Agglomeration Shadow:

Can Investment and Education Alleviate Geographic Disadvantage in Urban Growth?

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Abstract: Using Chinese city-level data from 1990 to 2006, this paper provides evidence for the non-linear CP model of urban systems (Fujita and Krugman, 1995; Fujita, Krugman and Mori (1999). Our results show that a proximity to major ports and international markets is essential for urban growth. Moreover, the geography–growth relationship follows the ⌣-shaped nonlinear pattern, following which Middle China lies in the agglomeration shadow of Eastern China. We also find that in the long run, geography plays a much more important role than in the short run. Investment and government expenditure can increase short-run growth, but not significantly in the long run. Only educational investment can help alleviate geographic disadvantage for laggard areas in the long run.

Key Words: core–periphery model, urban systems, investment, education, China

I. Introduction

For countries with vast territory, interregional balanced development is an essential policy goal. However, in a modern economy, industrial agglomeration and uneven distribution of production lead to interregional inequality, especially when labor is not perfectly mobile. In the globalization era, coastal regions near ports are more advantageous to develop international trade and attract FDI than interior regions are. To counteract the agglomeration forces of trade, central governments usually pursue interregional balanced development by central-to-local fiscal transfer and government-sponsored projects. However, some regions stay poorer persistently than others. Therefore, how important geography is in shaping interregional growth pattern and what kind of policies can help laggard regions grow faster remain questions to be explored.

From its position as the backbone of new economic geography (NEG) theory (Krugman, 1991), the core–periphery (CP) model suggests the existence of an uneven distribution of economic activities in spatial economy caused by the interplay of scale economies and transport costs. As proved by Fujita and Krugman (1995), Fujita, Krugman and Mori (1999), a nonlinear urban system indicates a ⌣-shaped correlation between the distance to the core and local market potential. In this urban system, regions close to the core are under the "agglomeration shadow", so their economic resources are absorbed by the core. However, current empirical studies using US and European data barely test the presence of such nonlinearities (Black and Henderson, 1999; Dobkins and Ioannides, 2004; Brülhart and Koenig, 2006). As Krugman (1991) points out, the share of manufacturing in national income matters in the presence of the CP pattern. As a consequence, the decreasing share of manufacturing in both the US and Europe may give some indication as to why previous studies have not filled the gap between theory and reality.

Using Chinese city-level data from 1990 to 2006, this paper proves the nonlinear CP pattern in Chinese urban systems by estimating the impact of the distance to major ports on urban economic growth. Industrialization and globalization have been two important forces underpinning rapid economic growth in China since the 1980s. Being a rapidly industrializing country with a vast geographic territory, China provides an appropriate context to examine how geography influences the spatial distribution of economic activities.

More particularly, when joined with globalization and developments in export-led manufacturing, coastal ports and nearby cities have greater access to international markets, thus providing key advantages for economic growth (Hanson, 1998). Therefore, in this paper, we assume that there are two national-level hierarchical monocentric urban systems in China, the cores of which are the major ports and megacities of Shanghai and Hong Kong. Further, as predicted by the CP model, we hypothesize that the spatial interaction within each urban system follows a ⌣-shaped nonlinear relationship between the distance to the port and urban growth, and test this using empirical methods. Our key finding is that a ⌣-shaped nonlinear correlation indeed exists in relation between the geographic distance of cities to major ports and economic growth in China's urban systems. Consequently, the economic forces entailed by the CP pattern are currently reshaping Chinese economic geography.

The empirical CP model also enables us to compare the impacts of geography and other growth factors. We find that the distances to major ports and regional agglomeration centers are much more powerful than other variables. In the long run growth over the time period of 1990-2006, only the two distance variables explain 6.9% of the growth variances, while a full model comprising all the growth factors can explain 40.4% of the growth. In contrast, investment-to-GDP ratio and government expenditure-to-GDP ratio are growth-enhancing factors in the short-run growth, but they are insignificant in the long run. Only education investment measured by teacher-student ratio can boost long-run growth and help periphery regions alleviate their geographic disadvantage.

The remainder of the paper is structured as follows. Section II briefly reviews the theoretical and empirical work on spatial interaction between cities. Section III introduces details of China's urban system and explains why it represents a feasible application of the CP theory. Section IV discusses the data and our chosen econometric approach. Section V presents the basic results. Section VI extends the model to medium- and long-run growth regressions, and compares the relative importance of geography and other variables. Section VII provides some concluding remarks.

II. Literature Review

The NEG theory emphasizes the interplay of centripetal and centrifugal forces in determining spatial economies (Krugman and Elizondo, 1996). Centripetal forces here include both pure external economies and a variety of market scale effects, such as forward and backward linkages, while centrifugal forces comprise pure external diseconomies, such as transport costs and land rents (Krugman, 1991). For the most part, the CP model formalizes the role of agglomeration and dispersion in the dynamic formation of a monocentric urban system, of which a prominent feature is the emergence of a hierarchy of cities based on market potential, featuring especially a symbiotic relationship among cities (Fujita, Krugman, and Mori, 1999).

Fujita and Krugman (1995), Fujita and Mori (1997), and Fujita, Krugman, and Mori (1999) assume that manufacturing concentrates in the core of these systems because of the presence of scale economies, while the periphery is the agricultural hinterland. Near the core, the market potential curve decreases by distance as the ever-closer proximity to demand and supply brings about scale economies and lowers transportation costs (Venables, 1996). However, as transportation costs increase by distance, firms producing goods that are close substitutes may find that they will earn more if moving away from the core city and instead serve customers in fringe areas (Fujita and Krugman, 1995).

In this case, the market potential curve will increase at distances further away from the core. However, as distance increases, the potential curve will eventually fall again for similar reasons as it did nearer the core. Using numerical simulation, the CP pattern is then a ⌣-shaped relationship between the distance to the core and market potential in the periphery in a monocentric urban system. This curve shows that as the distance to the core increases, the market potential in the hinterland first declines, when the agglomeration effects are stronger and

later rises as dispersion forces dominate. Later, the curve will again decline for more remote areas. Consequently, an agglomeration shadow exists for places not far enough away from the core (Fujita and Krugman, 1995; Fujita and Mori, 1997; Fujita, Krugman, and Mori, 1999).

As Fujita and Krugman (2004) conclude, "…buttressing the approach with empirical work" is one of the most important directions for future research in NEG. Based on the implications of CP theory, Dobkins and Ioannides (2001) suggest that nonlinearities should appear in the spatial interactions in urban systems. Consequently, directly examining the spatial interactions among cities in relation to the geographic distance between them, their urban economy, or their place in the urban hierarchy, has generally become one of the streams of empirical research, not only concerning agglomeration (Hanson, 2001), but also the spatial distribution of cities (Partridge *et al.*, 2010). However, "…due to the highly nonlinear nature of geographical phenomena", it's not easy "…to make the models consistent with the data" (Fujita and Krugman, 2004).

For the most part, the empirical work on spatial interaction has partly verified the CP model and the role of agglomeration forces in urban systems, more or less finding that closer (to core) is better. Nonetheless, the nonlinearity of the CP model remains unverified. For instance, Combes and Overman (2004) use a geographic information system map to depict gross domestic product (GDP) per capita at the country level in Europe in 1996, thereby suggesting the spatial distribution of economic activity in the European Union follows the CP pattern. However, there is no evidence of nonlinearity. More to the point, although maps of wages and employment can display similar patterns, they also suggest that this pattern may not as marked in terms of total GDP. Using regional data over 1996–2000, Brülhart and Koenig (2006) analyze the internal spatial wage structures of the Czech Republic, Hungary, Poland, Slovakia, and Slovenia, and find that real wages fall with distance to the national capital and Brussels. However, none of the estimates is statistically significant.

The empirical evidence drawn from the US urban system is even more complex and puzzling. For example, Black and Henderson (1999) examine the correlation between population growth in US metropolitan areas and initial conditions over the period 1950–1990. They conclude that population growth is faster in cities closer to the coast and to cities with larger initial populations; though this effect weakens as neighboring population masses become larger. Similarly, Dobkins and Ioannides (2001) and Ioannides and Overman (2004) employ US metropolitan data over the period 1900–1990 and conclude that distance from the nearest higher-tier city is not always a significant determinant of urban size and growth. Moreover, there is no evidence of the nonlinear effects of either size or distance on urban growth over such a long sample period. Finally, Partridge *et al.* (2010) explore whether the proximity to higher-tiered urban centers affected US county population growth over the period 1990–2000. Their results suggest that larger urban centers indeed promote growth in more proximate places, but only those with fewer than 250,000 persons. As a result, Partridge *et al.* (2010) conclude that NEG theory (and the CP model) only partly explains modern US urban growth, thereby suggesting the need for a broader framework.

Encouraged by the above studies, we believe the time is right to clarify whether the CP model is relevant in explaining contemporary urban systems. We also believe that an empirical study of the Chinese urban system is most suitable for testing nonlinearities in the CP model, especially as unlike the US and Europe, China is still experiencing urbanization and industrialization. During this critical process, transport costs and scale economies are essential determinants of the spatial distribution of urban economies. Besides, the globalization process is also helping to reshape China's economic geography and urban system, making coastal areas advantageous in attracting foreign direct investment (FDI) and developing export-led manufacturing (Wan, Lu, and Chen, 2007). Whether the evolution of the urban system in China approximates the purported nonlinear CP pattern is then an interesting topic and a useful empirical exercise. If China's urban growth indeed follows a nonlinear CP pattern, it is relevant to explore how important geography is relative to other growth factors and whether investment and education can alleviate geographic disadvantage of the cities in the agglomeration shadow.

