Korea and the World Economy
Vol. 26, No. 3 (December 2025) 257-274
https://doi.org/10.46665/kwe.2025.12.26.3.257

Assessing the Economic and Environmental Effects of CCS in China: An Applied Extended Input-output Analysis*

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This study examines the economic and environmental effects of deploying carbon capture and storage (CCS) in China using an extended input-output (IO) framework. A balanced 35-sector IO table is constructed to explicitly incorporate CO_2 capture, transportation, and storage activities. Based on sector-specific operating costs and projected CO_2 storage volumes, the analysis evaluates changes in production, CO_2 emissions, and prices over the period 2030-2060. The results indicate that CCS deployment generates substantial production spillovers due to its intensive demand for intermediate inputs, with induced output effects peaking at approximately 1.13 trillion yuan in 2050. CCS also delivers significant net emission reductions, as the decline in CO_2 emissions from the electricity and heat supply sector more than offsets the upstream emission increases associated with CCS operations. By 2060, net CO_2 emissions are reduced by about 2.48 billion tons. While CCS deployment raises electricity prices — resulting in a cumulative increase of 13.4 percent by 2060 — and disproportionately affects energy-intensive and materials-producing sectors, the aggregate price effects remain modest, ranging from 0.1 to 0.9 percent. Overall, the findings underscore the role of CCS as a key decarbonization option and highlight the importance of complementary policy measures to alleviate cost pressures and facilitate its integration into China's long-term carbon neutrality strategy.

JEL Classification: Q54, C67
Keywords: China, carbon capture and storage (CCS), input-output analysis, CO_2 emission, economic impacts, decarbonization policy

* This work was supported by a grant-in-aid of the Uruma Fund for the Promotion of Science.
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1. INTRODUCTION

China is currently the world's largest emitter of carbon dioxide (CO_2), accounting for more than 30% of global emissions in 2024. Despite recent efforts to slow emission growth,[1] the country continues to face substantial decarbonization challenges due to its coal-dominated energy structure and manufacturing-led industrial base. In line with its international climate commitments, China pledged at the 2015 Paris Agreement to peak carbon emissions by 2030 and reduce CO_2 intensity by around 60% as part of its Nationally Determined Contribution (NDC).[2] This commitment was reinforced in president Xi Jinping's 2020 announcement of achieving carbon neutrality by 2060, now widely known as the "30-60 target.[3]" Major policy documents — including the *Opinions on the Complete, Accurate and Comprehensive Implementation of Carbon Peaking and Carbon Neutrality* and the *Action Plan for Carbon Peaking by 2030* — further indicate the government's determination to pursue a long-term decarbonization pathway.[4]

Achieving these targets requires not only reducing emissions at their source but also deploying end-of-pipe mitigation technologies capable of addressing residual emissions. Among these options, carbon capture and storage (CCS) has emerged as a critical measure. CCS prevents CO_2 from entering the atmosphere by capturing emissions from industrial and power-generation facilities, transporting them to suitable sites, and storing them underground. According to the IPCC Sixth Assessment Report, the remaining global carbon budget consistent with the 2°C target is rapidly diminishing; at current emission levels, it would be exhausted within two decades. Under such constraints, large-scale deployment of CCS is widely regarded as indispensable.

The International Energy Agency (IEA) likewise underscores the importance of CCS in global mitigation pathways, estimating that annual CO_2 capture must expand to approximately 1.67 Gt by 2030 and 7.6 Gt by 2050 to achieve net-zero emissions.[5] While power generation and fossil-fuel-based industries remain the primary capture sectors, emerging technologies such as direct air capture (DAC) are expected to play an increasingly significant role by mid-century. These projections highlight CCS as a transitional technology essential for maintaining energy security while advancing deep decarbonization.

In China, CCS has gained strategic relevance due to the country's high reliance on coal and energy-intensive industries.[6] Recent large-scale demonstration projects span the oil, gas, chemical, and power sectors. China's CCS capacity is projected to reach 24 Mt by 2025, 60-150 Mt by 2030, and more than 2 Gt by 2060 — equivalent to 10-20% of current

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[1] According to the GCP Tsukuba International office (2024), China's CO_2 emissions in 2024 will account for 32% of the world's total, followed by the United States, whose CO_2 emissions will account for 13% of the world's total.

[2] For details, please refer to the Central Government of China (2021).

