012 | 0.024 | 0.035 | 31 |
| 3 | Natural Gas | 0.000 | 0.000 | 0.000 | 34 | 0.000 | 0.000 | 0.000 | 34 | 0.000 | 0.000 | 0.000 | 34 |
| 4 | Crude Petroleum | 0.131 | 0.108 | 0.239 | 22 | 0.066 | 0.033 | 0.099 | 25 | 0.120 | 0.058 | 0.178 | 21 |
| 5 | Mining and Querying (Metal & Non-metal) | 0.412 | 0.131 | 0.543 | 15 | 0.221 | 0.057 | 0.278 | 19 | 0.009 | 0.053 | 0.062 | 29 |
| 6 | Food Products | 0.017 | 0.202 | 0.219 | 23 | 0.008 | 0.114 | 0.122 | 23 | 0.004 | 0.169 | 0.173 | 22 |
| 7 | Beverages, Coffee & Tobacco | 0.007 | 0.074 | 0.081 | 28 | 0.001 | 0.055 | 0.056 | 27 | 0.001 | 0.075 | 0.075 | 28 |
| 8 | Cotton & Textile | 0.048 | 0.504 | 0.552 | 14 | 0.041 | 0.441 | 0.482 | 12 | 0.013 | 0.437 | 0.450 | 12 |
| 9 | Leather & Leather Products | 0.004 | 0.024 | 0.029 | 33 | 0.001 | 0.031 | 0.032 | 31 | 0.000 | 0.047 | 0.048 | 30 |
| 10 | Wood, Furniture & Products | 0.064 | 0.266 | 0.330 | 21 | 0.041 | 0.130 | 0.171 | 22 | 0.025 | 0.155 | 0.180 | 20 |
| 11 | Publishing, printing and allied activities | 0.011 | 0.049 | 0.060 | 31 | 0.005 | 0.017 | 0.022 | 32 | 0.004 | 0.030 | 0.034 | 32 |
| 12 | Rubber & Plastic | 0.063 | 0.279 | 0.342 | 20 | 0.056 | 0.253 | 0.309 | 16 | 0.021 | 0.232 | 0.253 | 17 |
| 13 | Petroleum Products incl. Coal Tar | 0.209 | 3.137 | 3.346 | 5 | 0.417 | 4.789 | 5.206 | 3 | 0.024 | 0.892 | 0.916 | 8 |
| 14 | Chemical, Fertilizer & Pharmaceuticals | 3.252 | 3.516 | 6.768 | 3 | 1.917 | 2.274 | 4.192 | 4 | 0.062 | 1.995 | 2.057 | 5 |
| 15 | Metal and Non-Metal Products | 1.302 | 1.461 | 2.763 | 7 | 0.361 | 0.762 | 1.122 | 8 | 0.107 | 0.889 | 0.997 | 7 |
| 16 | Non-electrical Machinery & Equipment | 0.240 | 0.547 | 0.787 | 13 | 0.026 | 0.270 | 0.297 | 17 | 0.006 | 0.121 | 0.127 | 26 |
| 17 | Electrical Machinery & Equipment | 0.058 | 0.323 | 0.380 | 19 | 0.017 | 0.181 | 0.199 | 21 | 0.014 | 0.178 | 0.193 | 19 |
| 18 | Motor Vehicles and Transport Equipment | 0.041 | 1.319 | 1.360 | 9 | 0.009 | 0.333 | 0.342 | 15 | 0.015 | 0.228 | 0.243 | 18 |
| 19 | Other Manufacturing incl. Gems & Jewellery | 0.012 | 0.134 | 0.147 | 26 | 0.010 | 0.066 | 0.076 | 26 | 0.189 | 0.272 | 0.461 | 11 |
| 20 | Construction | 0.760 | 3.941 | 4.701 | 4 | 0.200 | 3.400 | 3.600 | 5 | 0.435 | 4.597 | 5.032 | 1 |
