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UNDERSTANDING EDUCATION AND RESEARCH SECTOR THROUGH INTER-INDUSTRY LINKAGES: EVIDENCE FROM INDIA

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Abstract
This paper investigates the role of the education and research sector in Indian economy using input–output framework. It explores how forward and backward linkages of this sector contribute to economic development beyond its conventional social role. Findings of this study indicate strong forward linkages that enable productivity and innovation across industries, but weak backward linkages that limit demand generation for upstream sectors. By examining education within sectoral linkages, the study demonstrates how investments in education yield multiplier effects on output and contribute to Sustainable Development. The paper concludes with policy recommendations for strengthening digital infrastructure, academia–industry integration, and research capabilities to enhance the role of education and research as a catalyst for structural transformation.

Key Words: Education, Inter Industry Linkages, Sustainable Development Goal

1.1 Introduction

In India education and research sector has transformed significantly from colonial origins into an inclusive, technology-driven landscape. Recent decades have seen the rise of digital classrooms, AI-based tools, MOOCs, and virtual learning platforms that reshape teaching and learning. The National Education Policy (NEP 2020) and government-led programs like Digital India and Sarva Shiksha Abhiyan emphasize equitable access and quality. Yet, the sector's economic contribution remains under-explored. This study bridges that gap by examining the role of education and research sector in structural transformation using input–output framework. The objective is to quantify its contribution through forward and backward linkages, equilibrium output, and multiplier effects, and to derive findings in the global development context and in line with SDG-4.Accordingly, this study aims at providing evidence-based insights with regard to sectors that are linked to education and research.

1.2 Literature Review

Professor Wassily W. Leontief (1951) the recipient of noble prize in 1973 has developed the basic input-output model. This model helps in determining the level of output that need to be produced by each producing sectors to meet the total demand of a product. In addition, this model helps in understanding the interdependence between various producing sectors in an economy. Further, this framework also provides a vital tool which can be used for computation and measurement of growth in National Income. In fact, Kaur, G et al (2009) has highlighted the importance of interlinkages across sub-sectors to strengthen overall outcomes.

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Education, like any other sector is interdependent. It thrives when strong connections exist between teaching, research, industry, and policy. For instance, research contributes to knowledge creation and improved pedagogy, while industry linkages ensure employability and practical relevance. Similarly, financial and institutional support in the form of policy and governance acts as a stabilizing factor that sustains educational growth. Therefore, collaboration among universities, research institutions, and professional sectors contributes to skill development, innovation, and social progress. Hence, fostering these linkages is crucial for inclusive and sustainable development of the education and research ecosystem.

Bhattacharya et al. (2018) uses input–output analysis to assess sectoral productivity in the Indian economy. Bhandari & Bhattacharya (2021) extends IO analysis to examine how different sectors contribute to varied skill-level employment, highlighting the education sector's indirect impact. Motkuri & Revathi (2024) and Rana & Meher (2023) analyze trends in public versus private spending on education and its regional/economic implications—crucial for policy-based discussions.

1.3 Research Gap

Input-output framework, is a powerful tool, that can provide better insights than what the existing studies offer. Using this input output table, the study intends to identify the sectors that are the major users of education and research as input in their production process. In addition, this study interest is to explore the sectors whose outputs are being used as input by education and research sector. Further, through the lens of this framework, this study would explore the various types of forward and backward linkages to understand the inter-sectoral dependency of education and research sector with rest of the sector.

1.4 Database and Methodology

This study uses the **latest available input-output table of India** 2007-08, released by CSO and conducts a comparative static analysis in order to comprehend inter-industry relationships In an economy, the growth of one sector often stimulates other sectors through inter-industry linkages, creating multiplier effects. The **Input–Output (I–O) framework**, developed by Leontief (1951,1973), provides a systematic way to measure these linkages. This study aims at measuring 6 different types of linkages along with the computation of equilibrium level of output and conducting a comparative static analysis2 using following steps:

a) Basic Open Input-Output Model for Determining equilibrium level of Output

$$X^* = [I-A]^{-1}F \text{……(1)}$$

Provided the Hawkins-Simon condition is satisfied. [Hawkins D and Simon H A (1949)].