III. China's Urban System Evolution and an International Comparison

Krugman (1991) questions, "…how far will the tendency toward geographical concentration proceed?" Taking early nineteenth-century America as an example, with a small share of manufacturing employees, a combination of weak economies of scale, and high transportation costs, Krugman (1991) believes that pre-industrial society was satisfied by small towns serving local market areas. Consequently, the answer to the question posed earlier depends on the underlying parameters of the economy, such as the share of manufacturing, the presence of economies of scale, and transportation costs. However, Fujita and Krugman (1995) find that a reduction in transportation costs is most likely to cause a population migration from the city to the hinterland. Therefore, with the dramatic development of transportation technology and declining manufacturing shares, postindustrial societies, like the US and Europe, have since the late 1970s begun to exhibit a trend in "anti-urbanization" (Frey and Speare, 1992).

When compared with the US or Europe (e.g. France), China is still in the process of industrialization. According to the World Bank (2011), in 2008 the share of industrial value-added in GDP[1] in China was 47.4%, significantly more than in the US (21.3%) or France (20.3%), both of which were continuing to decrease year by year, as shown in Figure 1. Consequently, the large share of manufacturing in the Chinese economy combined with rapid economic growth makes China a better trial to test the CP model of urban systems. Besides, with the force of spatial agglomeration brought about by manufacturing, the rapid development of international trade continues to reconstruct China's urban economies, especially with China's increased openness to the world starting in the 1990s. This opening process is also a natural experiment to consider the role of distance to major ports and access to international markets in changing the urban system.

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[1] Industry value-added corresponds to ISIC divisions 10–45, including manufacturing (ISIC divisions 15–37). It therefore includes value added in the mining, manufacturing, construction, and electricity, water, and gas industries.

[Insert Figure 1 here]

3.1. Economic Openness and Urban System Adjustment

International trade changes the reference market for firms in a country by shifting resources to locations with low-cost access to foreign markets, such as border regions and port cities. Fujita and Mori (1996) propose a model of spatial economic development in which agglomeration economies and the hub effect of transport nodes interplay. Their simulation of a monocentric urban system shows a nonlinear relationship between market potential and distance to the core city. In this model, if the core city is a port, openness and international trade will strengthen the agglomeration effects of the core city and reshape the urban system within a country. Corresponding to the theoretical implications, Hanson (1998) finds that following trade reform and increased global openness, especially with the US, firms in Mexico began to locate in regions with good access to foreign markets, such as Mexican cities bordering the US.

A similar process of economic reform and openness began in China in 1978. After 1992, China quickly opened its doors to the world market, with reforms invoking a widespread opening up of markets and a commitment to the market economy (Ho and Li, 2010). Figure 2 depicts the increasing importance of international trade in China, especially after 1992. In 1994, the official and black market exchange rate for Renminbi (RMB) combined. Since then, China has exhibited an export-led growth pattern and has continuously increased its trade surplus to the present day.

[Insert Figure 2 here]

Besides the dramatic development in international trade and the rapid and steady GDP growth, another remarkable phenomenon in China is the rate of urbanization, increasing from 17.9% in 1978 to 49.68% in 2010,[2] almost one percentage point per year. What exactly is the linkage between international trade and urban system adjustment? Again taking Mexico as an example, Krugman and Elizondo (1996) find that the trade policies of developing countries and their tendency to develop huge metropolitan centers closely link. Fujita, Krugman, and Mori (1999) also argue that rapid urbanization in the world economy infers the increasing importance of cities as the basic unit of international trade. Therefore, international trade may not only reshape regional and national economic geography, but also greatly affect the evolution of the urban system.

Ever since the mid-1990s, with China increasingly open to the international market, international trade has become more and more important for Chinese urban development. For instance, Wei (1995) finds that Chinese cities with large export sectors generally grow faster. Further, international trade strengthens the agglomeration force in major ports in China. For example, Wei (1995) and Anderson and Ge (2005) provide some evidence that many emerging

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[2] Source: NBS, The Statistical Summary of the 6th Population Census, http://www.stats.gov.cn/tjfx/jdfx/t20110428_402722253.htm.

cities locate in coastal areas in the Pearl River Delta near Hong Kong. More and more empirical studies are finding that recent economic agglomeration has changed the distribution of China's regional and urban economies, thus coastal and large cities have higher economic growth rates (Chen *et al.*, 2008; Bao *et al.*, 2002).

For China's cities, which had hitherto developed evenly under central government planning before economic reform, the open-door policy represented an exogenous shock to city growth and the urban system. Unlike the 1980s, when China selected several coastal cities for opening, in the 1990s, the national policy was an open door. The geographic difference between cities, mainly the distances to major ports in determining international trade costs, plays an essential role in international trade, FDI inflow, and city growth. Therefore, the opening process in the 1990s is a natural experiment for economists to see whether and how the urban system evolves following a CP model.

3.2. Geography and Growth: Why China Can Contribute to NEG Studies?

Partridge *et al.* (2010) believe agglomeration economies may have a greater geographic scope than usually assumed by economists. From this perspective, economic geography, particularly the role of nonlinear spatial agglomeration, may require wide spaces and a long timeframe for accumulation, while national and geographic boundaries, wars, and other factors often limit the free flow of resources. As a result, it is sometimes difficult to use econometric models and real-world data to portray how agglomeration actually works. Therefore, studies of stably developing large countries, such as the US (and China after 1978) are particularly important for empirical research on NEG theory.

Research using Chinese data may helpfully contribute to the empirical study of NEG for the following reasons: First, China has a vast territory, as well as a large population. The vast territory not only provides the space required by agglomeration, but also plenty of samples for empirical study. Meanwhile, a large population provides sufficient market potential. Second, compared with the US, China has a larger interregional geographical diversity and a more obvious geographical heterogeneity because of the concentration of ports along the eastern coast. Interregional geographic differences are significantly less in the US, which has large ports on both its western and eastern coasts. Finally, China has witnessed rapid economic development in the past thirty years, especially after 1992, with corresponding changes in the spatial distribution of economic activities. This allows us to better observe the impact of spatial agglomeration on the urban system.

3.3. China's Urban System

In China, a "city" is a local administrative and jurisdictional entity, and there are comparable historical data and large enough cross-sectional observations of cities. There are three different administrative levels of cities in the Chinese urban system: municipalities, prefecture-level cities, and county-level cities. This does not include smaller settlements with townships or lower

administrative levels. The major administrative criteria announced in 1963 defined a city as an urban agglomeration with a total urban population of greater than 100,000 inhabitants. The economic and political importance of urban agglomeration is also one of the government's considerations in defining cities. However, the definition of cities has generally been consistent since at least 1949 when the People's Republic of China was established (Anderson and Ge, 2005).

China's National Bureau of Statistics (NBS) reports information about both prefecture- and county-level cities, but we use only data on prefecture-level and above cities in our research. As for county-level cities, their boundaries and number have fluctuated greatly in recent history (see Table 1). The number of prefecture-level cities has also increased greatly since 1990, so the boundaries of the prefecture-level cities may also have changed. However, for cities at the prefecture level and above, NBS reports information on both *Diqu* (urban area plus rural counties within the same administration) and *Shiqu* (urban area only). In general, *Shiqu* is a good definition of the metropolitan area by international standards (Fujita *et al.*, 2004), and the entities implied by new cities usually arise outside the *Shiqu*, so this information is comparable across time and is thus used in our study.

[Insert Table 1 here]

The definition of China's urban hierarchy is another problem. As mentioned above, three administrative levels of cities are included in China's urban system: municipalities (or province-level cities), and prefecture- and county-level cities; provincial capitals also comprise a special administrative level in prefecture-level cities. Cities of different levels have different population sizes. However, corresponding to the CP model, our study focuses on the spatial agglomeration in urban system, for which urban size (e.g. population) and market potential are much more important than administrative level. Accordingly, we distinguish between cities using different definitions and sizes, as shown in Table 2. In the model specification, we use dummies to control for administrative level, special economic zones (SEZ), and city size, etc.