| 21 | Electricity, Gas & Water | 0.236 | 0.713 | 0.949 | 12 | 0.112 | 0.467 | 0.579 | 11 | 0.051 | 2.083 | 2.133 | 4 |
| 22 | Trade | 3.700 | 3.582 | 7.281 | 2 | 2.955 | 2.886 | 5.841 | 2 | 0.647 | 2.263 | 2.910 | 3 |
| 23 | Repair & Maintenance of Vehicle | 0.018 | 0.031 | 0.048 | 32 | 0.185 | 0.185 | 0.370 | 13 | 0.050 | 0.101 | 0.151 | 24 |
| 24 | Hotel & Restaurants | 0.114 | 0.347 | 0.461 | 18 | 0.069 | 0.221 | 0.289 | 18 | 0.045 | 0.225 | 0.270 | 16 |
| 25 | transport & Storage | 0.250 | 3.063 | 3.314 | 6 | 0.174 | 2.658 | 2.832 | 6 | 0.282 | 1.304 | 1.587 | 6 |
| 26 | Information & Communication Services | 0.088 | 0.956 | 1.043 | 11 | 0.054 | 0.784 | 0.838 | 10 | 0.077 | 0.208 | 0.284 | 15 |
| 27 | Financial and Insurance Services | 0.170 | 0.358 | 0.528 | 16 | 0.099 | 0.144 | 0.243 | 20 | 0.152 | 0.228 | 0.380 | 13 |
| 28 | Real Estate Activities | 0.019 | 0.048 | 0.067 | 30 | 0.011 | 0.032 | 0.042 | 30 | 0.001 | 0.011 | 0.012 | 33 |
| 29 | Renting of Machinery & Equipment | 0.027 | 0.048 | 0.075 | 29 | 0.004 | 0.011 | 0.015 | 33 | 0.081 | 0.007 | 0.088 | 27 |
| 30 | Business Services | 0.073 | 1.212 | 1.284 | 10 | 0.094 | 0.754 | 0.848 | 9 | 0.309 | 0.254 | 0.563 | 9 |
| 31 | Public Administration & Defense | 0.000 | 0.201 | 0.201 | 24 | 0.000 | 0.113 | 0.113 | 24 | 0.000 | 0.155 | 0.155 | 23 |
| 32 | Educational Services | 0.009 | 0.501 | 0.509 | 17 | 0.021 | 0.326 | 0.347 | 14 | 0.037 | 0.334 | 0.371 | 14 |
| 33 | Community, social, personal & health services | 0.001 | 1.701 | 1.702 | 8 | 0.002 | 1.207 | 1.209 | 7 | 0.044 | 0.509 | 0.554 | 10 |
| 34 | Entertainment, broadcasting, and other services | 0.005 | 0.082 | 0.087 | 27 | 0.001 | 0.046 | 0.047 | 29 | 0.094 | 0.056 | 0.150 | 25 |
| | Total Indirect | 16.385 | 37.442 | 53.827 | | 9.818 | 28.973 | 38.791 | | 3.320 | 22.064 | 25.383 | |
| | Self-inducing effect | 9.623 | 9.623 | | | 5.194 | 5.194 | | | 2.762 | 2.762 | | |
| | Total (Direct + Indirect) | 26.008 | 47.065 | | | 15.012 | 34.167 | | | 6.081 | 24.825 | | |
| | Initial | 9.577 | 9.577 | | | 5.171 | 5.171 | | | 2.745 | 2.745 | | |
| | Type I Income and Employment Multiplier | 2.716 | 4.914 | | | 2.903 | 6.608 | | | 2.215 | 9.042 | | |
| | Type II Income and Employment Multiplier | 6.444 | 8.130 | | | 8.104 | 11.499 | | | 9.916 | 16.460 | | |