Where,

[2] Conducted using an exogeneous increase in final demand by 10% and examining its growth implications on equilibrium level of output.

- $[I-A]^{-1}$ is the Leontief inverse matrix.
- The elements of $[I-A]^{-1}$ represents the direct or indirect requirement of the output of sector i for the production of one unit of the output of sector j.

b) Performing a comparative static Analysis

Here the effects of an exogenous P% rise in the final demand of each sector independently on the equilibrium level of output is obtained using comparative static framework. The "new final demand vector" is pre-multiplied by the $[I-A]^{-1}$ matrix to get the "new equilibrium level of output".
Symbolically,

$$X_i^* = [I-A]^{-1}\tilde{F} \ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where, X*, is the "new equilibrium output vector" and; $\tilde{F} = (1+\Theta)F$ is the "new final demand vector" and the Θ is a "given change in the final demand for output" of the j^{th} sector.

Accordingly, different level of output vectors $\{\hat{x}_1, \hat{x}_2 \ldots\ldots \hat{x}_m\}$ is generated. Maximum of gross value of output (GVO) among these sectors can be represented as

$$\hat{\hat{X}} = \{\hat{x}_1, \hat{x}_2, \hat{x}_3, \hat{x}_4, \hat{x}_5, \hat{x}_6, \hat{x}_7, \hat{x}_8, \hat{x}_9, \hat{x}_{10}, \hat{x}_{11}, \hat{x}_{12}, \hat{x}_{13} \ldots\ldots\ldots, \hat{x}_m\} \ldots\ldots \text{(3)}$$

Where, $\hat{x}_1 = \sum_{I=1}^{24} X_i$ and so on. (Here, m=24)

Once the "new equilibrium level of output" is obtained, it is possible to compare the original level of output with that of the new level of output both at the sectoral level as well as at the national level. In fact, this kind of simulation analysis is useful for planning and targeting sectors to induce economic development.

c) Understanding Inter-industry linkages

Understanding the inherent capability of various economic sectors becomes easier when looked using the lens of the interindustry links. Through its interindustry ties, one sector may boost the economic activity of other sectors apart from having a multiplier effect on growth. Therefore, high-linkage industries should be the main focus of a country's growth strategy. The data in the basic "input-output matrix" could be used to calculate different linkage effects. Intermediate inputs are represented as a percentage of total input, including value added, by the input coefficient represented by the symbol a_{ji}. The inter-industry linkages are useful to understand the **inducement capacity** inherent in different sector of the economy.

The "***input coefficient matrix***" **(A)** shows how much input from one sector is required to produce output in another. The **column sum of A** reflects **direct backward linkages**, i.e., a sector's dependence on inputs from others. When indirect effects are included through the **Leontief inverse** $\mathbf{(I-A)^{-1}}$, we obtain **total backward linkages**, capturing the chain of input requirements across the economy.

On the other hand, **forward linkages** measure how a sector's output supports other sectors. Jones (1976) proposed the "**output coefficient matrix" (B)**, where the **row sum of B**

represents **direct forward linkages**—the extent to which a sector supplies to other industries. Further. the **output inverse matrix $(I-B)^{-1}$** yields **total forward linkages**, incorporating both direct and indirect sales.

