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The spatial impacts model of trans-strait fixed links: A case study of the Pearl River Delta, China

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ABSTRACT

The mage trans-strait fixed links are constructed in different countries to promote regional economic and social development. This paper proposes a spatial impacts model for the trans-strait fixed links in the Pearl River Delta, China. To verify the rationality of the model, four quantitative indicators, including weighted average travel time, the economic linkage intensity, the economic linkage membership grade, and the fractal index are used to investigate the effect by construction of Humen Bridge, Hong Kong–Zhuhai–Macao Bridge and Shenzhen–Zhongshan Bridge. The results show that the Hong Kong–Zhuhai–Macao Bridge and Shenzhen–Zhongshan Bridge greatly improve the regional accessibility with a maximum decrease weighted average travel time of 1.38 h and 0.4 h. The central part of the Delta has greatest impacts. The links increase the economic linkage of cities of each side. The cities directly connected to the fixed links (Hong Kong, Shenzhen, Macao and Zhongshan) experience the highest increasing economic linkage. The regional spatial pattern evolves from unipolarity to multi-polarity and integrates a more advanced and sophisticated spatial network. The theoretical spatial impacts model for the trans-strait fixed links accords with the actual development in the Pearl River Delta.

1. Introduction

Urban growth and regional development are closely related to the interactions with other cities or regions by overcoming the temporal constraints resulting from spatial distance. The transportation infrastructure decreases the spatial distance between cities, proliferates the economic linkages and reformulates the spatial pattern of the regional economy (Knowles, 2006a). Geographers have been aware of these changes for many years and have analyzed the impacts of new transportation networks, such as road (Roger, 1995; Zhao and Ma, 2013), high-speed rail (Meng and Lu, 2011; Wang et al., 2014; Wang et al., 2016) and aviation (Wang et al., 2009), on the cities' interactions by using the temporal distance instead of the spatial distance. Many case studies for given regions or transportation infrastructures have been analyzed, and there are also attempts to establish theoretical models and analytical frameworks.

Trans-strait fixed links are important transportation infrastructures. These links can help to break the spatial barriers caused by straits, enhance the convenience of outward transportation from urban areas, change both regional and intercity economic linkage modes (Knowles, 2006b; Knowles and Matthiessen, 2009), affect the strength and direction of intercity interactions, and shape the spatial pattern of the regional economy. However, spatial impacts of trans-strait fixed links depend on a wider range of factors. While travel time, resident population and gross regional products are key elements, other variables include complementarity, transferability, intermediacy and intervening opportunity (Fleming and Hayuth, 1994; Ullman, 1980), economic and cultural barriers, and economic and cultural opportunities (Knowles and Matthiessen, 2009). Literatures on the impacts of trans-strait bridges have focused on several aspects. The first was the qualitative prediction or macro-analysis of the benefits and influence factors of trans-strait fixed links. Much research has explored the Channel Tunnel impact on the core region (Bruyelle and Thomas, 1994) and the peripheral regions (Gibb and Essex, 1994), the cross-border functional integration of the fixed Öresund link (Matthiessen, 2004), and the socioeconomic impact of the Taiwan Strait Tunnel (Wang and Meng, 2004). Another longstanding preoccupation has been the impacts of trans-strait fixed links on local industrial development. Garnett (1993) predicted the impacts of the Channel Tunnel on Britain tourism market. Sen (2004) evaluated the actual tourism impacts based on the travel data between the UK and continental Europe at 1991–2000. Mckinnon (1994) specifically dealt with the time-sensitive sectors after the

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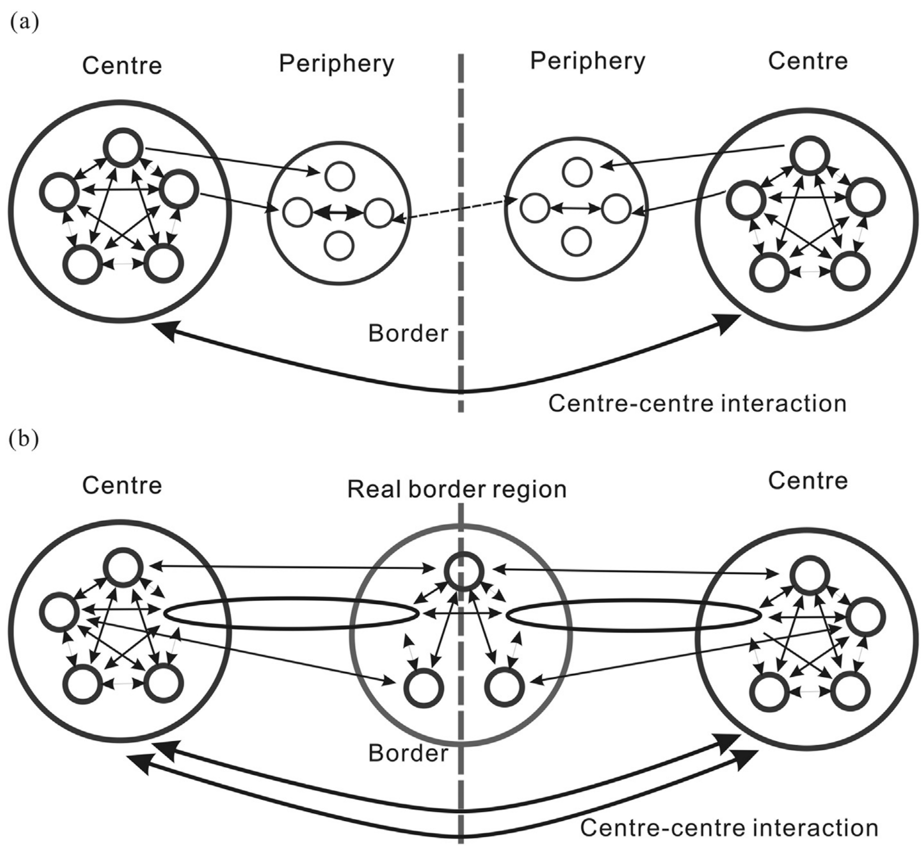