[Insert Table 2 here]

IV. Model Specification and Data
4.1. Model Specification

Our model is used to estimate how geographical location, mainly distance to a major port, affects urban growth. The reduced-form estimation, where geography is the focus, is widely used in earlier empirical studies of the spatial interaction between cities (Brülhart and Koenig, 2006; Dobkins and Ioannides, 2000). We also use cross-sectional ordinary least squares (OLS) regression for our basic reduced-form CP model of the urban system, as based on the economic growth model in Barro (2000). As the urban system is constantly evolving during the opening process, the different growth rates of cities in different locations will reflect the shifts in the

urban system. In addition, given all the explanatory variables are exogenous geographic factors or the initial values of the control variables, the potential endogeneity problem in OLS estimation is not a major concern. The model specification is as follows:

$$Dgdp_{it} = f(\ln gdp_{i0}, inve_{i0}, lab_{i0}, edu_{i0}, gov_{i0}, fdi_{i0}, con_{i0}, geo_{i0}, \cdots)$$

Per capita GDP growth is the dependent variable. The extant literature also uses urban per capita GDP growth as a measure of the urban economic activities (Glaeser *et al.*, 1995; Dobkins and Ioannides, 2000). We do not employ real wages, income, population, and per capita GDP in our analysis for the following reasons. First, wage and income data are not available at the city level in China. Second, in the early years of our sample, the urban population in China did not include migrants without local household registration identity (*hukou*) (Au and Henderson, 2006b), so it does not well represent the urban economy or size. Third, as we wish to illustrate the dynamics of urban economies following China's openness to the world, per capita GDP growth (not the level of GDP), should be a better measurement to observe the evolution of the urban system. Nevertheless, we also estimated models specifying per capita GDP instead of GDP growth as the dependent variable. However, our main results concerning the Chinese urban system were unchanged.[3]

In our study, we highlight the roles of openness and international trade in determining the distribution of China's urban economic activities, so the key variable of geography is the city's distance to the nearest major port. We construct our dataset over the period 1990–2006 to capture best the drastic openness in place since the early 1990s. Problematically, most of the information about China's cities in 1992 and 1993 is missing from the *Chinese Cities Statistical Yearbook* (National Bureau of Statistics, 1991–2007). Consequently, we use the data for 1994–2006 to check the robustness of our results after 1994 (coinciding with the period of far-reaching openness and depreciation of the RMB).

Hanson (2001) suggested that three issues might cause trouble in identifying agglomeration effects in empirical studies: (i) unobserved regional characteristics, (ii) simultaneity in regional data, and (iii) multiple sources of externalities, of which the former two are particularly crucial when it comes to the spatial interaction of cities. As for "unobserved regional characteristics," we attempt to control for as many variables as the data will allow according to both the literature on economic growth and past empirical studies of China. "Simultaneity in regional data," however, may be a minor issue in our study, as the core explanatory variables in our model are geographic and do not change. As for the other explanatory variables, we use their initial values in 1990 to counter simultaneity bias in the model. As such, the estimated results represent the long-term impact of these explanatory variables on urban economic growth. Besides, it is quite uncommon to control for so many initial state variables in the empirical studies employing NEG theory. Therefore, we also estimate several models including only geographic variables. However, the basic model follows the economic growth literature to control for other factors influencing growth and this helps control for heterogeneity across cities.

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[3] For brevity, we do not discuss these results, but they are available from the authors upon request.

4.2. Data

In this paper, we use China's urban area (*Shiqu*) data (1990–2006) complied from the *Chinese Cities Statistical Yearbook* (National Bureau of Statistics, 1991–2007), including 286 cities at the prefecture- and above level[4] from 30 provinces across mainland China. Hong Kong, Macao, Taiwan and Tibet are not included. Local statistical bureaus in China have for some years collected data on all enterprises in their local area, and report GDP figures at the level of the appropriately defined metropolitan area (Fujita *et al.*, 2004; Au and Henderson, 2006a). Though we may express some doubt as to the quality of statistical data in China, these GDP figures are of a high quality, as discussed by Au and Henderson (2006a), especially when econometric models find highly significant results that are consistent with established economic theory. The remaining data sources and the construction of the variables are as follows.

4.2.1. Urban Economic Growth

The dependent variable $Ddgp_{it}$ is the compound average annual growth rate of real per capita GDP from 1990–2006 deflated by the urban consumer price index (CPI) in each province for city i over t years. The theoretical assumptions of NEG emphasize the agglomeration of manufacturing and services (Krugman, 1991), so we correspondingly removed agricultural output and population from the GDP and population indicators, respectively.

4.2.2. Spatial Interactions among Cities

Hanson (1998, 2005) approximates the access of each region to its principal markets using geographic distance. Therefore, geographic distance, as well as driving or road/railway distance, is used to approximate the spatial interaction among cities (Dobkins and Ioannides, 2000; Brülhart and Koenig, 2006; Partridge *et al.*, 2010). In particular, we use straight geographic distances to major ports as our measure of spatial interaction, which avoids the potential endogeneity bias brought about by measures of traffic distance, such as driving hours.

We assume that there are two hierarchical monocentric urban systems in China. The first is the national urban system, the cores of which are the major ports, like Shanghai and Hong Kong. The distances to these ports measure the remoteness of cities to the global market. The second is the regional urban system(s), the cores of which are large cities like Guangzhou, Chongqing, and Wuhan, etc. The spatial interaction within each urban system exhibits the CP structure, which we testify to using our empirical results. Here, we use the distance to the nearest "big" city *(distbig)* to measure the interaction within regional urban systems, and the distance to the nearer major port *(disport)* to measure the interaction within national urban systems.

To exploit how the agglomeration of major ports affects urban economic activities in China's spatial system, we need to identify "major ports." According to the *China Statistical Abstract 2009*, in 2008, Hong Kong accounted for 10.8% of overall Chinese cargo throughput, Shanghai 10.6%,

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[4] We have data on 286 cities in 2006 and 211 cities in 1990.

and Tianjin 7.4%.[5] As to ports in different regions, the Bohai Sea ports (Tianjin, Qingdao, Qinhuangdao, Dalian) in total accounted for 24% of overall cargo throughput, with the Pearl River Delta ports (Hong Kong, Guangzhou, Shenzhen) representing 22.4%, and the Yangtze River Delta ports (Shanghai, Ningbo-Zhoushan) another 21.4%. The above data clearly show that cargo throughput in China mainly concentrates in these three areas. However, the distribution of the Bohai Sea ports is widely dispersed. Therefore, agglomeration in Tianjin may not be as strong as in Shanghai and Hong Kong. Therefore, we initially define Shanghai and Hong Kong as "major ports" in our study but include Tianjin when testing for robustness. In fact, Shanghai and Tianjin are provincial-level cities and respectively major ports in the Yangtze River Delta and Bohai Belt city cluster. Likewise, Hong Kong is the major port of the Pearl River Delta and an international financial center. Hong Kong is also adjacent to Shenzhen, another economic center and major port in the Pearl River Delta. Thus, the distance to Hong Kong actually represents the distance to Hong Kong and Shenzhen.[6] See Figure 3 for the location of the major ports.

[Insert Figure 3 here]

In Table 2, we attempt to reveal a proper definition for higher-level cities in the regional urban system using their nonagricultural population. To construct time-consistent data, we only use the information on cities in 1990 to identify large cities, with the information after 1990 merely used to illustrate how quickly urban sizes in China have evolved. We identify a nonagricultural population of 1.5 million as the lower boundary of large cities in China's regional urban hierarchy. The reasons for this criterion are as follows. First, in 1990, there were nine cities with a nonagricultural population greater than two million, eight of which located in coastal areas. Accordingly, this would not well represent the urban hierarchy in inland areas. Second, in 1990, there were 31 cities with a nonagricultural population of more than one million, most of which were municipalities and provincial capitals. Therefore, high-level cities defined according to this criterion may correlate highly with municipalities and provincial capitals in China. Moreover, if we set a nonagricultural population of one million as the lower boundary, there are simply too many large cities defined.

Considering these, we define large cities in China's urban hierarchy as those with a nonagricultural population of more than 1.5 million in 1990. Our assumption is that via agglomeration, these 14 large cities either already had or would generally become the regional centers of the domestic and regional market and thus play a central role in China's urban system for each region within the CP structure. Figure 3 depicts the distribution of large cities in China.[7]

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[5] Because of the different measurements of cargo throughput used, Shanghai sometimes ranks higher than Hong Kong. Fortunately, this is not a major issue in our study as both are classified as major ports.

[6] We compile our information about port cargo throughput from the China Statistical Abstract 2009 (National Bureau of Statistics, 2009). Though this publication also contains information on ports in mainland China and Hong Kong in 1990, measurement differs and they are therefore difficult to compare. Therefore, we were obliged to use the most recent year (e.g. 2008) of data for cargo throughput using the same measurement (tons).

[7] These are Shanghai, Beijing, Tianjin, Shenyang, Wuhan, Guangzhou, Ha'erbin, Chongqing, Xi'an, Nanjing,

As shown, almost all are provincial capitals, with the exception of Dalian. To test whether the results are sensitive to our definition of large cities, we substitute the distance to the nearest large city for the distance to the nearest municipality or provincial capital to check the robustness of our empirical results (as discussed in Section VI). We measure geographic distance using *China Map 2008*, issued by Beijing Turing Software Technology Co., Ltd., China Transport Electronic & Audio-Video Publishing House. As the CP model displays nonlinear characteristics, we also include the squared and cubed values of distance in some of our regressions to capture any nonlinearity.

For the 14 large cities defined, their distances to the nearest large city are all zero. Their economic growth may benefit from their city size, so we use a dummy *largecity* to control for this effect. However, this should not be a problem for our major ports as Hong Kong is not included in our sample and the *largecity* dummy already controls for Shanghai. In addition, the GDP level of the nearest large city in the initial year is also controlled for by *gdpofbig*, which is ln(GDP) in 1990, exclusive of agricultural output.