Thus, six measures emerge: direct and total backward linkages, direct and total forward linkages, which can be expressed mathematically as follows:

Direct Backward Linkages: [**L*B≡1'A .....(4)]**
Direct and Indirect Backward Linkage vector: [**LB≡1'Z.....(5)]**
Indirect Backward Linkage: [**LB(I) = LB-L*B…….(6)]**
Direct Forward Linkages: [**L*F≡ B1…… …….(7)]**
Direct and Indirect Forward Linkages: [**LF ≡W1 ..... (8)**]
Indirect Forward Linkages: [**FL(I)= LF-L*F…….(9)]**

The Leontief (1951,1973) approach states that "the increase in output of the ith industry" for supplying input needed for a "unit of final demand in the j^{th} industry" is the element of the A matrix. However, the element of the B matrix in the output coefficient matrix b_{ij} indicates the increase in the j^{th} industry's output needed to use the increased output that a unit of primary input into the i^{th} sector brings about.

1.5 Results and Findings

It is evident from the basic input Output table of India (2007-08) that the Education and research sector uses the output of 48 different sectors as input in its own production process other than its own output. However, the top 5 sector's outputs that are used as input by Education and Research is presented in table 1.

Table 1: Major Sectors whose output is used as input by Education and Research

Sectors	output of different sectors used as input in Education and research (in Rs. Lakh)	% of input used by education and research
Land tpt including via pipeline	553653	29.07
Banking	344921	18.11
Hotels and restaurants	240346	12.62
Construction	203872	10.71
Education and Research	109114	5.73

Source: Input-Output table of India [CSO-2007-08]

In fact, Sector like Land tpt including via pipe line uses software developed by research institutions to monitor flow, employs engineers trained in universities, implements safety protocols based on academic studies and son on. Similarly, banking sector requires knowledge and innovation, skilled human resources, Analytical tools and models and technology that are provided by the education and research sector. The Skilled manpower, knowledge of hospitality management, food science and nutrition research and technology service innovations are the major requirements of hotels and restaurant industry that are supplied by the education and research sector. Similarly, Construction Skilled professionals, technical knowledge and innovation, safety and environmental standards etc.) Finally, Education and research sector also needs the output of Education and research sector as inputs in their production process as it requires knowledge, skilled human capital along with research findings and innovations.

Similarly, the output of research and education is being used as inputs in 35 different sectors. However, 6 sectors alone use more than 95 percent of the output of Education and research sector as input in the production of their respective goods and services as per the details provided in table 2 below.

Table 2: Output of Education and research: Used as inputs in different sectors

Sectors	Total output of education and research used as input in different sectors (in Rs. Lakh)	% of total output of education and research used as input in different sectors
Computer & related activities	623268	59.88
Education and research	109114	10.48
Coal and lignite	98362	9.45
Communication	79324	7.62
Medical and health	44909	4.31
Air transport	42609	4.09

Source: Input-Output table of India [CSO-2007-08]

Form input-output table of 2007-08 it is evident that only 37 percent of the sectors i.e 48 out of 130 sectors uses the output of education and research as input in their production process. On the other hand, education and research uses the output of 31 sectors (24 percent of the sector's) as input in its production process. This, indicates the existence of scope for the expansion of education and research sector in India.

1.6 Input-output analysis: Empirical Findings

Table 3 provides the equilibrium output using simple I-O framework

Table 3: Equilibrium Output

SL	SECTORS	EQUILIBRUM OUTPUT	SL	SECTORS	EQUILIBRIUM OUTPUT
1	TRADE	89574651.48	13	VEGETABELES	8622091.38
2	CONSTRUCTION	111945234.3	14	HOTELSAND RESTAURANTS	23749417.25
3	OWNERSHIPOF DWELLINGS	25039215.55	15	OTHERS CROPS	11082556.87
4	PUBLIC ADMINISTRATION	23499199.92	16	MEDICALAND HEALTH	11693541.78
5	LAND TPT INCLUDING VIAPIPELINE	60093940.54	17	WHEAT	10928648.52
6	BANKING	24541659.86	18	ELECTRICITY	17207496.17
7	EDUCATION AND RESEARCH	18599111.62	19	COMMUNICATION	8851413.975
8	COMPUTER$RELATED ACTIVITIES	17995392.51	20	FRUITS	6669977.973
9	MILK AND MILK PRODUCTS	16527573.5	21	PETROLEUM PRODUCTS	42069520.72
10	PADDY	19279328.77	22	IRON, STEELAND FERRO ALLOYS	22384506.09
11	O.COM, SOCIAL& PERSONAL SERVICES	10885586.87	23	INSURANCE	6130844.872
12	FORESTRY AND LOGGING	10563627.67	24	OTHERS SECTORS	374402022.7

Source: The equilibrium output obtained using equation 2.

