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Coal endowment, resource curse, and high coal-consuming industries location: Analysis based on large-scale data

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ABSTRACT

Against the background of a long-term mismatch between coal-producing and consuming regions in China, this study analyzed the location of high coal-consuming industries and factors influencing it using large-scale data with 10,500 observed values for 25 industrial sectors. The results revealed that high coal-consuming industries in China are mainly located in the eastern coastal and northern areas and are gradually moving from south to north. An estimation of a 3-D panel data model showed that, in addition to the degree of coal abundance, capital stock, human resources, and market potentials affect the location of high coal-consuming industries. After controlling for dimensional influences, we also found that the tendency of high coal-consuming industries to locate in areas with poor coal resources can be attributed to the stronger effects of non-coal factors than coal-related ones. In addition, low coal-consuming industries prefer locating away from resource-abundant areas because of a “resource curse” in coal-producing regions, which further strengthens the mismatch between coal-producing and consuming regions. Our findings highlight the need for governments to prioritize improvements in infrastructure construction and education in western areas to steer industrial transfers.

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1. Introduction

Whether high energy-consuming industries tend to locate in areas with abundant energy endowments has been a long-standing research topic. In general, energy-intensive industries are attracted to energy-producing regions. According to [Marshall \(1890\)](#), metal industries choose or tend to be closer to mines or regions with cheap fuel resources. During the early phase of industrialization, England's steel industry prioritized areas with abundant charcoal resources. In modern society, with energies becoming easily transportable and tradable, the need for energy-intensive industries to be closer to energy-producing regions has declined. However, some empirical analyses, including [Kim \(1999\)](#), [Ellison and Glaeser \(1999\)](#), [Rosenthal and Strange \(2004\)](#), and [Michielsen \(2013\)](#), maintain that high energy-consuming industries are inclined toward energy-producing areas. Coal is an important energy resource in China that accounts for 65–70% of the nation's energy consumption structure. Using data from the China Statistical Yearbook on Energy, we calculated coal output and consumption per area for

2013 and found that coal output in western China was about 60%, whereas that for eastern areas was 8%. In addition, western areas consumed about 36% coal energy, while the eastern regions had the highest consumption level of about 40%.

The focus of this study is to decipher whether industries consider the endowment of regional coal resources during site selection. China has built several rail lines dedicated to transporting coal and more than 50% of the total railway freight volume is attributed to coal. Hence, coal transportability can reduce the tendency of high energy-consuming enterprises selecting energy-producing regions as their locations. However, there are several obstacles in China's energy transportation and bottlenecks in the process can push energy prices up. In 2010, the cost to transporting coal from Hami City to Zhengzhou City was RMB 570 yuan per ton, while the standard coal price in Hami was slightly more than RMB 200 yuan per ton. In this case, enterprises closer to energy-producing areas have a cost advantage. In addition to energy, high energy-consuming enterprises consider human and sales costs in their site selection, which can be reduced by increasing proximity to areas with abundant human resources and sales markets. Thus, this study accounts for multiple aspects when analyzing factors influencing the selection of industrial location. The present study has been triggered by certain policies published by the Chinese gov-

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ernment. For example, to control smog, the National Development and Reform Commission of China published the “Interim Measures to Reduce and Substitute Coal Consumption in Key Regions,” which restrains coal consumption in the eastern coastal provinces, except Fujian and Hainan. The measures specify the maximum consumption level for each province; for example, in Hebei Province, coal consumption in 2017 should be 40 million tons less than that in 2012. To satisfy this limit, these provinces must eliminate certain high coal-consuming industries, such as electric power, steel, cement, and coking. In 2012, the Ministry of Industry and Information Technology of China published the “Catalogue to Guide Industrial Transfer” that “supports major projects that rely on domestic energies and mineral resources to be transferred towards the central and western areas of China.” Evidently, China’s central government advocates the transfer of high energy-consuming industries from the east to west, but whether these industries have the impetus to do so is questionable. If the location of high energy-consuming industries is not affected by coal endowment, then transferring these industries solely based on policy support can be difficult. Even if such a transfer is realized, the level of efficiency is expected to be low. If coal endowments are attractive to high energy-consuming industries, then accelerating the transfer of such industries can be made feasible and the next step is to study how industrial transfers can be guided through policies.