4.2.3. Market Segmentation and Border Effect

Policy is an important factor affecting spatial agglomeration in NEG theory. When it comes to studies on the Chinese urban system, an important policy factor that affects regional economic development is interregional market segmentation. For example, several studies have suggested that there is a serious market segmentation problem among Chinese provinces (Young, 2000; Ponect, 2005; Chen, *et al.*, 2007). Interprovincial division is likely to increase the actual distance between cities in different provinces, and limit the spatial interaction among cities. Our study attempts to reveal whether the administrative boundary limits spatial interaction within the urban system. Denoted as *samepro*, the dummy variable represents whether a city is in the same province as its nearest large city. If the "border effect" of China's provinces does not affect spatial interaction between cities (and thus urban economic growth) this variable should be insignificant.

4.2.4. Other Geography Variables

In fact, spatial interaction is only the second nature of cities. For studies of China's urban economy, there are some other geographic factors of first nature that we should control for that may, according to Krugman (1993), also indicate potential initial advantages.

Mainland China is usually divided into three regions: East, Center, and West. The Eastern region has eight provinces and three municipalities, Central China has seven provinces, and the West has eleven provinces and one municipality. There are significant interregional differences in climate, access to water, topography, and other features of the environment (Ho and Li, 2010), along with economic development. National-level policies are also designed for achieving interregional economic balance between the East, Center, and West. Therefore, we use dummy

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Dalian, Chengdu, Changchun, and Taiyuan.

variables for "*west*" and "*center*" to capture any interregional differences in geography and policies.[8] However, the regional division of mainland China does not strictly follow geographic location. For example, Guangxi Province is geographically located in the south coastal area, but grouped by the Strategy of Western Region Development launched by Chinese government in 1999 with the West given its poor economic performance. Figure 3 illustrates the distribution of China's provinces.

Cities with ports in coastal area or with river ports along large rivers may also benefit from access to international or domestic markets, so we also specify *seaport* and *riverport* as dummies to control for this initial geographic advantage. The list of cities with seaports or river ports is from "*The First China Port City Mayors (International) Summit 2006*" held by the Development and Research Center, the Ministry of Communications, the Municipal Government of Tianjin, and the China Communications and Transportation Association.[9]

4.2.5. Initial State of Economic Growth Factors

Following the traditional economic growth literature (for example, Barro, 2000) and studies on China's economic growth, we will also measure some other factors that may contribute to China's urban economic growth, such as initial economic performance, investment, labor, education, etc.

$lngdp_{i0}$ is the logarithm of the per capita output of manufacturing and service in 1990, which is controlled for to observe whether the Chinese economy experiences conditional convergence at the city level.

$inve_{i0}$ is the ratio of investment to GDP, where GDP is the total output of manufacturing and services in 1990.

We use the ratio of teachers to students in primary and junior schools (edu_{i0}) in 1990 to control for the effect of education; this may not be a good measurement, but is the best we could identify. We specify the ratio of employees to total population (lab_{i0}) in 1990 to proxy for labor. China's urban labor market reforms radically pushed ahead in the mid-1990s, so in 1990 the number of urban employees contained a substantial amount of disguised unemployment in state- and collective-owned enterprises. Therefore, a high labor ratio may not be significantly positive for urban economic growth.

The government expenditure-to-GDP ratio and FDI-to-GDP ratio in 1990, as usually controlled for in the economic growth literature, are respectively gov_{i0} and fdi_{i0}, where GDP is the

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[8] West includes cities from 12 provinces and one municipality, namely, Chongqing, Sichuan, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia, Guangxi, and Guizhou. Center includes cities from seven provinces, namely, Hebei, Anhui, Jiangxi, Henan, Hubei, Hunan, and Shanxi. The cities of the remaining 12 provinces and municipalities are in the East. These are Heilongjiang, Jilin, Liaoning, Tianjin, Beijing, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan.

[9] There are 32 cities with seaports: Qingdao, Yantai, Weihai, Rizhao, Haikou, Sanya, Tianjin, Tangshan, Qinhuangdao, Cangzhou, Dalian, Jinzhou, Yinkou, Lianyungang, Fuzhou, Xiamen, Quanzhou, Zhangzhou, Guangzhou, Shenzhen, Zhuhai, Shantou, Zhanjiang, Zhongshan, Shanghai, Ningbo, Wenzhou, Zhoushan, Taizhou, Beihai, Fangchenggang, and Qinzhou. There are another 22 cities with river ports: Ha'erbin, Jiamusi, Wuhu, Ma'anshan, Tonglin, Anqinq, Yueyang, Nanjing, Wuxi, Suzhou, Nantong, Yangzhou, Zhenjiang, Foshan, Dongguan, Luzhou, Wuhan, Yichang, Nanchang, Jiujiang, Nanning, Wuzhou, and Chongqing.

total output of three sectors, as we cannot distinguish between the final flows of government expenditure and foreign direct investment across sectors. The effects of government expenditure and foreign direct investment on economic growth are conventionally difficult to predict beforehand (Barro, 2000; Clarke, 1995; Partridge, 1997).

con_{i0} represents several other control variables related to Chinese urban economic growth, including the ratio of the nonagricultural population to the total population (*urb*) (to account for the level of urbanization) and population density (*density*) and its square (*density²*) (to reflect internal population agglomeration in urban areas). We also use the ratio of service GDP to manufacturing to proxy for the industrial structure of the urban sector (*SM*).

4.2.6. Policy

We can never ignore policy in empirical studies of agglomeration and urban economies. Other than the administrative boundaries mentioned, there may be some other policy advantages affecting China's urban economic growth that are controlled for in the literature (Bao *et al.*, 2002; Ho and Li, 2010).

As discussed earlier, in our prefecture-level database, different administrative levels of cities remain, namely, municipalities, provincial capitals, and other cities. Because municipalities and provincial capitals potentially enjoy special policies from the central and provincial governments, we use a dummy variable (*capital)* to capture any benefits. For example, in 1997 Chongqing rose from an ordinary prefecture-level city to become a municipality. After considering its special history,[10] we define Chongqing as a provincial capital in 1990.

Likewise, in the process of Chinese reform and openness, starting in 1980 four special economic zones (SEZs) were created in China's coastal areas, and 14 cities later chosen as open coastal cities (OCCs) in 1994.[11] The intention of these SEZs and OCCs was to attract FDI, obtain access to international markets, and gain special policy advantages. We use the dummies *SEZ* and *open* to measure the effects of this preferential policy. However, as we expect these variables to correlate highly with distance to the nearest large city and major port, FDI, *seaport* dummy and some others, we do not expect significant estimated coefficients. Table 3 provides descriptive statistics for all the variables.

[Insert Table 3 here]

V. Estimation Results

Table 4 reports the estimated results of the model. In addition to the more conventional economic growth factors, we include the geographic variables in equations (1)–(3). In equation (1), we only add the linear item of distance to the nearest large city and major port, while we add

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[10] Chongqing was the capital of the Republic of China during World War II and is an important city in western China.
[11] The four SEZ established in 1980 are Shenzhen, Zhuhai, Xiamen, and Shantou. The 14 OCC in 1994 are Tianjin, Shanghai, Dalian, Qinhuangdao, Yantai, Qingdao, Lianyungang, Nantong, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang, and Beihai.

the squares and cubes of distances in equation (2) and drop the insignificant cube of distance to a large city in equation (3).

[Insert Table 4 here]

5.1. Nonlinearity of the CP Structure in China's Urban System

In equation (1), both of the distances are insignificantly negative, which means urban economic growth decreases away from large cities and major ports, but the effect is statistically insignificant. As discussed, the nonlinearity of the CP model may exist in China's urban system. If so, and as Fujita and Mori (1997) and Fujita, Krugman, and Mori (1999) have showed, the ∿-shaped correlation between distance and economic activity may be present in our estimated results. Consequently, we add the squares and cubes of distance in equation (2).

The results of equation (2) show that the distance to a major port and its square and cube are all significant, which proves nonlinearity in China's urban system. However, none of the three terms for distance to a large city is significant. We surmise a ∿-shaped curve could only occur when the distance to a large city is sufficiently long, otherwise, we would only observe a U-shape when using real data. Therefore, we drop the cube of the distance to a large city from equation (3). Obviously, in equation (3) all distance variables are significant: the distance to the large city is negative, its squared term is positive. In contrast, the distance to a major port is negative, while the squared term is positive and the cubed term is negative.

Based on estimated results, we respectively simulate the correlation between the distances to the major ports or large cities and the urban economic growth rate in Figures 4 and 6. The horizontal axis represents the distance (kilometers) away from major ports, and the vertical axis is the urban economic growth rate (%). We discover a CP pattern of urban system evolution consistent with theory.

[Insert Figure 4 here]

The dashed line in Figure 4 suggests that the impact of distance to major port on urban economic growth has basically the same shape as the market potential curve of the CP model in the urban system (Fujita and Mori, 1997; Fujita, Krugman, and Mori, 1999). While a city is located within about 600 km away from a major port, the closer it is to the major port and international markets, the larger market potential and the higher economic growth rate it has. When the distance is farther away, international market access is no longer that important. Therefore, a location far away from a port may promote the accumulation of regional and domestic market potential, as well as the development of local economies. When distance is sufficiently long (farther than 1,500 km from a port), cities remote from both the domestic and international markets suffer from low market potential and a lower economic growth rate. In addition, when we follow economic geography studies (Dobkins and Ioannides, 2001; Partridge *et al.*, 2009) and only control for the geographic variables in model (4), the results do not change much and all the

coefficients are statistically more significant. Interestingly, the model including only two distance variables explains 6.9% of the variance in city growth, compared with 42.8% when all the variables are included in model (3).