[3] In this study, the "30-60 target" denotes China's dual-carbon policy, under which carbon emissions are expected to peak by 2030 and reach carbon neutrality by 2060.

[4] For details, please refer to the State Council of China (2021).

[5] IEA (2021), IEA has published its forecast for CO_2 captured by sector in the world in its "Net Zero Emissions Scenario."

[6] In China, the term CCUS is often used, which also considers the effective use of captured carbon dioxide, but in this paper, CCS and CCUS will be referred to collectively as CCS.

national CO_2 emissions (Zhang and Yang, 2023). These trends suggest that CCS will play a non-negligible role in supporting China's long-term carbon neutrality agenda.

Despite rapid technological progress, most existing research focuses on engineering assessments, cost analysis, or project-level environmental impacts, while comparatively few studies investigate the broader economy-wide implications of CCS deployment. Macro-level analyses are crucial for understanding how CCS affects industrial structure, economic output, and national mitigation costs — information essential for designing long-term energy and climate policies.

To address this gap, this study incorporates detailed CCS technological information into China's 2020 input-output (IO) framework and evaluates the economic and environmental effects of CCS deployment. The primary contribution of this study lies in its modeling approach, which explicitly embeds CCS activities — capture, transport, and storage — as separate intermediate sectors within a fully balanced national input-output table. This framework allows CCS to be treated strictly as an intermediate input to the electricity and heat supply sector, thereby improving economic realism and avoiding the overstatement of production effects commonly observed in existing CGE- and IO-based studies. Specifically, the analysis quantifies both the CO_2 reductions achieved through CCS and the associated economic burdens under alternative mitigation configurations. By integrating CCS into a macroeconomic accounting structure, the study provides a comprehensive assessment of the role of CCS in China's transition toward carbon neutrality.

This paper extends our preliminary analysis presented in Ye and Fujikawa (2026) by constructing a fully balanced CCS-extended input-output table and generating more robust estimates of the economy-wide impacts of CCS deployment in China. While this study focuses on China, the proposed CCS-extended input-output framework is readily applicable to other East Asian economies with similar energy structures, such as coal-dependent power systems and emerging CCS deployment pathways.

2. LITERATURE REVIEW

2.1. Economic Evaluations of CCS Technologies

Research on CCS has developed rapidly, particularly regarding its technical feasibility and cost structure. Many studies consistently find that CO_2 capture accounts for 60-80% of the total CCS cost, making it the most cost-intensive stage (Hao *et al.*, 2019; Guo and Huang, 2020). Using Carbon Emission Pinch Analysis, Ramsook *et al.* (2023) demonstrated that improvements in capture rate and system integration can reduce total CCS cost by 20-35%, indicating strong cost sensitivity to process optimization.

In China, economic feasibility is highly dependent on carbon pricing and industrial deployment. Zhou *et al.* (2024) estimated that CCS investment in coal-fired power plants becomes economically viable when the carbon price exceeds 80-150 CNY/t-CO_2. Based on projected CO_2 injection volumes, Cai *et al.* (2021) and Zhang and Yang (2023) estimated total CCS chain expenditures to reach 83.8 billion CNY by 2030, increasing to 651.1 billion CNY by 2050. As learning effects accumulate, the average CCS cost is expected to fall from 570 CNY/t in 2030 to 255 CNY/t by 2060, nearly a 55% reduction.

Internationally, full-chain CCS economics has been studied across multiple countries. Japan's Ministry of the Environment (2014) provides a lifecycle assessment covering capture, liquefaction, ship transport, injection, and monitoring, highlighting substantial cost variations across transport distance and storage conditions. Economic evaluation models developed by Yanagi (2019) and RITE (2021) further assess CCS within Japan's long-term mitigation pathways, illustrating its potential to minimize system-wide abatement costs under stringent decarbonization scenarios.

Overall, the literature indicates that although CCS offers significant mitigation potential, it remains highly cost intensive. Most economic evaluations focus on specific facilities or sectors, offering limited insights into broader economy-wide implications. This highlights the need for analytical frameworks capable of assessing CCS within national economic structures.