In addition to evaluating whether high coal-consuming industries account for the degree of coal abundance, we attempt to determine whether low coal-consuming industries are squeezed out of coal-producing regions. To do so, we focus on a key economic phenomenon, a “resource curse.” A resource curse indicates a negative correlation between the degree of resource abundance and economic growth rate (Neary and van Wijnbergen, 1986; Pegg, 2010; Sachs and Warner, 1995, 1997, 2001). Existing empirical analyses have examined the relationship between resource exploitation and economic growth from the viewpoint of total quantity. However, from a structural perspective, resource abundance is not a “curse” to all industries. More specifically, it applies to low resource-consuming industries and not industries needing large resource quantities as input. In this study, we re-investigate the phenomenon of a resource curse in the context of China’s coal energy from a structural viewpoint rather than total quantity.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data and model. Section 4 presents the characteristic of China’s coal output and industrial locations and reports the empirical results. Section 5 offers concluding remarks and relevant policy implications.

2. Literature review

Numerous theories in the literature explain industrial location, with neoclassical economists emphasizing the importance of resource endowment. For example, Heckscher–Ohlin’s (H–O) model suggested that the spatial distribution of economic activities is determined by comparative advantage, including that of natural resource endowment, and thus, the location of an enterprise is contingent on exogenous factors. According to Marshall’s famous externality theory, manufacturers gather in a certain place to acquire positive externality on the basis of information spillovers, specialized input, and accessibility to skilled labor force; however, the concept of externality remains abstract. According to new economic geography (NEG), market access can bring increasing returns to scale, which in turn would attract industries to a given area (Krugman, 1990, 1991; Krugman and Venables, 1995). Economic geography theories comprise several formal propositions that suggest considerably high or low transportation costs could lead to dispersed enterprise locations. When transportation cost is within

an “appropriate” range, market access can bring increasing returns to scale and enterprises will choose to be closer to their consumers, raw material suppliers, or similar production enterprises, even if these places have no resource endowment advantage.

Many researchers using data-based tests have attempted to determine whether factor supply or market access is the more important variable affecting industrial location. However, these studies mostly offer inconsistent results. Some studies have shown factor supply as more important for industrial location. For example, Kim (1999) studied the location of America’s manufacturing industry during 1880–1987 and found that factor endowment was the most crucial factor affecting geographical location. Similarly, Ellison and Glaeser’s (1999) empirical research supported the importance of factor endowment. Tirado et al. (2002) analyzed the trend in Spain’s industrial location in the latter half of the 19th century and found its industries to be mainly centralized in regions with abundant human resources, proper geographical positions, and favorable specialization bases, thus also stressing the importance of factor supply. Crafts and Mulatu (2006) examined the conditions determining industrial location in England before the First World War while considering factor endowment and NEG variables and stated the former to be more important than market access. However, several NEG studies propose that market access plays a leading role instead of factor supply. Davis and Weinstein (2003) investigated the manufacturing sectors in OECD countries and found that NEG theories offer more satisfactory conditions for empirical observations than factor supply theories. Klein and Crafts (2012) investigated discussed location in America for 1880–1920 and stated that market potential was key in forming the clustering area of manufacturing industries, while factor endowment became non-significant and lost its importance in the 20th century. Badia-Miró and Yáñez (2015) analyzed industrial location in Chile and indicated that market potential was prioritized over natural resources.

Research has also considered factor supply to be as important as market access. Kim (1995) found that both factor endowment and scale economy could be used to explain industrial specialization and location. Karen Helene et al. (2002) first used cross-terms for regional and industrial characteristics in their regression equations and then introduced NEG variables to examine the location of the EU’s manufacturing industry during 1970–1990. They found NEG variables to be significant and that the supply of technical labor force and researchers was important to attract industries. Industries with increasing returns to scale are inclined toward central areas with market potential, which are also more attractive to front and rear correlative industries. Accounting for comparative advantage and market access, Wolf (2007) examined the conditions determining industrial location from the Civil War to the unification in Poland and found that both variables were statistically and economically significant. Bao et al. (2013) investigated changes in the location of China’s manufacturing industry during 1998–2009 and found that both factor endowment and NEG variables were significant, although the influence of the latter was higher after China’s accession to the WTO.

Most existing research advocates that high energy-consuming industries tend to gather at places with favorable energy endowment. For instance, Crafts and Mulatu (2006) analyzed historical cross-section data for England for the years 1881, 1891, 1901, and 1911 and stated that industries with high coal consumption prefer being located at places with rich coal resources. Gerlagh and Mathys (2011) analyzed 18-year panel data for 10 high-income countries in Europe, the Americas, and Asia and found that countries with abundant energy resources are more inclined toward exporting high energy-consuming products, concluding that energy was the key force driving specialized activities. Michielsen (2013) studied industrial locations in 50 American states from 2001 to 2009 and

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