To make the effects of the distances to major ports clearer, we mark the two turning points of economic growth curve on the map of mainland China in Figure 5. Here, 600 km from Hong Kong and Shanghai, denoted with a dashed curve, is the location with the lowest average growth, all other things being equal, while 1,500 km away, marked by a solid curve, is the place with second-highest growth rate.

[Insert Figure 5 here]

In Figure 6, we simulate the correlation between the distance to the nearest large city and urban economic growth using the results of our regressions. When a city is close to a large city, spatial agglomeration effects promote large cities to absorb economic resources from their surroundings, which is a significant centripetal force. Meanwhile, being closer to a large city, also means greater market access for a regional economic center. Therefore, the closer to the central cities, the faster a city grows. However, when further away from large cities, instead of the centripetal force, the centrifugal force plays the dominant role. Therefore, the further the distance, the faster a city grows. Our estimated result shows the turning point is about 300 km, which means that within about 300 kilometers, the interplay between cities displays a strong centripetal force, which is similar to the findings in Hanson (2005). The difference is that we also find that when the distance is greater than 300 km, because of transportation costs and other external diseconomies, centrifugal force dominates the spatial interaction between cities performance.

[Insert Figure 6 here]

However, in the regional urban systems, there is no sign of the possibility of multicentric systems. This may be because of the limited population or scope surrounding the cores. In Figure 4, the complete ∽-shaped curve requires at least 1,400 km distance, while the real distance to the nearest large city in regional systems is not sufficiently long. In fact, China's urban system today is the result of a long-term evolution, thus new large cities may have emerged where there was a greater market potential because of the spatial agglomeration of established large cities, as shown by the numerical simulation in Fujita, Krugman, and Mori (1999). Therefore, in Figure 4, what we can see may be only the left half of the ∽-shaped curve, not the whole. Moreover, the impact of major ports is stronger than large cities on urban economies because within a certain distance economic growth decreases much faster as distance from major ports increases than it does away from a large city.

Based on the above, we can safely conclude that the national urban system in China has presented a complete CP structure because of the adjustment of urban economies to

international markets. The importance of large cities in regional urban systems is less significant but also verified. We also find evidence for the agglomeration shadow modeled by Krugman (1993) in the Chinese urban system. This suggests that being closer to an agglomeration center is not always good news for the local economy. This finding adds new evidence in helping solve the paradox that Partridge *et al.* (2009) found between the positive closeness–growth relationship when using real data and the theoretical hypothesis of an "agglomeration shadow."

5.2. Border Effect

The same-province dummy (*samepro*) is always significantly negative, which means cities have a lower growth rate if they are in the same province as their nearest large city. This is because the absorptive effects of large cities will be larger in this circumstance. This means that the border effect, similar to the findings in Parsley and Wei (2001) and Poncet (2005) exists between Chinese provinces, which is likely to increase the actual distances between cities in different provinces. Based on our estimates, China's interprovincial border effect is equivalent to as much as 260 km[12] for two neighboring cities. Poncet (2005) finds that the interprovincial border in China is like an international border in Europe, so our estimate of the interprovincial border effect is acceptable.

The border effect in this paper presents as the distortion of the spatial concentration. We believe this is consistent with China's history of province-level market segmentation (Young, 2000; Ponect, 2005) and migration restrictions (Au and Henderson, 2006a, 2006b). Moreover, Chen *et al.* (2007) argue that provincial governments have an incentive to restrict the agglomeration effects from large cities in other provinces using administrative force to protect their own economic development. Further, Lu and Chen (2009) find that for most observations at provincial level market segmentation increases economic growth. These conclusions are also consistent with the findings in this paper. Although in cities of the same province segmentation can prevent them from the absorptive effects of large cities in other provinces, market segmentation always brings losses in resource allocative efficiency. In turn, this lowers the growth rate for the whole economy, resulting in an underdeveloped city scale (Au and Henderson, 2006a), and a smaller scale inequality among Chinese cities (Fujita *et al.*, 2004).

5.3. Geography and Policy

We also note that in equations (1)–(3), the *center, west,* and *capital* dummies are not significant. This differs from the findings in previous research, including Bao *et al.* (2002) and Ho and Li (2010). This is because with the spatial interaction among cities controlled for in our paper, no other growth disadvantages significantly exist in the western or central regions, and there are no other obvious advantages in provincial capitals or municipalities. In other words, spatial agglomeration in China's urban system contributes most to interregional economic

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[12] We simply estimate this border effect by dividing the coefficient of the same-province dummy by the linear term of the distance to the nearest large city in equation (3).

disparity in China.

Though correlated with the dummy variables for *open* and *SEZ*, the dummy *seaport* is significantly positive, whereas *open* and *SEZ* are insignificant. This implies the possibility that geography is more important than policy for China's long-run urban growth. Nevertheless, this needs further study. Furthermore, the *riverport* dummy is insignificantly positive.

5.4. Other Economic Growth Factors

In our regressions, we also control for other urban economic growth factors, the impacts of which do not vary significantly across equations (1)–(3). Most of the factors are insignificant, except for education as measured by the teacher–student ratio. Education (*edu*) is significantly positive. This is because education investment in the initial stage promotes human capital accumulation and economic growth in the long run.

Our regression results also imply that the impact of investment (*inve*) is insignificantly negative which may be because Chinese cities with high investment have no obvious economic advantage in the long term because, as a whole, the Chinese economy suffers from low efficiency spawned by overinvestment (Zhang, 2003).

Some other factors, like labor (*lab*), government expenditure (*gov*), FDI (*fdi*), urbanization (*urb*), population density (*density, density²*), and industrial structure (*SM*) all have insignificant impacts on urban economic growth in the long run based on our regression results. Finally, the initial level of per capita GDP has an insignificant negative impact on China's urban economic growth, showing no significant trend in conditional convergence at city level. The insignificant variables do not become significant even if we drop the variables for distance to major ports and large cities. We also exercised estimation by substituting right-hand-side variables with their average values across the time span of our data, and the results do not change significantly.[13]

5.5. Robustness Checks

We estimate several models based on equation (3) to test the robustness of our key findings in Table 5. In equations (5) and (6), we change the definition of a large city to retest the hypothesis about regional urban systems. In particular, we redefine large cities as provincial capitals and municipalities. Thus, distance to the nearest large city is replaced by distance to the provincial capital (*distcap*). We again measure the geographic distance using *China Map 2008* (Beijing Turing Software Technology Co., Ltd., China Transport Electronic & Audio-Video Publishing House, 2008). We only include the linear term of distance to the provincial capital in equation (5) and add the squared term to equation (6). For consistency with the variable for which we control, we drop the dummies *samepro* and *largecity*, and replace the variable *gdpofbig* by *gdpofcap* (the economic scale of the provincial capitals, that is, ln(GDP) in 1990 excluding agricultural output).

In equation (7), we add Tianjin into our definition of major ports and replace distance to the

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[13] Results available from authors upon request.

nearer major port between Shanghai and Hong Kong (*disport*) by distance to the nearest major port among Shanghai, Hong Kong and Tianjin (*disport3*).

Time span is also an important issue for our study as we highlight the role of China's openness and international trade in the changing urban system. However, a large amount of information in 1992 and 1993 are missing from the Chinese *Urban Statistical Yearbooks* (National Bureau of Statistics, 1993–94). Therefore, we use the urban data from 1994 and replace the dependent variable with the average annual growth rate of real per capita GDP from 1994 to 2006 (*dgdp2)* deflated by provincial urban CPI, where agricultural output and population are also excluded. Another benefit of this robustness check is the greater number of observations, increasing from 133 in equation (3) to 193 in equation (8). Table 5 includes the results of the robustness checks, with only the variables relevant to spatial interaction reported to save space.

[Insert Table 5 here]

As shown in Table 5, in equation (5), instead of distance to nearest large city and its square, we only include distance to the provincial capital, which is significantly negative, suggesting the provincial capitals have strong absorptive effects on the surrounding cities. In equation (6), we include both the distance to the provincial capital and its square, both of which are not significant. Consequently, provincial capitals have only significant centripetal forces, which is not conducive to the economic growth of remote cities. One explanation is that the number of provincial capitals is about twice that of large cities, so that for most observations the distance to the provincial capital is much shorter than to the nearest large city. In this context, only a negative distance–growth relationship would appear, which we can see as the first part of the U-shape we find for the relationship between the distance to the nearest large city and urban growth. Moreover, the larger initial economic scale of the provincial capital, the slower its urban economic growth, as *gdpofcap* is significantly negative. This result shows a stronger absorptive effect for larger central cities. The variables for the distance to major ports are usually significant.