2.2. CCS within Macroeconomic and Energy System Models

Compared with project-level analyses, a smaller yet expanding stream of research incorporates CCS into macroeconomic and multi-sector modelling. Using a dynamic GTAP framework, Chen and Jiang (2022) and Turner *et al.* (2024) conclude that CCS can alleviate production constraints and enhance GDP and employment under carbon mitigation policies. Hu and Wu (2023), embedding CCS cost curves into a CGE model, show that the marginal abatement cost in 2060 drops from 1,211 yuan/ton to 557 yuan/ton when CCS becomes available — illustrating its systemic role in reducing mitigation cost burdens.

Other studies explore interactions between CCS and broader energy-transition strategies. Li *et al.* (2017) examine synergies between electric vehicles and CCS in China, finding CCS increasingly indispensable in deep-decarbonization scenarios where residual industrial emissions persist. Vennemo *et al.* (2014) analyze CCS within a China-specific CGE model and conclude that, while CCS facilitates compliance with stringent climate constraints, it may negatively affect long-term GDP unless accompanied by institutional reforms or external financing.

Input-output approaches also shed light on CCS's economy-wide effects. IO-based analyses of CCS deployment in China's power sector show that CCS generates positive employment and value-added effects through interindustry linkages, although higher electricity prices are inevitable (Jiang *et al.*, 2019). Liu *et al.* (2025), examining CO_2-EOR deployment through IO models, further demonstrate this framework's suitability for tracing sectoral interactions.

In Japan, macro-level assessments by RITE (2021) and Yanagi (2019) evaluate CCS's economic feasibility under long-term decarbonization scenarios, finding that CCS becomes cost-effective once emission reductions exceed levels achievable solely through efficiency improvements and renewable energy. However, such findings cannot be directly transferred to China due to fundamental differences in industrial structure and energy dependence.

In sum, macroeconomic and IO studies indicate that CCS can play an important role in reducing national mitigation costs and supporting industrial activity. However, most models rely on simplified CCS representations and often lack detailed engineering parameters such as capture efficiency, energy penalties, transport modes, or geological storage conditions. Moreover, few studies explicitly embed CCS into national IO tables, and those that do typically focus on specific sectors. These limitations reveal the need for analytical frameworks that integrate engineering-based CCS parameters into detailed input-output structures.

2.3. Research Gaps

Despite substantial progress, several important gaps remain.

First, most techno-economic analyses evaluate individual CCS projects or sectors, which prevent them from capturing economy-wide spillover effects transmitted through interindustry linkages. As a result, indirect adjustments such as upstream input expansion, downstream cost increases, and cross-sector substitution are often overlooked.

Second, macroeconomic studies frequently adopt simplified or aggregated CCS cost assumptions that do not fully incorporate technological characteristics, including capture efficiency, auxiliary power demand, transport choices, and geological storage conditions. This disconnect reduces the accuracy and policy relevance of long-term mitigation assessments.

Third, only a limited number of studies explicitly integrate CCS into national input-output tables. Existing IO based analyses generally focus on partial outcomes such as employment or value-added effects in the power sector without providing a comprehensive national-level evaluation of both the economic and environmental implications of CCS. Moreover, few studies use detailed CCS cost structures derived from engineering-based sources such as the *China CCUS Annual Reports* or RITE's economic evaluation models.

These gaps highlight the need for an analytical framework that links engineering-based CCS parameters with an economy-wide modeling structure. This study directly addresses these gaps by integrating engineering-based CCS cost and performance parameters into a CCS-extended national input-output framework, enabling a consistent evaluation of both economy-wide economic impacts and CO_2 mitigation effects under realistic technological constraints. Addressing this need requires modifying input-output tables to incorporate CCS technologies explicitly, allowing simultaneous evaluation of their CO_2 reduction potential and macroeconomic impacts under realistic technological constraints.

3. METHODOLOGY AND DATA CONSTRUCTION

This section describes the analytical framework used to evaluate the economy-wide effects of CCS deployment in China. The analysis proceeds in two steps. First, an input-output model is developed to assess changes in production, CO_2 emissions, and prices resulting from the introduction of CCS. Second, a CCS-extended IO table is constructed by integrating technical and cost parameters for CO_2 capture, transport, and storage, enabling the implementation of the analytical model.

3.1. Analytical Model

This study builds on the preliminary version of our CCS-input-output analysis developed in Ye and Fujikawa (2026). In that earlier work, the construction of the CCS-extended input-output table was limited to adjusting the input coefficients of the newly created CCS sectors, without performing a systematic balancing of the entire input-output matrix. As a result, row and column totals were not reconciled, and the numerical results presented there should be regarded as provisional and indicative rather than fully consistent.