The monetary contributions in terms of the Gross Value Added (GVA) are listed in the table 3. Top Contributor: with ₹. 89,574,651.48/-, the trade sector is the one that contributes the most to the national income. **Education and research Sector:** Contributes ₹ **18599111.62**, placing it in **seventh place** in terms of GVA.

Construction, Ownership of Dwellings, Public administration, Land TPT Including VIA Pipeline and Banking sectors are among others who uses

Table 4: Equilibrium Output After 10 Percent Increase in Exogeneous Demand

SL	SECTORS	EQUILIBRIUM OUTOUT	SL	SECTORS	EQUILIBRIUM OUTPUT
1	TRADE	89561195.63	13	VEGETABELES	8621909.008
2	CONSTRUCTION	111945508.7	14	HOTELSAND RESTAURANTS	23743548.02
3	OWNERSHIPOF DWELLINGS	25039215.55	15	OTHERS CROPS	11080844.31
4	PUBLIC ADMINISTRATION	23499199.92	16	MEDICALAND HEALTH	11693545.75
5	LANDTPTINCLUDINGVIA PIPELINE	60062731.11	17	WHEAT	10928271.71
6	BANKING	25222316.73	18	ELECTRICITY	17213398.09
7	EDUCATIONAND RESEARCH	18599130.1	19	COMMUNICATION	8865027.264
8	COMPUTER&RELATED ACTIVITIES	17993321.2	20	FRUITS	6669362.587
9	MILK AND MILK PRODUCTS	16526910.85	21	PETROLEUM PRODUCTS	42049883.53
10	PADDY	19278735.38	22	IRON, STEEL AND FERRO ALLOYS	22382472.13
11	O.COM,SOCIAL&PERSONAL SERVICES	10886145.6	23	INSURANCE	6136262.075
12	FORESTRY AND LOGGING	9634796.188	24	OTHERS SECTORS	374336879.9

Source: The equilibrium output obtained using equation 3.

Table 4 presents the revised GVA values for each sector after a 10% increase in final demand, demonstrating the new equilibrium.

This table show how a 10% increase in final demand affects the output of each sector. Top Contributors in terms of absolute increase are Trade which increased from 89,574,651.48 to 89,561,195.63, construction which increased from ₹111,945,234.3 to ₹111,945,508.**7.** The Education and research sector has registered an increase from 18599111.62 to 18599130.1 exhibiting a small positive increase of 0.0001%. It is one among the 7 sectors showing positive increase in the equilibrium level of output (with rank 7).

The other sectors are Banking [2.77 percent (rank 1)], Communication [0.15 percent (rank-2)], Insurance [0.088 percent (rank-3)], Electricity [0.034 percent (rank-4)], o.com, social & personal services, [0.005 percent (rank-5)] & construction [0.002 percent (rank-6)]. Thus, there are 6 other sectors where increase in final demand have better impact on the increase in equilibrium level of output.

In addition, 6 different types of interlinkages have been computed to understand the growth implications of "Education and Research" sector using equation 1.6 through equation 1.11. These linkages along with their ranks are presented in table 5 through table 10.