In equation (7) where Tianjin is included as a major port in China's urban system, the variables for distance to major ports are still significant, but the significance levels decrease, which proves that the economic agglomeration of Tianjin is not as strong as Shanghai and Hong Kong. We also estimated three separate regressions using the data within each city group. The ⌣-shaped relationship between distance-to-port and urban growth is robust in city groups centered on Shanghai and Hong Kong. However, for the cities centered on Tianjin, the relationship is insignificant. This is understandable as Tianjin is not comparable with Shanghai and Hong Kong in terms of economic scale and cargo throughput. What is more, the difference between Tianjin and other leading ports in the Bohai Belt is not huge in terms of cargo throughput. If we construct a variable of distance to the four major ports in the Bohai Belt weighted by their cargo throughputs, then the distance–growth relationship becomes

significant.[14] This indicates again that Tianjin is not strong enough to act as a core of a national level urban system. In addition, the variables for distance to nearest large city are insignificant with the same sign as in equation (3). This suggests that the robustness of the importance of large cities and regional urban systems is less than major ports and the national urban system.

In equation (8) with the dependent variable now specified as economic growth during 1994–2006, the significance of the distance-to-port variables are almost the same as in equation (3), while the significance of the distance to large cities decreases substantially. It is then possible that ever since China's rapid openness to the international market in 1994, the agglomeration patterns of China's urban system change to meet the needs of developing international trade, so that the distance to major ports is becoming more and more important, at least when compared with that to large cities. However, this is beyond the scope of this paper and further study is required.

In existing NEG literature, per capita GDP, rather than its growth, usually serves as the dependent variable. In our study, we also attempt to substitute the growth rate of per capita GDP with its level, and conduct panel data regression and year-by-year estimation. To ensure that our results are robust, even if we only consider the manufacturing and service sector, we regress GDP per worker for secondary and tertiary industries on the geographic and other explanatory variables. These additional regression exercises do not alter our major findings significantly.[15]

VI. How Important Is Geography? Long-Run, Medium-Run and Short-Run Comparison

There are three possible explanations for the insignificance of the growth factors in the long run. First, the most obvious is that these factors may have no long-term impact on urban economic growth. Second, measurement error in the variables and small sample size may have reduced their levels of significance. To expand the sample size, we extend our long-run growth regression to medium- and short-run analyses.

In Table 6, there are three equations for urban economic growth in the short, medium and long run, respectively. In equation 9, to minimize the simultaneity bias, we lag the explanatory variables by 1 year and use the city-level panel data during 1990-2006 to run the regression for yearly growth. In equation 10, per capita compound average GDP growth rate over 5-year periods, namely, 1990-1995, 1996-2000, and 2001-2005, is used as dependent variable. The explanatory variables are initial values over those 5-year periods. Again, random-effects GLS estimations are employed, since geographic variables are time-invariant. Equation 3 is duplicated for easy comparison with short- and medium-run growth regressions. In all the three equations, both distance-to-ports and distance-to-large cities are significant, showing the importance of geography through short to long run. In equation 3 duplicated from Table 4, the sample size is the smallest, but the distance-to-ports variables have the most significant effects. So in the long run, international market is more important.

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[14] These results are not reported to conserve space, but available upon request.
[15] We do not report these results to save space, but they are available upon request.

[Insert Table 6 here]

Based on the estimation results, we add to Figure 4 a solid line simulating the relationship between distance-to-ports and growth in the short run. The two curves lie close to each other, showing that the long-run relationship between distance and growth is the accumulative effect of that in the short run.

It's quite interesting to compare other variables' effects on growth in the short, medium and long run. Investment-to-GDP ratio has positive effect on growth in the short run, but the magnitude of the coefficient shrinks in the medium run, and it becomes insignificant and negative in the long run. This is alarming for China's growth pattern that highly relies on investment. Although in the short run investment enhances growth, in the long run, more investment does not generate higher growth. Inefficiency and poor returns to investment might be the potential reason (Zhang, 2003). More recent data analysis shows that Middle and Western China has seen a faster capital deepening process during 1997-2007, which worsens the efficiency and returns to investment (Brandt, Tombe and Zhu, 2010; Lu, 2013). Similarly, government intervention significantly increases growth in the short run, since it may boost demand. But it has no significant effects in the long run, because government intervention distorts the market and offsets its growth-enhancing effects. [16] In the medium- and long-run regressions, we substitute the initial value of those time-variant variables by their average values of over 5 or 16 years, the insignificant coefficients don't change into significant. So, the insignificant effect is not because the short-run positive effect fades away as time goes by.[17]

Labor has negative effects on growth in the short run, as in the period we study China still had surplus labor. And labor is not significant in the long-run. In contrast, education significantly increases growth, and the effect is even greater and more statistically significant in the long run. The education measurement, teacher-student ratio, is actually an investment variable that has lagged effects on growth, and this may partly explain why education is more important in the long run. According to our estimation, if the number of teacher is increased by 1 per 100 students, the long-run growth would be 1.07 percentage points higher. FDI does not affect growth, since FDI correlates with geography. After controlling for a lot of geography variables, FDI does not have separable growth-enhancing effects. Finally, cities with lower initial per capita income level grow faster, showing a conditional convergence in the short run, but this convergence effect does not exist in the long run.

For a comparison, we drop the distance variables and the dummy for whether the nearest big city is in the same province, and run traditional growth regressions. In the long-run model, the labor and investment variables become significant at 10% level, and the provincial capital dummy turns significant at 5% level. In other words, some traditional growth factors are

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[16] Usually, in the long-run growth regression, government expenditure-to-GDP ratio has negative effects (Barro, 2000)。

[17] This result is available upon request.

correlated with the geographic variables we construct for the locations of cities. So, geography is a more fundamental factor to explain urban economic growth. [18]

Furthermore, we want to know how important geography is relative to other variables. Can other growth-enhancing factors alleviate geographic disadvantages? This is relevant for regional development policy making. To answer this question, we only control variables other than the distance-to-ports, distance-to-large cities variables and their non-linear terms. The results are reported in Table 7. In the short-run growth model, 34.6% of variations in growth are explained by model (9), and in model (11) the two distance variables explain 0.2% of growth variations. Another comparison is between model (3) and (4) for long-run growth. In model (3), all the explanatory variables explain 40.4% of growth, while the two distances explain 6.9% in model (4). This is another signal that geography plays an essential role in long-run economic growth at city level, and much more powerful than its short-run role.

[Insert Table 7 here]

To compare the effects of distances with and without other variables more visible, we simulate the distance-growth relationship in Figure 7. It shows that without controlling for other variables, the effect of distance-to-ports is much smaller than that with other factors controlled for. The difference is greater in middle China than the remote interior areas, so there must be something that can help counteract the geographic disadvantages. Based on equation (3), education investment is the major factor that significantly enhances long-run growth. In China, the middle regions have even slightly higher educational level, measured by per capita schooling years, than the eastern cities do (Lu, 2013). So, human capital investment is a policy tool that can be used to enhance growth in the geographically disadvantageous regions. In contrast, as shown already, moving money by investment and government expenditure is not effective to help laggard regions in the long run.

[Insert Figure 7 here]

VII. Conclusions

This paper represents an early attempt to verify the spatial pattern of China's urban system following the non-linear CP model. China's large territory and its open policy since the 1990s makes China a feasible application and suitable experimental field for testing the non-linear CP model of urban systems.

The most important finding of this paper is to verify the ∽-shaped nonlinear correlation between the geographical distance to major ports and urban economic growth, which is consistent with the non-linear CP model of urban systems. We find that China's urban economies adjust to increasingly important international trade according to their access to global market, especially after China's drastic opening up since the mid-1990s. Compared with distance to port,

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[18] This result is available upon request.

the distance to the nearest large city has a U-shaped relationship with urban growth.

The agglomeration shadow first modeled by Krugman (1993) is also evident in China's urban system, which means that being closer to agglomeration centers is not always good news for the local economy. We find that within a scope about 600 km away from Shanghai and Hong Kong growth rate falls with distance to major ports, while growth goes up for regions 600-1200 km away and falls again for more remote areas. This finding adds new evidence in helping solve the paradox that Partridge *et al*. (2009) found between the positive closeness–growth relationship found when using real data and the theoretical hypothesis of an agglomeration shadow.

Our study also shows that in the long run, geography plays a much more important role than in the short run, in terms of the significance levels of the distance-to-ports variables, their magnitudes and explanatory power in the model. Investment and government expenditure can increase short-run growth, but not significantly in the long run. Only educational investment is found effective to help alleviate geographic disadvantage for laggard areas in the long run. Therefore, regional policies for balanced development should be "moving people", in other words, free mobility of labor out of disadvantageous regions, rather than "moving money" by physical capital investment and government-sponsored projects. The only effective "moving money" policy is to invest in human capital in laggard regions to make people more capable of making choices between moving out and staying.