This paper substantially improves upon that preliminary analysis by constructing a fully balanced CCS-extended input-output table for China's 2020 economy. Through a complete reconciliation of row and column sums and a consistent integration of CCS-related intermediate transactions, the updated table ensures internal accounting coherence and provides a more reliable empirical foundation for estimating both the economic ripple effects and the CO_2 emission reduction effects of CCS deployment. This methodological enhancement allows for a more rigorous assessment of CCS as part of China's long-term decarbonization strategy.

3.1.1. Production effects of CCS

Let x denote the production vector, A the matrix of input coefficients, and f the final demand vector. The standard Leontief equilibrium production system is expressed as:

$$x_0 = [I - A_0]^{-1} f \; . \tag{1}$$

To assess the impact of CCS, we extend the IO table by adding three CCS sub-sectors: CO_2 capture, CO_2 transport, and CO_2 storage. These sectors supply intermediate services to the electricity and heat supply sector, and in turn require intermediate inputs from energy, machinery, and construction-related industries.

When CCS is deployed, the equilibrium production system becomes:

$$\begin{bmatrix} x_1 \\ x_c \end{bmatrix} = \begin{bmatrix} I - A_1 & -a_{1c} \\ -a_{c1} & I \end{bmatrix}^{-1} \begin{bmatrix} f \\ 0 \end{bmatrix} \; . \tag{2}$$

Where:
x_1: productions of existing industries after CCS adoption
x_c: productions of CCS sub-sectors
a_{1c}: input coefficient from CCS to existing industries
a_{c1}: inputs from existing industries to CCS

Comparing equations (1) and (2) allows the estimation of economic ripple effects from CCS-induced structural adjustments.

3.1.2. CO_2 emissions effects of CCS

Let e denote the vector of CO_2 emission coefficients for each industry. Total emissions prior to CCS adoption are:

$$g_0 = \hat{e}x_0 = \hat{e}[I - A_0]^{-1}f \ . \tag{3}$$

The CCS sectors are assumed to emit no CO_2 directly, and the emission coefficient of the electricity and heat supply decreases after CCS deployment.

Post CCS emissions are given by:

$$\begin{bmatrix} g_1 \\ 0 \end{bmatrix} = \begin{bmatrix} \hat{e} & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} I - A_1 & -a_{1c} \\ -a_{c1} & I \end{bmatrix}^{-1} \begin{bmatrix} f \\ 0 \end{bmatrix} . \tag{4}$$

Comparing (3) and (4) indicates the extent to which CCS reduces CO_2 emissions across the entire economy.

3.1.3. Price effects of CCS

Let p denote the row vector of product prices and v the row vector of value-added rates. The standard price model is:

$$p_0 = v[I - A]^{-1} \ . \tag{5}$$

In this analysis, CCS influences output prices through changes in the value-added rate of the electricity and heat supply sector. CCS sector prices are treated as exogenous, reflecting their regulated or cost-based nature in early-stage deployment.

The equilibrium prices after CCS adoption are:

$$p_1 = [v + a_{c1}][I - A]^{-1} \ . \tag{6}$$

Comparing (5) and (6) reveals the degree to which CCS raises sectoral prices and, ultimately, the burden borne by the wider economy.

3.2. Construction of the CCS-Extended Input-output Table

To evaluate the economic and environmental impacts of CCS, it is necessary to construct an input-output table that explicitly incorporates CCS activities. Since no official IO tables currently include CCS as a distinct set of sectors, this study reconstructs China's 2020 IO table by adding three CCS-related sectors — CO_2 capture, CO_2 transport, and CO_2 storage — using engineering and cost information from China's CCUS Annual Reports (Cai *et al.*, 2021; Zhang and Yang, 2023) and the economic evaluation models developed by RITE (2021). These sources provide unit costs, projected storage volumes, and detailed process-level cost structures that enable us to embed CCS consistently within the IO framework.

3.2.1. Estimation of CCS operating costs

Before creating the CCS-extended IO table, we first estimate the operating costs associated with the three CCS processes: capture, transportation, and storage. The analysis focuses on operating costs only and does not include capital investment.