Source: Author's Computation

Table 5. Supply shortage effect of the Natural Gas sector on other sectors

| Sl. No. | Product * Industry | Supply Shortage Effect | | | | | | Relative Price Effect | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011-12 | | 2015-16 | | 2019-20 | | 2011-12 | | 2015-16 | | 2019-20 | |
| | | Value | Rank | Value | Rank | Value | Rank | Value | Rank | Value | Rank | Value | Rank |
| 1 | Agriculture & Allied Activities | 0.046 | 10 | 0.055 | 8 | 0.051 | 8 | 0.005% | 32 | 0.003% | 31 | 0.002% | 32 |
| 2 | Coal & Lignite | 0.011 | 26 | 0.006 | 27 | 0.008 | 27 | 0.026% | 7 | 0.009% | 12 | 0.010% | 9 |
| 3 | Natural Gas | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4 | Crude Petroleum | 0.011 | 24 | 0.006 | 26 | 0.024 | 18 | 0.014% | 20 | 0.006% | 22 | 0.021% | 4 |
| 5 | Mining and Querying (Metal & Non-metal) | 0.011 | 25 | 0.011 | 21 | 0.020 | 20 | 0.015% | 18 | 0.009% | 11 | 0.010% | 11 |
| 6 | Food Products | 0.026 | 16 | 0.024 | 16 | 0.042 | 11 | 0.007% | 28 | 0.004% | 26 | 0.005% | 23 |
| 7 | Beverages, Coffee & Tobacco | 0.004 | 29 | 0.004 | 30 | 0.008 | 28 | 0.006% | 30 | 0.004% | 27 | 0.006% | 22 |
| 8 | Cotton & Textile | 0.037 | 12 | 0.041 | 12 | 0.050 | 9 | 0.014% | 21 | 0.009% | 14 | 0.009% | 12 |
| 9 | Leather & Leather Products | 0.002 | 32 | 0.003 | 31 | 0.005 | 30 | 0.007% | 29 | 0.006% | 23 | 0.009% | 13 |
| 10 | Wood, Furniture & Products | 0.017 | 20 | 0.012 | 20 | 0.017 | 21 | 0.020% | 12 | 0.007% | 19 | 0.007% | 19 |
| 11 | Publishing, printing and allied activities | 0.003 | 30 | 0.001 | 33 | 0.003 | 32 | 0.016% | 16 | 0.006% | 24 | 0.007% | 15 |
| 12 | Rubber & Plastic | 0.021 | 19 | 0.025 | 15 | 0.030 | 14 | 0.021% | 11 | 0.011% | 9 | 0.014% | 5 |
| 13 | Petroleum Products incl. Coal Tar | 0.917 | 1 | 0.919 | 1 | 0.297 | 2 | 0.182% | 1 | 0.128% | 1 | 0.090% | 1 |
| 14 | Chemical, Fertilizer & Pharmaceuticals | 0.269 | 2 | 0.228 | 2 | 0.230 | 3 | 0.044% | 3 | 0.024% | 2 | 0.024% | 3 |
| 15 | Metal and Non-Metal Products | 0.110 | 5 | 0.098 | 7 | 0.135 | 5 | 0.023% | 9 | 0.013% | 7 | 0.012% | 6 |
| 16 | Non-electrical Machinery & Equipment | 0.033 | 15 | 0.024 | 17 | 0.013 | 24 | 0.022% | 10 | 0.011% | 8 | 0.007% | 16 |
| 17 | Electrical Machinery & Equipment | 0.022 | 18 | 0.016 | 19 | 0.025 | 16 | 0.019% | 14 | 0.009% | 15 | 0.008% | 14 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Motor Vehicles and Transport Equipment | 0.101 | 8 | 0.032 | 13 | 0.029 | 15 | 0.052% | 2 | 0.008% | 16 | 0.007% | 17 |
| 19 | Other Manufacturing incl. Gems & Jewellery | 0.012 | 22 | 0.009 | 23 | 0.041 | 12 | 0.019% | 13 | 0.009% | 13 | 0.011% | 8 |
| 20 | Construction | 0.148 | 4 | 0.121 | 4 | 0.227 | 4 | 0.016% | 17 | 0.008% | 17 | 0.010% | 10 |
| 21 | Electricity, Gas & Water | 0.109 | 6 | 0.106 | 5 | 0.584 | 1 | 0.038% | 5 | 0.020% | 4 | 0.065% | 2 |
| 22 | Trade | 0.107 | 7 | 0.099 | 6 | 0.096 | 7 | 0.015% | 19 | 0.007% | 18 | 0.007% | 18 |
| 23 | Repair & Maintenance of Vehicle | 0.001 | 33 | 0.005 | 28 | 0.004 | 31 | 0.013% | 22 | 0.006% | 21 | 0.006% | 20 |
| 24 | Hotel & Restaurants | 0.012 | 23 | 0.008 | 24 | 0.011 | 26 | 0.009% | 26 | 0.003% | 30 | 0.004% | 28 |
| 25 | transport & Storage | 0.163 | 3 | 0.167 | 3 | 0.105 | 6 | 0.040% | 4 | 0.021% | 3 | 0.012% | 7 |
| 26 | Information & Communication Services | 0.050 | 9 | 0.046 | 11 | 0.016 | 22 | 0.033% | 6 | 0.014% | 5 | 0.005% | 24 |
| 27 | Financial and Insurance Services | 0.035 | 13 | 0.022 | 18 | 0.045 | 10 | 0.012% | 24 | 0.004% | 29 | 0.005% | 25 |
| 28 | Real Estate Activities | 0.025 | 17 | 0.027 | 14 | 0.013 | 25 | 0.008% | 27 | 0.004% | 28 | 0.002% | 31 |
| 29 | Renting of Machinery & Equipment | 0.003 | 31 | 0.002 | 32 | 0.003 | 33 | 0.023% | 8 | 0.014% | 6 | 0.004% | 27 |
| 30 | Business Services | 0.035 | 14 | 0.053 | 9 | 0.033 | 13 | 0.012% | 23 | 0.006% | 20 | 0.003% | 29 |
| 31 | Public Administration & Defense | 0.016 | 21 | 0.011 | 22 | 0.022 | 19 | 0.005% | 31 | 0.002% | 33 | 0.002% | 33 |
| 32 | Educational Services | 0.007 | 27 | 0.007 | 25 | 0.014 | 23 | 0.004% | 33 | 0.002% | 32 | 0.003% | 30 |
| 33 | Community, social, personal & health services | 0.042 | 11 | 0.051 | 10 | 0.024 | 17 | 0.017% | 15 | 0.010% | 10 | 0.004% | 26 |
| 34 | Entertainment, broadcasting, and other services | 0.004 | 28 | 0.004 | 29 | 0.006 | 29 | 0.010% | 25 | 0.005% | 25 | 0.006% | 21 |
| | Total indirect | 2.409 | | 2.245 | | 2.232 | | | | | | | |
| | Direct | 0.005 | | 0.004 | | 0.006 | | 1.445% | | 1.561% | | 1.962% | |
| | Total (Direct + Indirect) | 2.414 | | 2.249 | | 2.238 | | 0.063% | | 0.056% | | 0.068% | |

Source: Author's Computation

Note: The last row of the table for relative price impact presents the percentage change in average price level in the economy.

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