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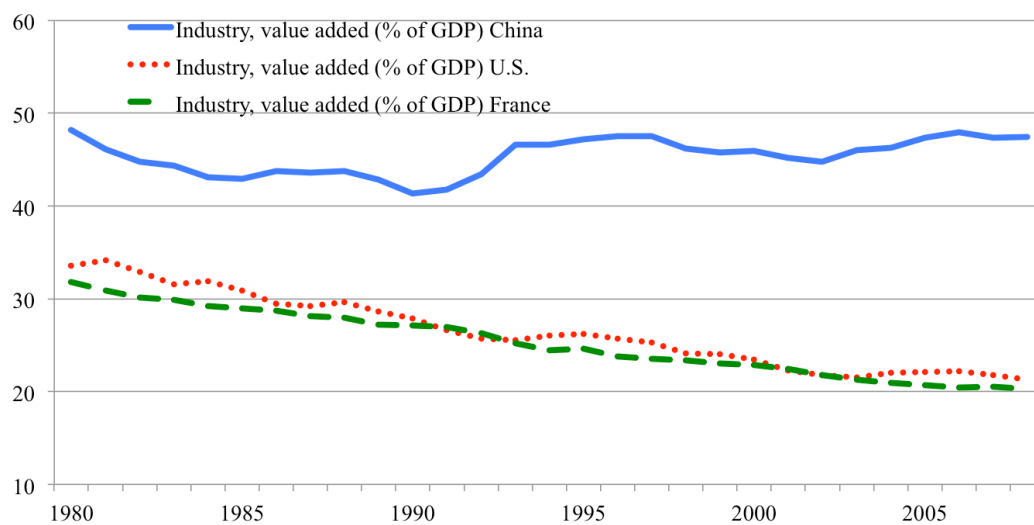
Figure 1: Share of Industry Value-Added in GDP (%) in China, US and France (1980–2008)

Sources: World Bank National Accounts data and OECD National Accounts data files.
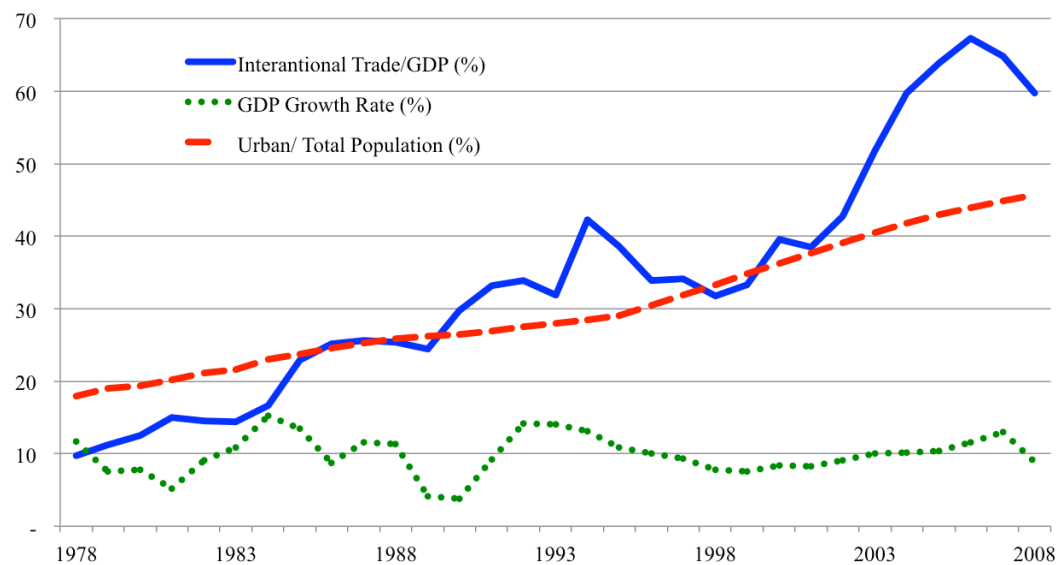
Figure 2: International Trade, Urbanization, and GDP Growth in China (1978–2008)

Source: NBS, China Statistical Abstract 2009.

Figure 3: Distribution of Large Cities, Major Ports, and Provinces in Mainland China

Note: (1) Deltas and squares are large cities and major ports using our definitions, respectively.

(2) Provinces in square brackets are located in the West, those in parentheses are in the Center, and the remainders are in the East.
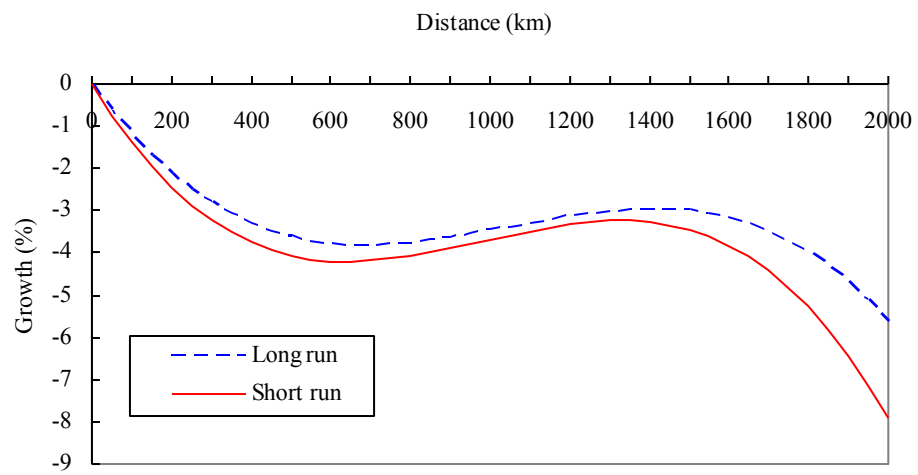
Figure 4: Distance to Major Port and Urban Economic Growth

Figure 5: Geographic Distance and Urban Economic Growth
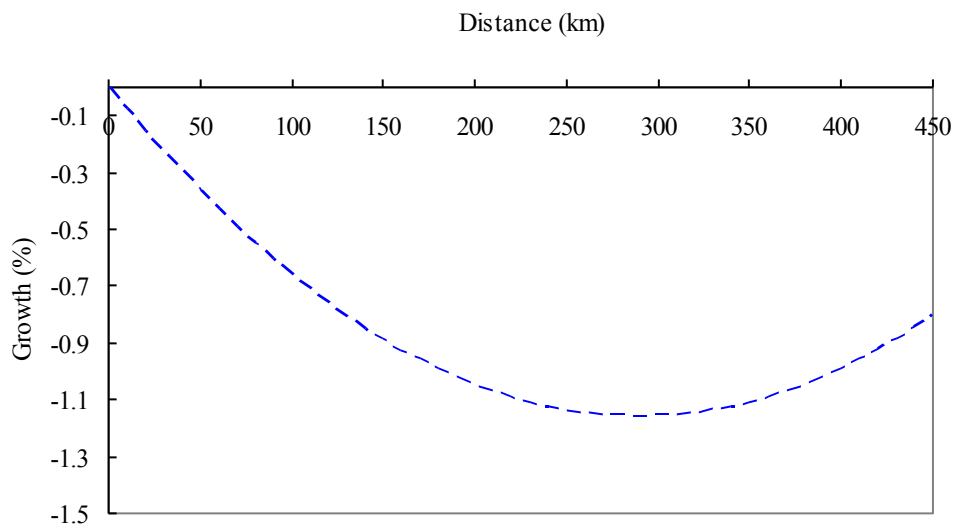
Distance (km)

Figure 6: Distance to Large City and Urban Economic Growth
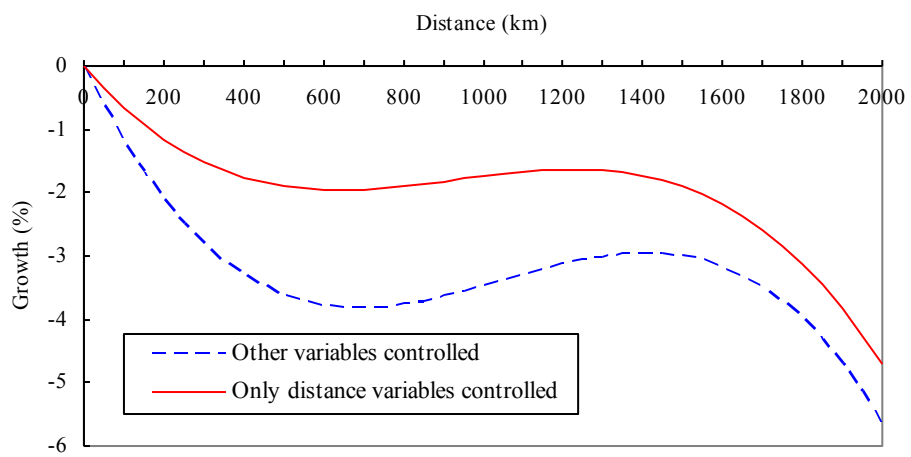
Figure 7: Distance to Major Ports and Urban Economic Growth

Table 1: Number of China's Cities

Year	Total	Municipalities	Prefecture-level cities	County-level cities
1990	467	3	185	279
1995	640	3	210	427
2000	663	4	259	400
2005	657	4	283	370

Source: NBS, *Chinese Urban Statistical Yearbooks* (1991–2006).

Note：1）Our database does not include information for Hong Kong, Macao, Taiwan and Tibet.

2)   Sub-provincial cities are also included in the prefecture-level cities.

Table 2: China's Urban Hierarchy

Year	Prefecture-level and above cities	Provincial capitals	Nonagricultural population>2 million	Nonagricultural population>1.5 million	Nonagricultural population>1 million
1990	185	29	9	14	31
1995	210	29	10	16	32
2000	259	30	13	18	38
2005	286	30	22	31	54

Source: NBS, *Chinese Urban Statistical Yearbooks* (1991–2006).

Note：Provincial capitals include both municipalities and other provincial capitals.