Following Cai *et al.* (2021), unit operating costs are obtained for each process. These unit costs are then multiplied by the projected CO_2 storage volumes reported by Zhang and Yang (2023) to derive total annual operating costs. The results are summarized in Table 1. In 2030, the costs for capture, transportation, and storage are 57.3 billion yuan, 19.1 billion yuan, and 7.4 billion yuan, respectively, for a total of 83.8 billion yuan. In 2040 and 2050, total operating costs increase substantially as CCS deployment expands, reaching 448.5 billion yuan and 651.1 billion yuan, respectively. By 2060, total operating costs are 645.2 billion yuan.

Despite this increase in total expenditure, the cost per unit of CO_2 processed declines markedly over time. The unit cost falls from 570 yuan/ton in 2030 to 290 yuan/ton in 2050 and further to 255 yuan/ton in 2060, reflecting expected technological learning, efficiency gains, and economies of scale. Capture consistently accounts for the largest share of total operating costs across all years. These operating cost estimates form the quantitative basis for calibrating the CCS sectors in the IO table.

Table 1 Estimated Operating Costs for CCS in China

	Capture	Transportation	Storage	Total (bill. yuan)	Storage volume (bill. ton)	Cost per unit (yuan/ton)
2030	57.3	19.1	7.4	83.8	0.15	570
2040	275.1	131.6	41.9	448.5	1.20	375
2050	336.8	247.0	67.4	651.1	2.25	290
2060	328.9	253.0	63.3	645.2	2.53	255

Source: Calculated by the author by multiplying the unit cost in Cai *et al.* (2021) by the storage volume in Zhang and Yang (2023).

3.2.2. Creating an input-output table incorporating CCS

Figure 1 shows the structure of the IO table after incorporating the CCS sectors. The shaded cells indicate the entries newly added in this study. We assume that CCS is introduced only in the electricity and heat supply sector, which is consistent with current deployment priorities in China. The operating costs of capture, transport, and storage estimated in Table 1 are treated as intermediate inputs from the CCS sectors to the electricity and heat supply sector.

Conversely, the CCS sectors themselves require intermediate input from existing industries. They obtain goods and services from the energy sector (petroleum products, electricity and heat supply), the general machinery industry, and the construction and civil engineering industry, among others. In this way, the CCS sectors are embedded within the existing interindustry linkage structure of the Chinese economy.

Figure 1 Template for an Input-output Table Incorporating CCS

	Industrial sector	1	2	…	29	…	36	37	38
		Agriculture	Mining	…	Electricity/ Heat supply	…	CCS / Capture	CCS / Trans	CCS / Storage
1	Agriculture								
2	Mining								
…	…								
11	Petroleum prod								
12	Chemical prod								
…	…								
29	Electricity/ heat supply								
…	…								
36	CCS / Capture	0	0	0					
37	CCS / Trans	0	0	0					
38	CCS / Storage	0	0	0					
Added value									
Production value									

Estimating the CCS input coefficient

Only electricity and heat supply sector receives input from CCS

Notes: The shaded cells include (i) intermediate inputs from CCS sectors to electricity and heat supply and (ii) intermediate inputs from existing industries to CCS sectors.
Source: Created by the author based on RITE (2021).

To determine the detailed cost structure of each CCS process, this study uses the estimates reported by RITE (2021). Table 2 presents the cost breakdown for each CCS process, showing the percentage shares of major cost categories such as energy inputs, materials, equipment, construction, operation and maintenance, and other intermediate requirements. Based on these figures, we set the input coefficients for the three CCS sectors in the IO table. Specifically, the total operating costs for each process shown in Table 1 are allocated across intermediate inputs according to the cost shares in Table 2. This procedure yields the monetary values of intermediate transactions and value-added components required for the CCS-extended IO table.

Because reliable information on labor costs for CCS operations in China is not yet available, the labor cost share for each CCS process is set at 26% of total costs, following the assumptions used in RITE (2021). Profit margins for all CCS processes are assumed to be zero. Based on these settings, the CCS-extended IO table is constructed and used for the subsequent analysis.

Table 2 Cost Breakdown of Each CCS Process

(unit: %)

No	Industrial sector	Capture	Transport	Storage	Total
2	Mining	0	0	58	5
12	Inorganic chemical industry products	16	0	0	11
21	General-purpose machinery	18	12	2	15
28	Automobile maintenance and machine repair	8	14	2	9
29	Electricity and heat supply	30	25	2	26
32	Architecture	2	23	10	7
41	Labor costs (added value)	26	26	26	26
	Total	100	100	100	100

Note: This estimation is based on a scenario where CO_2 is transported 100km via onshore tanker trucks and subsequently injected into an underground reservoir from an onshore installation.