Forward Linkages

Table 5. DIRECT INDIRECT FORWARD LIKAGES

SECTORS	$[I-A]^{-1}$	RANK	SECTORS	$[I-A]^{-1}$	RANK
Others sectors	3.057632485	1	Trade	1.511494278	13
Hotels and restaurants	2.639311338	2	Iron, steel and ferro alloys	1.4998889	14
Petroleum products	2.519774891	3	Insurance	1.470652216	15
Education and research	2.422089861	4	Public administration	1.424413919	16
Ownershipof dwellings	2.414350391	5	Milk and milk products	1.408850046	17
Other crops	2.394703475	6	Communication	1.342433556	18
Paddy	2.373048846	7	Forestry and logging	1.317938007	19
O.com, social & personal Services	2.317113721	8	Banking	1.215454038	20
Wheat	1.868430313	9	Computer & related activities	1.190084658	21
Land tpt including via pipeline	1.863262581	10	Construction	1.17332593	22
Medical and health	1.80911556	11	Fruits	1.103154486	23
Electricity	1.565883539	12	Vegetables	1	24

Source: Computed using equation 8

The table 5 ranks economic sectors based on their forward linkages, both direct and indirect. It measures the extent to which a sector's output is used as input by other sectors, with higher values indicating greater influence. Here Education and research **ranks-4.**

Table 6: DIRECT FORWARD LINKAGE

SECTORS	$[I-A]^{-1}$	RANK	SECTORS	$[I-A]^{-1}$	RANK
Public administration	1	1	**Computer & related activities**	0.743253025	13
Ownershipof dwellings	0.953967432	2	**Other crops**	0.641283096	14
Fruits	0.916196803	3	**Medical and health**	0.631833733	15
Vegetables	0.909697946	4	**Wheat**	0.582936565	16
Education and research	0.897590626	5	**Land tpt including via pipeline**	0.432026799	17
Forestry and logging	0.854098998	6	**Paddy**	0.421828727	18
Banking	0.840168409	7	**Electricity**	0.410439709	19
Trade	0.807329002	8	**Construction**	0.382405278	20
Milk and milk products	0.778518788	9	**others sectors**	0.335879571	21
O.com, social & personal services	0.778427714	10	**Hotels and restaurants**	0.331769861	22
Insurance	0.770452566	11	**Iron, steel and ferroalloy**	0.286837255	23
Communication	0.762601188	12	**Petroleum products**	0.181139066	24

Source: Computed using Equation 9

The table 6 ranks sectors based on direct forward linkages, indicating how much of a sector's output is directly used by other sectors. Here Education and research ranks 4.

Table 7: INDIRECT FORWARDLINKAGES

SECTORS	$[I-A]^{-1}$	RANK	SECTORS	$[I-A]^{-1}$	RANK
Petroleum products	2.876493	1	**Computer& related activities**	0.768241	13
Iron,steeland ferro alloys	2.352474	2	**Insurance**	0.729436	14
others sectors	2.183895	3	**O.com, social & personal services**	0.692225	15
Hotels and restaurants	2.062934	4	**Milk and milk products**	0.630331	16
Construction	2.031945	5	**Trade**	0.617085	17

Land tpt including via pipeline	1.990063	6	**Forestry and logging**	0.488335	18
Electricity	1.962609	7	**Banking**	0.47777	19
Paddy	1.895285	8	**Education and research**	0.317863	20
Wheat	1.280326	9	**Vegetables**	0.280387	21
Medical and health	1.236597	10	**Fruits**	0.257129	22
Other crops	1.167832	11	**Ownershipof dwellings**	0.149187	23
Communication	0.803282	12	**Public administration**	0	24

Source: Computed using 9

The table 7 shows the strength of forward linkages between various economic sectors. It ranks sectors based on their forward linkage values, with petroleum products having the strongest linkages. Iron, steel, and ferro alloys have the highest linkages, while other sectors have the lowest. Public administration and ownership of dwellings have weakest linkages, while electricity, paddy, and medical and health have moderate levels. This analysis aids in economic planning and policy-making, suggesting high forward linkage sectors as potential investment targets.