Fig. 1. The model of activities and interaction (a) before and (b) after the Fehmarn Belt region.
Source: Matthiessen and Worm, 2011

Channel Tunnel. Skjött-Larsen et al. (2003) analyzed the logistics development after the Öresund link and concluded the Öresund region would be one of the leading logistical centers of Europe. Sun et al. (2010) calculated the impacts of trans-Bohai Strait passageway on the Chinese logistics. Wu et al. (2012) showed the Hong Kong's logistics and ports would benefit after the operation of Hong Kong-Zhuhai-Macao Bridge. The debate on spatial distribution of the impacts of trans-strait fixed links continues, especially on identification of the spatial impacts of agglomeration and an analysis of the diffusion process. Wang et al. (2010) concluded the east coastal cities were the winner after the Bohai Sea-Crossing Passage in China. Meijers et al. (2012) stated the center–periphery effect of the Westerscheldetunnel in Netherlands. Thomas and Donoghue (2013) found the greatest impacts have distributed in metropolitan regions (Lille and East London) instead of trans-frontier zone (Kent and Nord-Pas-de-Calais) after the Channel Tunnel. The ex ante and ex post appraisals of economic benefits of trans-strait fixed links has been analyzed with the construction of the fixed links. Jensen-Butler and Madsen (1996) stated the effects of the Danish Great Belt link by integrated approaches. Anguera (2006) evaluated the poor viability of the investment both in financial and cost benefit terms after the Channel Tunnel opened for 10 years. Knowles (2006b) assessed the disparity of actual and forecasted transport impacts of the Öresund link.

In contrast to the abundance of literatures on the impacts of fixed links on the economic benefits and its distribution, is the comparatively limited attention for the studies of cities' interaction promoted by the fixed links. Few scholars have carried out research on the impacts of trans-strait fixed links on the spatial intensity of intercity interactions. Wu et al. (2012) analyzed the impacts of the Hong Kong–Zhuhai–Macao Bridge on accessibility to the banks of the Pearl River estuary and its transportation network, but did not formulate an economic linkages model for the cities in the region. Sun et al. (2014) used a gravity model to analyze the fixed link across the Bohai Straits. Their researches showed that the link has significantly increased the economic linkage intensity between the Shandong and Liaodong peninsulas and markedly changed the spatial pattern of economic linkage between the cities on these peninsulas. Although a number of studies on the spatial impacts of a trans-strait fixed link have been reported, the analytical model is still under development. Matthiessen and Worm (2011) proposed a theoretical spatial impacts model for a trans-strait fixed link based on the fixed Fehmarn Belt link between Germany and Denmark. Despite its theoretical significance, this model is not universal as the assumptions are confined to the case study.

The purposes of this paper are (1) to improve the theoretical spatial impacts model for trans-strait fixed links and verify the model by; (2) quantitatively investigating the impacts of the trans-strait fixed links across the Pearl River estuary (the Humen Bridge, the Hong Kong–Zhuhai–Macao Bridge and the Shenzhen–Zhongshan Bridge) on accessibility to the Pearl River Delta (PRD); and (3) analysis of spatial distribution changes and evolution in economic linkage intensity and its structure between the east and west banks of the Pearl River estuary.

The remainder of this paper is structured as follows. Section 2 proposes a spatial impacts framework for the trans-strait fixed links across the PRD; Section 3 describes the analytical techniques and indicators, including an introduction to the study area and data sources; Section 4 reports and discusses the results; and Section 5 presents the conclusions and future outlook.

2. The spatial impacts model for trans-strait fixed links

Both straits and rivers are barriers to transportation and increase temporal costs, and affect business activities between the two sides of the waterway (Gibb, 1988). Trans-strait fixed links could remove or reduce barriers to transportation and shorten the temporal distances between the two sides of straits (Knowles, 2006a). The Channel Tunnel and the Oresund Bridge have produced significant spatial impacts. According to Thomas and Donoghue (2013), the Channel Tunnel shortens the distance between the UK and continental Europe, but its impacts vary from place to place. Metropolitan areas further from the