Source: Created by the author based on RITE (2021).

4. ANALYSIS RESULTS

Below we examine the changes in production volume and CO_2 emissions that will result from the introduction of CCS, as well as the burden that the introduction of CCS (and its costs) will place on the overall economy.

4.1. Changes in Production Volume

Table 3 presents the estimated changes in production induced by the introduction of CCS for the years 2030, 2040, 2050, and 2060. Compared with the benchmark year 2020 I-O table, the introduction of CCS increases total production by 145.8 billion yuan in 2030, 780.4 billion yuan in 2040, and 1,132.8 billion yuan in 2050. In 2060, the induced production slightly decreases to 1,122.6 billion yuan. Although the volume of CO_2 storage continues to rise toward 2060, the unit operating cost of CCS declines over time, resulting in a modest reduction in the production-inducing effect between 2050 and 2060.

The sectors experiencing the largest ripple effects are those directly involved in CCS operations — namely CO_2 capture, CO_2 transport, and CO_2 storage — which consistently account for the highest induced production across all years. In addition, increased output is observed in electricity and heat supply, general-purpose machinery, chemical products, Repair of metal products, machinery and equipment, transportation equipment, and construction, reflecting the rise in intermediate demand for equipment, materials, and related services required for CCS deployment. These results show that, despite having no final demand of its own,[7] the CCS sector — introduced solely as an intermediate activity — generates substantial upstream and downstream economic ripple effects when implemented at scale.

Table 3 Production Ripple Effects of CCS Introduction (Top 10 Sectors)

(unit: billion yuan)

No	Industrial sector	2030	2040	2050	2060
36	Capture	57.3	275.1	336.8	328.9
29	Electricity and heat supply	22.1	115.8	163.4	162.6
37	Transport	19.1	131.6	247.0	253.0
21	General chemical industry products	12.5	63.9	87.3	86.4
12	Chemical products	9.2	44.0	53.9	52.6
38	Storage	7.4	41.9	67.4	63.3
28	Automobile maintenance and machine repair	6.1	32.0	45.1	44.7
23	Transport equipment	5.9	40.8	76.6	78.4
2	Mining	3.3	18.8	30.3	28.5
32	Construction	2.7	14.4	21.3	20.5
	Total	145.8	780.4	1,132.8	1,122.6

Source: Created by the author.

It should be noted that this study assumes no final demand for CCS, and only intermediate demand from the electricity and heat supply sector is introduced. This differs from RITE (2021), which treats CCS as having final demand when estimating its economic impact. Such an assumption does not reflect the actual industrial structure of CCS, whose services are not consumed directly by households or firms, and therefore tends to overestimate the resulting production effects.[8] By modeling CCS strictly as an intermediate service and by constructing a fully balanced IO table, the present study provides a more realistic estimate of the economic ripple effects associated with CCS introduction.

4.2. CO_2 Reduction Effect

Since CCS reduces the CO_2 emission coefficient of the electricity and heat supply sector, the same level of electricity output results in substantially lower emissions once CCS is introduced. Although the CCS sectors themselves are assumed not to emit CO_2 directly, their operation requires intermediate inputs from upstream industries such as general-purpose machinery, chemical products, mining, and construction. As a result, these upstream sectors experience slight increases in emissions when CCS is deployed. Table 4 summarizes the resulting changes in sectoral CO_2 emissions.

[7] The authors are fully aware that intermediate inputs required for CCS operation may indirectly stimulate final demand and increase GDP through production activities in related industries. However, for the sake of analytical simplicity, the final demand of the CCS sector is set to zero in the current model.

[8] RITE (2021) assumes the existence of final demand for CCS, although CCS activities in practice function solely as intermediate inputs. This assumption may lead to overestimation of production-inducing effects.