Backward Linkages

Table 8: DIRECT BACKWARD LINKAGE

SECTORS	$[I-A]^{-1}$	RANK	SECTORS	$[I-A]^{-1}$	RANK
Public administration	1	1	Computer & related activities	**0.819943006**	13
Ownership of dwellings	0.983897756	2	Banking	**0.81026374**	14
Fruits	0.975457098	3	Petroleum products	**0.80459753**	15
Vegetables	0.972508112	4	Iron, steel and ferro alloys	**0.792941554**	16
Forestry and logging	0.966289804	5	Wheat	**0.773241001**	17
Communication	0.965148644	6	Electricity	**0.71773968**	18
Education and research	0.942688925	7	Paddy	**0.592507764**	19

Insurance	0.935647094	8	Trade	**0.538115716**	20
O.com, social & personal services	0.932001678	9	Hotels and restaurants	**0.534237863**	21
Medical and health	0.918711515	10	Land tpt including via pipeline	**0.118334509**	22
Other crops	0.881013974	11	Construction	**-0.249096902**	23
Milk and milk products	0.83548811	12	others sectors	**-3.623254525**	24

Source: Computed using equation 4

The table 8 evaluates the dependence of different sectors on other sectors for inputs, assessing their connection to upstream suppliers in the economy. The backward linkage coefficient, I-A, indicates how much input a sector requires from others. Sectors with high I-A values are heavily dependent on other industries, while those with low I-A values are net-output-focused or have low input needs. Moderate linkage sectors have average reliance on inputs from other industries.

Table 9: DIRECT & INDIRECT BACKWARD LINKAGE

SECTORS	$[I-A]^{-1}$	RANK	SECTORS	$[I-A]^{-1}$	RANK
others sectors	11.91269641	1	**O.com, social & personal services**	1.235587655	13
Ownership of dwellings	3.953169873	2	**Petroleum products**	1.232745959	14
Forestry and logging	2.784170527	3	**Iron, steel and ferro alloys**	1.202809235	15
Hotels and restaurants	2.176649985	4	**Other crops**	1.123684826	16
Public administration	1.889235035	5	**Education and research**	1.103093538	17
Banking	1.84011346	6	**Construction**	1.099150708	18
Medical and health	1.780719165	7	**Paddy**	1.090971136	19
Land tpt including via pipeline	1.605735495	8	**Milk and milk products**	1.071171032	20

Electricity	1.548467779	9	**Computer & related activities**	1.045053969	21
Wheat	1.353988118	10	**Fruits**	1.043747479	22
Insurance	1.278980771	11	**Trade**	1.036130211	23
Communication	1.275310737	12	**Vegetables**	1	24

Source: Computed using equation 5

The table 9 analyzes the backward linkage effects of different economic sectors using their I-A inverse values. The highest backward linkage is found in "Others sectors", indicating the most reliance on inputs from other sectors. The lowest backward linkage is found in "Vegetables", indicating the least dependence. Sectors like "Ownership of dwellings", "Forestry and logging", and "Hotels and restaurants" also show high interdependence.

Under this category Education and Research has 17th Rank.

Table 10. INDIRECT BACKWARD LINKAGES

SECTORS	$[I-A]^{-1}$	RANK	SECTORS	$[I-A]^{-1}$	RANK
others sectors	15.53595093	1	**Milk and milk products**	0.400099545	13
Construction	4.202266775	2	**Other crops**	0.351731985	14
Land tpt including via pipeline	2.665836018	3	**Medical and health**	0.28409772	15
Petroleum products	1.372052456	4	**O.com, social & personal services**	0.191683148	16
Trade	1.351119319	5	**Insurance**	0.163503614	17
Hotels and restaurants	1.305875596	6	**Education and research**	0.160404613	18
Paddy	1.188211401	7	**Communication**	0.125822492	19
Electricity	0.830728099	8	**Forestry and logging**	0.104881228	20
Iron, steel and ferro alloys	0.812793941	9	**Vegetables**	0.072545856	21
Wheat	0.580747116	10	**Fruits**	0.060673112	22
Banking	0.465046998	11	**Ownership of dwellings**	0.059849723	23
Computer & related activities	0.459037765	12	**Public administration**	0	24

Source: Computed using equation 6

The Education and Research Sector has 18th Rank in terms of indirect backward linkages.

