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Transport corridors and regional balance in China: the case of coal trade and logistics ☆

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ABSTRACT

Coal plays a vital role in the socio-economic development of China. Yet, the spatial mismatch between production centers (inland Northwest) and consumption centers (coastal region) within China fostered the emergence of dedicated coal transport corridors with limited alternatives. Serious problems of energy shortage and power rationing have already affected southeastern China. At the same time, enormous interregional coal transfers face a lack of transport capacity along the transport system. Based on first-hand statistics, a disaggregated analysis of coal distribution patterns since the late 1970s provides novel evidences about the local effects of macroscopic trends, such as the shift from dominant exports to dominant imports in terms of changing traffic concentration levels and distribution patterns among routes and ports. The spatial evolution of coal distribution is also discussed in terms of related industry linkages and local influences, coal trade policies and market pricing, port system evolution, and transport network planning. The paper also discusses possible improvements of the current situation through enhancing multimodal transport based on a review of current policies.

1. Introduction

Since the mid-1840s, coal has been playing a significant role in global socio-economic development (Vaninetti and McKevitt, 1995). The Chinese economy is largely dependent on coal (Kuby et al., 2011; Todd, 1997; Sun and Gu, 2005), which accounts for more than 66.6% of its total energy consumption as opposed to 18.8% for oil, 9.4% for hydroelectricity, and 5.2% for natural gas in 2012. Since 1978, China has witnessed substantial economic growth and it has become nowadays the world's largest energy consumer (Shen et al., 2012), handling about a quarter of global coal trade in 2013. While it is currently the world's largest coal producer, its coal consumption reached 3.61 billion tons of standard coal in 2012, 6.16 times the amount in 1980. Domestic coal production has long remained its main resource, in addition to limited imports, but the latter has gradually occupied an unprecedented importance. Important effects of such changes are felt globally in terms of trade routes reorientation and energy security (Ekawan and Duchene, 2006; Lin and Liu, 2010; Ma, 2008; Ritschel, 2009) as well as locally. Notably, coastal provinces are confronted with coal insufficiency (Shealy and Dorian, 2010) due to rising transport and mining costs (Paulus and Trüby, 2011) that lead to regular shortages and power rationing. New questions thus emerge about China's ability to tackle those challenges. In such context, the mismatch between the spatial distribution of coal mining, transformation, transfer activities and the pattern of transport infrastructure (i.e., ports and railways) and other socio-economic activities is seen in this paper as one major constraint when responding to the aforementioned issues. How can transport and logistics alleviate this situation, and what are the relevant planning solutions?

Such questions are not new in general academic literature, and specifically within a Chinese context. Earlier studies by renowned experts have provided a clear understanding of the major trends affecting China's changing energy structure and policy (Sinton et al., 1998; Smil, 1998). A brief overview, however, is needed to identify more specific issues in relation to coal trade and logistics. Coal-related literature traditionally focuses on transport costs and modal split as well as their optimization (Chang et al., 1980; Kania, 1984) in different contexts (Elmes, 1984), such as North America (Ash and Waters, 1991; Kuby et al., 1991; Leblanc et al., 1978).

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Studies conducted in China analyzed the exploitation potential of coal reserves and its relation with domestic demand (Tang, 2008; Ma et al., 2009), the relationship between coal consumption and Gross Domestic Product (GDP), the forecast of such linkages (Chan and Lee, 1997; Crompton and Wu, 2005; Shiu and Lam, 2004; Yuan et al., 2008; Lin and Liu, 2010), and coal policies (Shen and Philip, 2001). Spatial dynamics have also been studied, such as the westward shift of coal production due to higher costs of deeper extraction in East China (Dorian, 2005; Tao and Li, 2007), the interregional transfer of coal resources since the 1970s (Cheng et al., 2008), and the construction of the coal transport network and spatial pattern of coal traffics (Fan, 1997; Liu, 1999). Some scholars have particularly stressed the emergence of transport bottlenecks (Wang et al., 2009) and the widening gap between supply and demand of coal (Todd, 1997; Todd and Jin, 1997), notably from a historical perspective, while others have adopted more sophisticated methods, such as Geographical Information Systems (GIS), to examine China's future railway developments (Kuby et al., 2001).

Yet, the existing research remains much dispersed across the disciplinary spectrum. The changing spatial linkages between distribution, production, and consumption have only been partly addressed. A synthetic analysis taking into account transport, logistics, trade, industrial, and policy issues is thus the target of this paper. The discussion in this paper will cover the time from 1980s to now, paying special attention to the time since the early 1990s.

2. Main trends of coal production, distribution, and trade in China

2.1. Production and consumption of coal resources

According to the statistics of BP, China possessed approximately 114.5 billion tons of proved coal reserves in 2012, and China's Statistics Bureau stated that 229.9 billion tons are basic resources in 2012. Yet, coal reserves are concentrated in North and Northwest China, north of the Kunlun, Qinling, and Dabie mountains. The area north of this belt accounts for 93.1% of the national total, with a decreasing gradient from west to east and from north to south (Ma et al., 2009). Disparities can also be measured at the province level. Shanxi and Inner Mongolia account for 39.5% and 17.5% of reserves, respectively. Other provinces of Xinjiang, Shaanxi, and Henan concentrate 15.7% altogether while Shandong, Guizhou, Heilongjiang, Yunnan, and Sichuan provinces account for 14.1%. Although the region of West Guizhou, South Sichuan, and East Yunnan possess about 9% of total reserves, they represent the largest coal base in South China.