Table 4 Changes in CO_2 Emissions due to the Introduction of CCS (Top 10 Sectors with Increases)

(unit: million tons)

	Industrial sector	2030	2040	2050	2060
28	Repair of metal products, machinery and equipment	0.2	1.2	1.7	1.7
12	Chemical products	0.1	0.7	0.8	0.8
21	General-purpose machinery	0.0	0.2	0.3	0.2
2	Mining	0.0	0.1	0.2	0.2
11	Petroleum / coal products	0.0	0.1	0.1	0.1
23	Transportation Equipment	0.0	0.0	0.0	0.0
32	Construction	0.0	0.0	0.0	0.0
25	Electronic and Telecommunications Equipment	0.0	0.0	0.0	0.0
10	Cultural, Educational and Sports Articles	0.0	0.0	0.0	0.0
29	Electricity and heat supply	−132.5	−1,137.2	−2,186.5	−2,478.4
	Total	−132.0	−1,134.8	−2,183.3	−2,475.3

Source: Created by the author.

The electricity and heat supply sector achieves large reductions of about 130 million tons in 2030, 1.14 billion tons in 2040, 2.19 billion tons in 2050, and 2.48 billion tons in 2060. In contrast, emissions in upstream sectors such as metal product repair, chemical products, general-purpose machinery, mining, and petroleum/coal products increase only marginally, reflecting the additional intermediate inputs required for CCS operation.

Since these increases are extremely small relative to the emission reductions in electricity and heat supply, the net effect of CCS is a substantial decline in economy-wide CO_2 emissions. Thus, the results clearly confirm that CCS is an effective decarbonization policy.

4.3. Impact on Prices

The introduction of CCS substantially reduces CO_2 emissions in the electricity and heat supply sector, confirming its effectiveness as a climate mitigation measure. However, CCS also involves additional costs. Beyond the installation of CO_2 capture, compression,

Table 5 Impact of CCS on Prices (Top 10 Sectors with Price Increases)

	Industrial sector	2030	2040	2050	2060
29	Electricity and heat supply	1.0174	1.0932	1.1353	1.1341
31	Water production and supply	1.0026	1.0138	1.0200	1.0198
19	Non-ferrous metals	1.0018	1.0097	1.0140	1.0139
20	Metal products	1.0017	1.0089	1.0128	1.0127
12	Chemical products	1.0016	1.0084	1.0122	1.0121
18	Steel	1.0015	1.0082	1.0119	1.0118
17	Ceramic and stone products	1.0015	1.0081	1.0117	1.0116
14	Synthetic fibers	1.0015	1.0079	1.0115	1.0114
2	Mining	1.0012	1.0063	1.0091	1.0091
16	Plastic products	1.0011	1.0059	1.0086	1.0085
All-industry average (weighted by production value)		1.0012	1.0062	1.0090	1.0089

Note: The numbers on the table are prices set at 1 before the introduction of CCS.
Source: Created by the author.

transportation, and storage facilities, its operation requires intermediate inputs from other industries such as transportation and chemical products. This increases resource use across the economy and raises production costs relative to the pre-CCS baseline, resulting in higher prices for various industries.

In this section, we estimated the price increase rate associated with the introduction of CCS by incorporating each CCS process into China's 35- sector input-output table for 2020. However, we treated the CCS price as exogenous and used a simple method in which the added value of the electricity and heat supply sector increased by the cost of CCS (calculated using equation (6)). Table 5 shows the results (the top 10 sectors with the largest price increases). As expected, the electricity and heat supply sector which directly adopts CCS shows the highest increase, with prices rising by 13.4% in 2060. Other sectors experiencing relatively large increases include water supply, non-ferrous metals, metal products, chemical products, ceramic and stone products, and synthetic fibers industries that are energy-intensive or serve as upstream material suppliers. While some sectors show noticeable price increases between 2030 and 2060, the overall economy-wide price rise remains modest, range between 0.1 and 0.9%. This price analysis is conducted under the assumption of full cost pass-through in the electricity and heat supply sector and therefore represents an upper-bound estimate of the potential price impacts of CCS deployment. Under alternative regulatory regimes — such as partial cost pass-through, electricity price regulation, or targeted subsidies — the magnitude of price increases would likely be smaller, although the direction of the price effects is expected to remain unchanged.

Thus, although CCS provides a substantial environmental benefit through significant reductions in CO_2 emissions, it also imposes additional cost burdens on specific industries. These results suggest that future policy design must account not only for the effectiveness of emission reductions but also for the economic implications of price increases — particularly the potential pass-through of higher electricity prices and the associated risk of reduced competitiveness in energy-intensive sectors.

