Analyzing the changing characteristics of inter-industrial linkages and economic effects of the coal industry in China using Input-Output model.

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1. Research background and purpose of this study

Considering that moving away from dependence on coal across industrial sectors and promoting industrial structure optimization and upgrading are important aspects of achieving a low-carbon economy, it is necessary to understand the relationship between various industries and the coal industry in the national economic system and the economic effects of the coal industry on other industries in order to provide references for the formulation of future low-carbon transition policies. Through input-output analysis of the Chinese coal industry, this study quantifies its inter-industry linkages and economic effects in different periods, as well as their changing characteristics. Based on the results of these analyses, policy insights are provided for China's low-carbon transition.

2. Methods adopted

The Input-Output model (I-O model) is an analytical framework that Wassily Leontief developed in the late 1930s. It aims to create a comprehensive framework that captures the interdependence and interrelationships between different industries and sectors in an economy. This study used China's IO tables for 2005, 2010, 2015 and 2020 to conduct the IO analysis. Specifically, (1) The total input coefficient and power of dispersion index of the coal industry are calculated to comprehensively analyze the backward linkages of China's coal industry. (2) The total output coefficient and sensitivity of dispersion index of the coal industry are calculated to provide a comprehensive analysis of the forward linkage of China's coal industry. (3) The production-inducing effect and supply shortage effect of the Chinese coal industry are calculated to quantify its economic effects.

(1) Total input coefficient: $B = (I-A)^{-1} - I$; Power of dispersion index: $r_j = \dfrac{\frac{\sum_{i=1}^{n} L_{ij}}{n}}{\frac{\sum_{j=1}^{n}\sum_{i=1}^{n} L_{ij}}{n^2}}$

(2) Total output coefficient: $W = (I-R)^{-1} - I$; Sensitivity of dispersion index: $s_i = \dfrac{\frac{\sum_{j=1}^{n} L_{ij}}{n}}{\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} L_{ij}}{n^2}}$

(3) Production-inducing/ Supply shortage effect: $\Delta X_e = (I-A_e)^{-1} A_m \Delta X_m$; $\Delta X'_e = R_m \Delta X_m (I-R_e)^{-1}$

3. Key findings

(1) From an overall view, the linkages between the coal sector and other sectors and the economic effects of the coal sector have tended to weaken in recent years and both of these

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two indicators for the coal sector in 2020 are weaker than the levels in 2005.

(2) Individual sectors differ from the overall trend: **Non-metal mineral products industry** has shown an upward trend in recent years in the degree of total demand for coal industry products and the degree of influence by supply shortages in the coal industry, while these two indicators for the **construction industry** have been on an upward trend since 2005; **Electricity, heat production and supply sector** is most influenced by supply shortages in the coal industry, and this effect has shown an upward trend in recent years.

(3) A comparison of the coal production/consumption for 2005-2020 with the results of the total input/output coefficient reveals some changes in the coal industry. That is, the coal industry's technological advances and efficiency improvements in recent years have allowed it to require fewer upstream resources and services to achieve the same or higher coal production. In addition, the consumption of coal by areas beyond the production process in the downstream sectors, for example, individuals and households (especially in rural areas) use coal for cooking or heating, may be the main reason for the rebound in coal consumption in recent years.

4. Policy insights

1) Since the degree of total demand for coal in the non-metallic mineral products and construction industries and the degree of being influenced by the supply shortage in the coal industry are different from the overall trend with an upward trend in recent years and since 2005, respectively, the government should provide relevant policy support and incentives to promote technological innovation as well as green transition in these two industries to achieve industrial upgrading. 2) The government should focus on coal consumption in areas other than production activities in the downstream sectors, such as individuals and households use coal for cooking or heating in rural areas. The government should provide subsidies or incentives to promote the use of clean energy equipment and energy efficient equipment by individuals and households in rural areas. 3) Although in recent years, with the development of clean energy, the total degree of demand for coal in the electric power and heat production and supply industry has tended to weaken, it has been most influenced by the shortage of coal supply, and this effect has been on the rise in recent years. This shows that coal is still the main source of energy for the power, heat production and supply industry, and getting rid of the dependence on it cannot be done too sharply. The development of clean energy should be further encouraged, while the establishment of a comprehensive coal supply and reserve management system to ensure that the power and heat production and supply industry can respond in a timely manner when the coal supply is tight, in order to implement a steady and orderly transition measures.