The table 10 provides indirect backward linkages across various sectors, highlighting the economy's interconnection. It lists sectors like "others sectors," "construction," and "land transport including via pipeline." The table calculates the indirect backward linkage for each sector and ranks them. The highest backward linkage is found in "others sectors," while "public administration" has the least. Sectors like construction, land transport, and petroleum products also show high backward linkages, while others have low level of backward linkages.

We conclude that the equilibrium output values for 24 economic sectors, indicating the output level where supply equals demand. Sectors like Trade, Construction, and Public Administration show high output, indicating significant economic contribution. Other sectors, like Fruits and Vegetables, have lower outputs, indicating smaller scale activities. This data helps analyze sectoral performance, guide resource allocation, and predict economic trends. The table also shows the new equilibrium output for 24 economic sectors after a 10% increase in final demand. Key sectors like Trade, Construction, Banking, and Electricity exhibit noticeable growth, reflecting the economy's responsiveness. The table shows Direct and Indirect Forward Linkages across 24 economic sectors, measured using the Leontief inverse. Higher values indicate stronger forward linkages, meaning the sector significantly contributes to downstream production. Public Administration ranks highest, followed by "Ownership of Dwellings," "Fruits," and "Vegetables," suggesting their outputs are widely used across industries. The table also shows Direct Backward Linkages, indicating their reliance on inputs from other sectors. Public Administration ranks highest, followed by "Ownership of Dwellings" and "Fruits," reflecting their high dependency on other sectors. The analysis helps identify sectors with broad economic influence through input demand, guiding policymakers in prioritizing sectors for development and investment. Education and research have low backward linkage of 18.

1.7 Conclusion

The education and research sector in India emerges as both a vital social service and an economic driver, ranking seventh in equilibrium output and contributing significantly to Gross Value Added (GVA). The sector’s stronger forward linkages highlight its role in supplying essential knowledge, skills, and human capital that stimulate productivity, innovation, and structural transformation across industries. However, its relatively weaker backward linkages indicate limited demand generation for upstream sectors, emphasizing the need for stronger integration through research–industry collaborations, skill-based education, and technology transfer. The equilibrium analysis further confirms that investment in education and research yields multiplier effects on national output, underlining its strategic importance in driving growth. In alignment with Sustainable Development Goal-4 (SDG-4), prioritizing digital education, robust research infrastructure, and academia–industry partnerships will ensure the sector evolves as both a foundation for human development and a catalyst for India’s future economic competitiveness.

The paper contributes to the existing literature by moving beyond the conventional view of education as a purely social service and positioning it as an economic driver within the input–output framework. By applying sectoral linkage analysis to the education and research sector in India, it provides empirical evidence of its structural role in the economy, highlighting strong

forward linkages in knowledge and skill creation but relatively weak backward linkages in input demand. This dual insight enriches the understanding of how education fosters productivity, innovation, and structural transformation across industries. Furthermore, by linking its findings to Sustainable Development Goal-4, the study adds global policy relevance, showing how educational investment can yield multiplier effects on growth and inclusivity. Finally, the paper expands the knowledge base by proposing pathways for academia–industry integration, digital transformation, and skill-oriented education as future directions for strengthening the sector's economic impact.

1.8 Policy Implications

1) Strengthen research–industry collaboration to enhance backward linkages.
2) Expand digital education infrastructure to reduce disparities and increase reach.
3) Prioritize skill-based training aligned with labor market demands.
4) Enhance funding for research institutions to foster innovation.
5) Align national policies (NEP 2020, Digital India) with global frameworks like SDG-4 for inclusive growth.

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