5. CONCLUSION

This study examined the economy-wide impacts of introducing CCS in China by incorporating CO_2 capture, transportation, and storage processes into a balanced 35-sector input-output table for 2020. The analysis focused on three dimensions: production effects, CO_2 emission reductions, and price impacts. The main findings are summarized below.

5.1. Economic Effects

CCS functions purely as an intermediate input to the electricity and heat supply sector, while its own operation requires substantial inputs from upstream industries. As a result, CCS generates notable production ripple effects across the economy. The induced production value increases from 2030 to 2050, peaking at approximately 1,133 billion yuan, before slightly declining in 2060 due to falling unit costs. The largest impacts occur in industries directly linked to CCS operations — such as general-purpose machinery, chemical products, construction, electrical machinery, and transportation — highlighting the importance of technological progress and cost reductions in these sectors.

5.2. CO_2 Reduction Effect

The introduction of CCS significantly lowers the CO_2 emission coefficient of the electricity and heat supply sector, leading to substantial reductions in emissions for the same level of electricity output. Although upstream industries supporting CCS operations generate minor additional emissions, these increases are negligible relative to the reductions achieved in electricity and heat supply. Net CO_2 reductions grow markedly over time — from about 132 million tons in 2030 to around 2.48 billion tons in 2060 — confirming that CCS is a highly effective measure for decarbonizing the economy.

5.3. Impact on Prices

CCS raises production costs in the electricity and heat supply sector, resulting in higher electricity prices and moderate price increases in related energy-intensive or material-supplying industries. By 2060, electricity and heat supply prices are projected to rise by 13.4%, while the economy-wide price increase remains modest, within 0.1-0.9% depending on the year. Although the overall macroeconomic impact is limited, the burden is concentrated in certain upstream sectors.

In conclusion, CCS offers substantial CO_2 reduction benefits but also increases costs in specific industries. Future policy design should therefore consider both dimensions ensuring that electricity prices can be appropriately passed through in downstream markets, while providing targeted support such as subsidies or cost-sharing mechanisms for CCS operators and affected industries. As CCS will play an essential role in achieving long-term carbon neutrality, comprehensive policy measures will be necessary to facilitate its deployment and mitigate associated economic burdens.

5.4. Future Challenges and Methodological Considerations

The CCS-oriented input-output table constructed in this study is based on currently available technical information and cost estimates. In particular, the input coefficients for CCS-related sectors are derived from the operating cost structures reported by RITE (2021), while the scale of CCS activities is determined using unit operating costs from Cai *et al.* (2021) and projected CO_2 storage volumes from Zhang and Yang (2023). As these data reflect operating costs only and exclude capital investment, the economic burden associated with the early stages of CCS deployment may be understated.

A key methodological contribution of this study lies in its treatment of CCS within the input-output framework. In contrast to RITE (2021), which models both capital investment and operating expenditures as increases in final demand, this study treats CCS strictly as an intermediate input to the electricity and heat supply sector. By holding final demand constant, the analysis avoids overstating economy-wide ripple effects and more accurately characterizes CCS as a production-supporting technology rather than a final-demand-driven industry. This modeling strategy enables a clearer identification of the channels through which CCS affects production structures, prices, and emissions along supply chains.

This study also explicitly quantifies CO_2 emission reductions during the operational phase of CCS deployment. The results show that emission reductions in the electricity and heat supply sector substantially exceed the relatively small indirect emission increases generated by upstream industries supporting CCS operations. This finding complements the existing literature, which often focuses on economic impacts without directly assessing net emission outcomes.

The estimated price effects should likewise be interpreted with caution. By incorporating an equilibrium price model into the input-output framework, the analysis clarifies the mechanisms through which CCS-related cost increases are transmitted across sectors. Although price increases are concentrated in electricity and heat supply and in several energy-intensive or materials-producing sectors, the aggregate price effects remain limited. Nevertheless, these sectoral concentrated impacts raise important issues related to cost pass-through, competitiveness, and distributional consequences that merit further investigation.

Several avenues for future research emerge from this analysis. First, jointly modeling the investment and operational phases of CCS deployment would allow for a more comprehensive assessment of its economic and environmental impacts over the project life cycle. Second, as more detailed and updated technical data become available, the estimation of CCS input coefficients and cost structures can be further refined. Finally, integrating the input-output framework with dynamic or general equilibrium models would help capture behavioral responses, demand adjustments, and long-term structural changes induced by large-scale CCS deployment.

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