The exploitation and production of coal resources is influenced in its spatial pattern by factors other than production volumes. As shown in Fig. 1, total coal output has increased to such an extent that it now dominates China's energy structure, accounting for 66.6% of total China's energy consumption in 2012, with a temporary decline between 1996 and 2001. The Asian financial crisis provoked a production drop for many companies, resulting in the reduction of coal consumption and production. Coal mining occurs in 1100 of the 2100 counties possessing this resource, but it is highly concentrated in few locations. Concentration has increased over time, as demonstrated by Todd (1997) when calculating a coefficient of localization by province. In 2007, Shanxi achieved about 25% of China's total raw coal production, maintaining its rank as the largest production center. Yet, Shanxi dropped to the second rank (21.96%) in 2012 after Inner Mongolia (25.05%). Together with Shaanxi and Henan, the four provinces constitute the leading coal base and exporting region with about 62.1% of China's total in 2012.

Coal consumption is concentrated in North China and the Bohai Rim, with Shandong accounting for more than 9.2% of China's total in 2012. Shanxi, Hebei, Henan, Inner Mongolia, and Jiangsu concentrate one-third. Shanxi, Inner Mongolia, and Shandong are important for consumption, production, and export. China's coal consumption was forecasted to reach 4.8 billion tons in 2020 and to grow by 1.2 billion tons in the subsequent eight years, according to the Annual Report on Coal Industry in China (2013) edited by the China National Coal Association. According to the report on China's Energy and Long-term Development Strategy (2030–2050), coal consumption may reach 5.1–6.4 billion tons in 2030 and increase to 5.9–7.8 billion tons in 2050 (Chinese Academy of Engineering, 2011).

In addition to those trends, some major changes in China's industrial structure over the contemporary period are important factors that need to be considered. The two first five-year plans from the 1950s to the early 1960s focused on the development of heavy and chemical industries, which shared total economic activity and grew rapidly but long remained inferior to the share of other sectors. In more recent decades, notably after 1998, China's economic development relied mostly on energy-intensive industries (i.e., thermal power, metallurgy, and construction), which fostered the consumption of domestic and also foreign coal. In 2012, China owned the world's largest coal-fired power generation with 819 GW. Coal consumption grew at an annual rate of 9.8% over the period 1998–2012 (Shen et al., 2012) while thermal power output grew from 512.8 billion kW h in 1997 to 3787 billion kW h in 2012. It is likely that such trend will be prolonged in light of the 7.2% GDP annual growth rate forecasted by the 12th Five-Year Plan.

Most of the imported coal is steaming coal for thermal power plants, followed by coking coal for steelworks, fueling the expansion of heavy industries in this region (Table 1). For example, many thermal power plants located in this region benefit from maritime shipping. As shown in Table 2, the installed capacity and output of thermal power plant in this region accounts for about 48.7% and 50.4% of China's output in 2011. Particularly, Jiangsu, Shandong, Guangdong, and Zhejiang become the core, and their above indicators amount to 30.2% and 31.4%, respectively. The thermal power plants in the YRD consume mainly domestic coal and import a small quantity of the foreign coal while the plants at the south of the Yangtze River depend largely on the import coal. The thermal power plants in this region consumed about 70% of import coal in 2012. The thermal coal of Shandong, Jiangsu, Guangdong, and Hebei exceeded 100 million tons in 2011, and Zhejiang, Liaoning, and Fujian reached over 5×107 tons. Importantly, all coastal provinces have a high share of thermal power coal in their total coal consumption. The share of Hainan exceeds 70%, those of Guangdong and Zhejiang exceed 60%, and Shanghai, Fujian, Jiangsu and Tianjin reach over 50%. The rapid growth of electricity demand since 2000 led by increased industrial and residential use led to power shortages in many provinces of China. The increasing import of coal, to some extent, accommodated the growing shortfalls of the aforementioned regions.

Among the coal bases, most provinces constructed a great amount of mine-mouth power, as shown in Table 3. Shandong, Inner Mongolia, Shanxi, and Henan generated most thermal power, over 240 billion kW h, followed by Anhui, Shaanxi, and Guizhou, surpassing 100 billion kW h. Between 2006 and 2012, thermal power generation has increased greatly, specifically in areas such as in Anhui (145%), Ningxia (154.4%), Inner Mongolia (116.8%), and Shaanxi (115.3%). Correspondingly, this stimulated the growth of thermal power coal consumption. In 2012, Inner Mongolia, Shandong, Henan, and Shanxi consumed over 100 million tons of thermal power coal, respectively. In view of the electricity transmission, Shandong has the highest transmission, with a rate of over