Table 3: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min.	Max.
dgdp(%)	208	8.36	2.82	−0.37	17.10
distbig(km)	286	291.33	251.35	0	2351.8
disport(km)	286	896.75	542.90	0	3526.4
largecity	286	0.07	0.26	0	1
gdpofbig(100 million yuan)	286	114.93	80.74	37.36	344.47
samepro	286	0.41	0.49	0	1
seaport	286	0.11	0.32	0	1
riverport	286	0.08	0.28	0	1
center	286	0.35	0.48	0	1
west	286	0.29	0.46	0	1
gdp per capita(yuan)	210	3581.30	2120.26	382.23	19820.83
inve(%)	210	25.91	16.67	1.54	127.88
labor(%)	209	57.60	7.79	30.01	93.79
edu(%)	205	4.61	0.803	3.02	7.48
gov(%)	199	10.27	3.82	1.04	29.16
fdi(%)	145	3.28	9.78	0.01	100.99
urb(%)	211	59.40	23.62	8.05	96.53
density (per km²)	210	11849.77	4180.96	3631	32920
SM(%)	210	59.53	31.95	7.14	188.51
capital	286	0.11	0.31	0	1
open	286	0.05	0.21	0	1
SEZ	286	0.02	0.15	0	1

Table 4: Geography and Urban Economic Growth

(Dependent variable is the compound average growth rate between 1990 and 2006.)

	(1) dgdp	(2) dgdp	(3) dgdp	(4) dgdp
$disport/10^3$	−0.215	−12.9**	−11.2**	−7.37***
	(0.716)	(5.55)	(4.29)	(2.79)
$disport^2/10^6$		15.0**	12.8***	8.81***
		(6.79)	(4.82)	(3.03)
$disport^3/10^9$		−4.98**	−4.17**	−3.14***
		(2.36)	(1.60)	(0.995)
$distbig/10^3$	−1.69	−4.99	−8.02**	−5.58**
	(1.49)	(7.35)	(3.52)	(2.21)
$distbig^2/10^6$		6.76	13.2**	12.1***
		(14.8)	(5.40)	(3.54)
$distbig^3/10^9$		3.57		
		(7.59)		
largecity	0.754	0.883	0.724	
	(0.918)	(0.988)	(0.925)	
gdpofbig0	−0.549	−0.742	−0.763	
	(0.625)	(0.637)	(0.633)	
samepro	−1.947***	−2.165***	−2.211***	
	(0.666)	(0.707)	(0.697)	
seaport	1.978**	2.022**	1.962**	
	(0.838)	(0.843)	(0.831)	
riverport	0.752	0.730	0.614	
	(0.649)	(0.693)	(0.645)	
center	−1.391*	−0.989	−1.025	
	(0.797)	(0.812)	(0.806)	
west	−0.980	−1.349	−1.330	
	(0.878)	(0.878)	(0.874)	
lngdp	−0.845	−1.249*	−1.201	
	(0.726)	(0.745)	(0.735)	
$inve/10^2$	−3.45*	−2.78	−2.74	
	(2.01)	(2.01)	(2.00)	
$labor/10^2$	4.27	4.16	4.11	
	(3.36)	(3.44)	(3.43)	
edu	0.552***	0.590***	0.584***	
	(0.172)	(0.171)	(0.170)	
$gov/10^2$	4.39	2.69	3.07	
	(7.43)	(7.53)	(7.46)	
$fdi/10^2$	3.05	1.46	1.32	
	(2.56)	(2.62)	(2.59)	
$urb/10^2$	0.70	0.35	0.46	
	(1.35)	(1.36)	(1.33)	
$density/10^4$	2.15	2.70	2.80	
	(2.07)	(2.08)	(2.06)	
$density^2/10^9$	−5.07	−7.77	−7.99	
	(6.00)	(6.05)	(6.01)	
$SM/10^3$	−8.87	−5.16	−4.75	
	(10.6)	(10.7)	(10.6)	
capital	1.051	0.598	0.548	
	(0.775)	(0.792)	(0.782)	
open	−0.348	−0.287	−0.282	
	(1.043)	(1.031)	(1.027)	
SEZ	−1.798	−1.976	−2.005	
	(1.436)	(1.416)	(1.410)	
Constant	13.06*	19.72**	19.39**	10.39***
	(7.626)	(8.290)	(8.230)	(0.847)

Observations	132	132	132	202
R^2	0.387	0.430	0.428	0.069

Notes: (1) Standard errors in parentheses;

(2) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Robustness: Distance and Urban Economic Growth

	(3) dgdp	(5) dgdp	(6) dgdp	(7) dgdp	(8) dgdp2
disport/10^3	−11.2**	−3.73	−3.84		−13.9***
	(4.29)	(2.50)	(2.53)		(5.27)
disport^2/10^6	12.8***	3.59*	3.70*		14.6**
	(4.82)	(2.10)	(2.13)		(6.19)
disport^3/10^9	−4.17**	−0.854*	−0.876*		−4.28**
	(1.60)	(0.463)	(0.4.69)		(2.07)
disport3/10^3				−8.81	
				(5.54)	
disport3^2/10^6				14.4*	
				(7.55)	
disport3^3/10^9				−7.42**	
				(3.30)	
distbig/10^3	−8.02**			−9.53**	−9.25*
	(3.52)			(4.30)	(5.40)
distbig^2/10^6	13.2**			14.7**	10.7
	(5.40)			(5.68)	(8.04)
distcap/10^3		−7.48***	−10.4		
		(2.50)	(8.53)		
distcap^2/10^6			7.05		
			(19.8)		
gdpofcap		−2.011***	−2.036***		
		(0.423)	(0.430)		
Other controls	Y	Y	Y	Y	Y
Observations	132	132	132	132	192
R^2	0.428	0.492	0.493	0.434	0.373

Notes: (1) Standard errors in parentheses;

(2) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Urban Economic Growth in the Short, Medium and Long Run

	(9) short run	(10) medium run	(3) long run
disport/10³	-15.6**	-16.3***	−11.2**
	(6.8)	(5.8)	(4.29)
disport²/10⁶	18.0**	17.4***	12.8***
	(7.5)	(6.5)	(4.82)
disport³/10⁹	-6.09**	-5.41**	−4.17**
	(2.40)	(2.12)	(1.60)
distbig/10³	-17.2***	-10.8**	−8.02**
	(5.5)	(4.5)	(3.52)
distbig²/10⁶	22.5***	16.3**	13.2**
	(8.1)	(7.1)	(5.40)
largecity	1.436	2.354*	0.724
	(1.849)	(1.424)	(0.925)
gdpofbig0	-1.355	-0.301	−0.763
	(1.083)	(0.886)	(0.633)
samepro	-5.359***	-4.171***	−2.211***
	(1.112)	(0.907)	(0.697)
seaport	3.298**	3.198**	1.962**
	(1.588)	(1.247)	(0.831)
riverport	-0.111	0.548	0.614
	(1.309)	(1.012)	(0.645)
center	-0.138	-0.287	−1.025
	(1.358)	(1.102)	(0.806)
west	-0.365	-0.004	−1.330
	(1.485)	(1.221)	(0.874)
lngdp	-2.680***	-2.858***	−1.201
	(0.809)	(0.720)	(0.735)
inve/10²	8.7***	3.5**	−2.74
	(2.0)	(1.7)	(2.00)
labor/10²	-10.4***	-10.0***	4.11
	(2.0)	(1.6)	(3.43)
edu	0.482	0.289	0.584***
	(0.468)	(0.321)	(0.170)
gov/10²	26.9***	16.7**	3.07
	(8.9)	(7.5)	(7.46)
fdi/10²	1.6	2.4	1.32
	(18.9)	(17.5)	(2.59)
urb/10²	6.7***	1.5	4.60
	(1.9)	(1.6)	(13.3)
density/10⁴	-17.50***	-0.77	2.80
	(1.50)	(3.04)	(2.06)
density²/10⁹	68.20***	8.48	−7.99
	(2.25)	(11.00)	(6.01)
SM/10³	-5.72	-7.19	−4.75
	(8.52)	(7.22)	(10.6)
capital	0.549	-0.248	0.548
	(1.558)	(1.186)	(0.782)
open	-0.614	-0.050	−0.282
	(2.070)	(1.587)	(1.027)
SEZ	-5.811**	-2.364	−2.005
	(2.801)	(2.216)	(1.410)
Constant	49.38***	41.05***	19.39**

	(11.10)	(9.52)	(8.23)
Observations	2793	561	132
R²	0.346	0.170	0.428

Notes: (1) Standard errors in parentheses;

(2) $^{*}\, p < 0.10,\, ^{**}\, p < 0.05,\, ^{***}\, p < 0.01$.

Table 7：Urban Economic Growth in the Short, Medium and Long Run (Only Distance Controlled)

	(11) short run	(12) medium run	(4) long run
disport/10³	-11.8**	-2.7	−7.37***
	(5.9)	(4.0)	(2.79)
disport²/10⁶	13.1**	4.5	8.81***
	(6.2)	(4.2)	(3.03)
disport³/10⁹	-4.04**	-1.88	−3.14***
	(1.99)	(1.37)	(0.995)
distbig/10³	-7.1	-3.9	−5.58**
	(5.0)	(3.2)	(2.21)
distbig²/10⁶	12.8*	8.7*	12.1***
	(7.3)	(4.9)	(3.54)
Constant	12.85***	8.82***	10.39***
	(1.92)	(1.24)	(0.847)
Observations	3185	706	202
R²	0.002	0.006	0.069

Notes: (1) Standard errors in parentheses;

(2) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.